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

20 February 1985

COMMISSION HEARING

IN THE MATTER OF:

The hearing called by the Oil Conservation Commission on its own motion to define the vertical and areal extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in conjunction 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
Commissioner Ed Kelley

TRANSCRIPT OF HEARING

A P P E A R A N C E S

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I N D E X

I N D E X CONT'D

E X H I B I T S

MR. STAMETS: We'll call next Case 8224, in the matter of the hearing called by the Oil Conservation Commission on its own motion to define the vertical and areal extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in conjunction with the production of oil and gas in McKinley, Rio Arriba, Sandoval, and San Juan Counties, New Mexico.

Before we start this case today I'd kind of like to go over some of the -- some of the ground rules.

Based on a 1958 Attorney General's opinion, anyone who is here attempting to represent a corporation or another person must be represented by a New Mexico attorney.

Any person may represent himself as an individual.

Any person may testify. All testimony, though, will be subject to cross examination.

Any person may make a statement and the statements are not subject to cross examination.

The intent today is to hear the report of the committee which has been studying this issue. We'll be hearing from the committee chairman. Also, I'd like to hear from any committee member who might like to make a statement or has anything to say relative to the committee report or the committee activities.

We will be hearing from the Division's Environmental Bureau Chief and the Division's Environmental Engineering Specialist.

I would hope today that we can get everything out on the table that would sort of set out where we might wind up in this case; anything from, say, total abolition of -- of disposal of produced water on the surface, to twenty barrels a day being allowed.

We will allow cross examination of the witnesses today. They will also be available at the second session of this hearing for additional cross examination. The second session of the hearing is currently scheduled for this same time, same place, on March the 20th.

I would ask that at the conclusion of the day, if at all possible, that participants could identify those issues they will be addressing at the hearing twenty days from now.

We will also accept proposed orders in this case at the conclusion of the hearing.

At this time I would like to call for appearances in this case and any attorney who doesn't practice here on a regular basis or any other person that's going to make an appearance, if you've got a card that you could give the reporter, that would certainly help.

At this time we will call for appearances.

MR. TAYLOR: Mr. Chairman, I'm Jeff Taylor and I'll be representing the Produced Water Study Committee.

We'll have three witnesses.

MR. KELLAHIN: Mr. Chairman, I'm Tom Kellahin of Kellahin and Kellahin in Santa Fe, New Mexico, appearing on behalf of Tenneco Oil Company.

MR. CARR: Mr. Chairman, my name is William F. Carr with the law firm Campbell and Black, P. A., in Santa Fe. l

I'm appearing on behalf of Northwest Pipeline Corporation.

I'd also like to enter my appearance for Amoco Production Company.

MR. WRIGHT: Mr. Chairman, I'm Tom Wright with El Paso Natural Gas Company. I'm associated today for purposes of this hearing with the firm of Montgomery and Andrews.

We don't expect at this time to have anything to say. At the appropriate time I wish to make a statement.

MR. SHUEY: Mr. Chairman, my name is Chris Shuey and I'm appearing for myself.

I don't anticipate having anything to say in the way of testimony; however, there may be a procedural matter that I would like to bring up at the appropriate time.

MR. PAULSON: Gary Paulson, appearing in association with Mr. Carr for Amoco Production Company.

MR. STAMETS: Any other appearances in this case?

Mr. Taylor, you may proceed.

MR. TAYLOR: Do you want to swear the witnesses at this time?

MR. STAMETS: Oh, yes, that's a good idea.

How many witnesses will you have today, three? Okay.

Are there any other persons planning to put on testimony today?

(Witnesses sworn.)

MR. TAYLOR: We'd first like to call Mr. Marty Buys.

MARTIN BUYS,

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

DIRECT EXAMINATION

BY MR. TAYLOR:

Q Mr. Buys, for the record would you state your name, by whom you're employed, and in what capacity?

A My name is Martin Buys. I'm employed by Tenneco Oil Company in their Western Rocky Mountain Division in Denver, and our largest producing area in that division is the San Juan Basin, northwest New Mexico.

Q You're appearing here today in your capacity as the Chairman of the Produced Water Study Committee?

A That's right, I am.

Q Have you ever testified before the Oil Conservation Commission and had your qualifications as an expert accepted?

A I've never testified before them, no.

Q Would you please then state for the Commission your educational and professional background, please?

A Sure, fine. I have a Bachelor of Science degree in environmental chemistry from Rutgers University in New Jersey.

I've been a director of a Public Health Water Quality Lab for two and a half years.

I have a Master's degree in environmental engineering, also from Rutgers University, and I've conducted several hazardous waste ground water contamination studies for the State of New Mexico -- for the State of New Jersey as a hazardous waste inspector, and as the Hazardous Waste Coordinator of Tenneco Chemicals, have also conducted several ground water studies and closures of landfills.

MR. TAYLOR: Are the witness' qualifications acceptable?

MR. STAMETS: They are.

Q Mr. Buys, could you just for the record explain the purpose of the Produced Water Study Committee, its make-up, and how it functioned?

A Well, the Study Committee was put together at an OCD meeting in this room last July 18th to try to attempt to identify any problems that might exist with the disposal of produced water from oil and gas operations in the four-county area of northwest New Mexico.

The committee is composed -- the total committee is composed of approximately fifty people. Of that, about half, a little bit more than half, worked on the -- were actively involved in this short term study group.

At the time of the July 18th meeting I was asked to be chairman in that, and that afternoon everybody who wanted to be on the committee sat down and we divided the committee into two study groups, short term and long term.

The long term has not -- has not done anything at this point; it's all been short term work, although members who are officially on the long term have done short term work.

Q Could you briefly explain how the committee arrived at its recommendations, what process they went through?

A I can do it, but I don't know how -- brief, I don't know, but yes, we can, certainly.

One thing I'd like to give out is the recommendations of the committee to the -- oh, you have to stamp them?

As I said, the committee was formed on the afternoon of July 18th, this past summer, and essentially the committee consists of people from the oil and gas industry, the Oil Conservation Division, the Environmental Improvement Division, several environmental groups that I think you could say for the State of New Mexico and the League of Women Voters from Santa Fe, and I was asked to be chairman.

To facilitate the work of the committee on what our charges were, we tried to divide up into two groups, long and short term study groups.

As I said, the long term group has been on hold until -- I would assume that fairly soon it would start up with some tasks.

By consensus we agreed within the committee that there would be four goals.

One was to determine what constitutes a vulnerable aquifer.

The second was map the vulnerable aquifers.

The third was attempt to determine the probability unlined pits may have in contaminating the vul nerable aquifers.

And the fourth was prepare a recommandation to the OCD for an order which will address the problems identified by the committee.

Of the four tasks, I believe we've completed three of them. I don't really think that we ever determined the probability of unlined pits as a pollution source, or at least came to a consensus.

We were given six months, essentially six months, to complete the work.

General meetings were held on August 2nd, October 17th, November 29th, and January 9th.

In addition, a small mapping group was put together with people from the short term group, and they met on August 20th, September 10th, and November 1st and 2nd.

On top of all of that we had a field trip to the San Juan Basin, which was held on October 16th, 1984.

The mapping group, which was sort of a sub set-up of the short term committee, used various sources to list water wells in the San Juan Basin in preparation for mapping the vulnerable areas.

The following criteria was used to determine what data would be included in the water well maps. Also they had a good amount of literature that within it had listings of various water wells, and they went through this large list to narrow it down to wells that would be relevant to what we were looking at.

And the first thing that they said was they'd record all springs that showed up.

Second, record all wells whose principal water-bearing unit was listed as Quaternary alluvium; record all wells whose depth to water was reportedly between zero and 400 feet; and when no other information was available, record all wells whose producing interval was reported to be between zero and 400 feet.

When only the perforation intervals were listed, they assumed that the top interval was the depth of the ground water.

This was really a very large task and took a lot of work on several people's part.

The water well information was put onto Northwest Pipeline's computer mapping program. The program was then used to generate two sets of maps; the one map, which could be overlaid on topographic maps for the four-county area; the one map listed zero to 50-foot, wells that feel in the zero to 50-foot range, and the other map was 51 to 400 feet.

We then used produced water maps and the water supply maps, or I should say we used production maps that listed oil and gas wells in the Basin, and water supply maps that were generated from this computer program, to divide the Basin into long and short term study areas.

If a township had no production, they

were eliminated from the short term study.

Q You're talking about water well production?

A No, I mean oil and gas production.

Q Okay.

A Secondly, if a township has only isolated oil and gas wells, it was eliminated for short term study, with provision that this would be looked at longer, or be looked at when the long term committee started its work.

This exercise delineated the area for the short term study group; essentially, it eliminated about 60 percent of the surface area of the four-county -- surface area within the four counties.

Using production maps, the oil and gas production maps; water hazard maps, which are from a Federal agency; topographic maps; and the water well maps that were developed, we're now able to -- already to try to map the vulnerable areas in the Basin.

Various attempts were made to try to do this and in the beginning weren't very successful.

They tried to use definitions and that didn't work very well in the beginning; contour lines of equal elevation, and there was difficulty with that; and approaches in section, township and -- section, township and range delineations, and nothing really seemed to work well.

The mapping group met in El Paso, Texas, on November 1st and 2nd. At that time it was determined that by overlying a water well map on a topo map and tracing 100-foot contour lines perpendicular to the river flow, about 90 percent of the 50-foot water wells were covered.

If you then -- and that was -- that was very important because now we had taken in the better part of the water wells that we cared about.

If you then designated the sections that contained the remaining 50-foot wells as special areas, you essentially, then, took in all the area that we knew about that contained water wells that were producing from 50-foot or less.

Let me read that definition to you now.

We came up with several definitions in the committee and that were agreed upon.

One was for vulnerable aquifer, and it says:

For the purpose of this order the following are defined as vulnerable aquifers:

Unconfined aquifers that are less than 40 -- 50 foot from the surface, or unconfined aquifers in floodplain areas, or aquifers in unconsolidated materials. That's where we got the 50-foot, or cared about 50-foot water wells.

From that, then, we said the vulnerable area is an area which lies over or adjacent to a vulnerable aquifer and is defined as an area within the river valleys of the San Juan, Animas, and La Plata Rivers, which is bounded by the topographic line on either side of the river that is 100 vertical feet above the river channel measured perpendicularly to the river channel.

That's a map -- we have a map to show what that looks like.

The second thing we then defined was the special areas, areas which were areas outside the vulnerable area in which ground water is subsequently found to be within 50-foot of ground surface.

Special areas presently identified are listed below, and that's in the recommendations. It lists all those sections that were not in the continuous area, or the vulnerable area.

We also then listed those areas which lie between the rivers and irrigation ditches in this area, in the river valley areas of the San Juan Basin, and there's about one, two, three, four, seven of those listed.

I'd like to now run through the map.

Q For the record, also, let us point out that the special areas the definition is referring to, are listed on your -- the recommendations of the Produced Water Study Committee, dated January 21st, 1985, which we'll denominate as Exhibit One.

A Okay. So, anyhow, using those definitions, the water wells maps, we came up with a vulnerable area, which we've listed on the map that I have here as, I think it's Exhibit Two. The other one is Exhibit One.

Q So, essentially what you're saying here is that in trying to determine vulnerable areas you came to certain areas, which essentially, from the map look like they lie along water courses, and your other areas, which you defined as special areas, are really contiguous to those.

A They're noncontiguous but they meet the same criteria, which, essentially, in this case would be 50-foot -- water wells producing from 50-foot or less.

Q So they're all vulnerable areas and the only difference between special areas is that they're not contiguous with the rest of them.

A That's right. They are -- they are exactly the same, and would be treated the same.

The second thing that these definitions allowed us to do was the vulnerable area and the special areas are not absolute in that if some -- at some future time we find, by whatever means, we find that water is being produced, we find water that is -- we know to be at least than 50 foot, and then it would be considered to be -- the Commission, we believe, would then consider to add that into the vulnerable or special areas, depending on whether it was continuous or not.

The other thing that this did, it reduced the area of study for the short term committee and for an order from approximately 15,000 square miles to 350 square miles.

The other thing it does, within that area there's contained approximately, we calculated, 1200 oil and gas wells, where in the very beginning a complete order would have covered -- an order for the whole area would have covered approximately 17,000 oil and gas wells.

Now, the second thing that we worked on was various definitions for different type pits at a typical oil and gas well, and then some prohibitioin exemptions and permits, and I'd like to use the easel to draw something right now.

MR. TAYLOR: Would anybody in the audience like copies of these maps?

A We worked on various definitions and I'm using this to represent an average oil -- an average gas well in the San Juan Basin. This does not by any means represent every well, or every configuration in the San Juan Basin.

Various definitions of the work line were the produced water pit, and that is the pit which received produced water from the primary separation in conjunction with the production of oil and gas, and that would be this pit here.

On average this is the pit that receives the most water in any day on that site, on an average.

Secondly, there's the dehydrator pit, which would only receive produced water, only from the dehydration, and that is this pit here.

The third pit is the blowdown pit, which receives liquid only when a well is blown down. That would be this one here.

The fourth one is the tank drain pit, which is the pit receives water when the production stock tank is drained.

And two other definitions, which I haven't drawn in the line here, are pipeline drip collector pit, which is the pit which receives liquids when accumulated in gas pipelines, and a compressor scrubber pit, which, you know, usually -- I won't say usually -- can be on the site. Many times it is, and that's a pit that receives liquids when the compressor suction is receiving water because of primary separator failure.

One section in the order, or in our recommendations, is entitled PROHIBITIONS AND EXEMPTIONS, and it clarifies what is covered by the order, specifically, disposal of produced water or fluids produced in conjunction with the production of oil and natural gas, or both, in unlined pits is prohibited, except for the disposal of produced water as described herein.

And the first thing it clarifies is that pits that lie outside the vulnerable area or special areas at this time are not covered by the order.

The other three things it covers are -- or the other thing it covers is pits, ponds, lagoons, or impoundments that are covered by other regulatory programs, whether it be State or Federal, as an example, EID regulations, RCRA regulations, NPDES permits, Coal Mining, Surface Mining, Land Reclamation, various acts that are in force or recognized by the State.

And the one -- the other thing that it attempted to address were the ancillary pit, which is any pit on a site that is not routinely receiving water, but specifically the compressor scrubber pit, pipeline drip pit, tank drain pit, blowdown pit, and dehydrator pit, and the committee, I mean, it has to be said that the committee agreed not to agree on allowing any small item exemptions within the order as we -- within the recommendations of the committee.

And so then on the recommendations, these areas where you see blanks were meant to be blank, because of this agreement.

The Commission will have to decide if a small item exemption, small volume discharges are to be allowed in the vulnerable area.

The second section I'm talking about now is permits and the purpose of that section is to allow for disposal of a certain amount of water into unlined pits based on depth to ground water beneath such pits and provided such pits meet certain criteria specifically demonstrating the quality of the produced water to go in the pit and the quality of the ground water underneath the pit, and the quality of soil and geologic conditions adjacent to and underlying the pits.

The committee, I think it's fair to say, agreed on a concept of a permit; however, they couldn't agree on the volume of produced water or the depth to groundwater that would be acceptable, so in that case, also, there are blanks left which were meant to be blank.

The other thing in the compliance schedule was it allowed for eighteen months, and I'll read it. After eighteen months of the date of the order, the use of unlined pits for the treatment, storage, and disposal of produced water within vulnerable or special areas defined herein is prohibited except by permit as defined above, and any pits or tanks that are installed after that time, I'm going to say after the time to be installed, shall be -- meet New Mexico Oil and Gas Conservation Division specifications.

And then we have the conclusion and it says, and I'm going to read this verbatim, very simply because this was worked out over a period of time and various people have various feelings about certain sentences:

The committee feels that these recommendations will provide the basis -- basic structure for an order from the OCD which will provide some immediate protection to vulnerable ground and surface waters in northwest New Mexico.

It should be understood that the committee worked essentially with limited data available in the records of various agencies, and to date only limited evidence of contamination of these waters was found.

Hydrologic mechanisms exist for transporting contaminants into the ground water. These mechanisms also provide some attenuation of such contaminants before reaching the ground water.

The ultimate disposition of various liquids deposited to unlined pits and a determination of the probability an unlined pit may have in contaminating vulnerable aquifers depend on the hydrological, geological, and soil and geochemical conditions at the individual pit sites.

Shallow ground water conditions and permeable surface materials present at these vulnerable areas provide a contamination risk from discharges of produced water. Until and unless quantifications of such risks become possible, protection of ground water for uses defined herein must be based on a rational but conservative methodology, keeping in mind the need to apply limited resources to address the potentially serious problems first.

Q Okay. Now just for a moment if I could try to summarize what you're saying and then maybe you can tell me if I understand it.

What you're saying is that the committee, in looking at solutions for potential pollution from produced water, decided that, the short term committee, what they would do is look at the most vulnerable areas, and on Exhibit Two those have been shaded in in the San Juan Basin, and those areas are the ones to which a proposed order would be applicable, and this order would prohibit disposal of produced water to unlined pits in those areas, unless an exemption is granted.

But the committee was unable to reach a consensus on any guidelines for granting exceptions.

A Yes, I think that's --

Q Is that more or less correct?

A That's a fair summary, yes.

Q And the committee recommends that a compliance schedule of approximately eighteen months be set up so that after that period of time these requirements would have to be met by all producers in any of the vulnerable areas in the San Juan Basin.

A Yes, that's right.

Q Okay.

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

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

MR. KELLAHIN: Thank you, Mr. Chairman.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Mr. Buys, when you referred to Exhibit Number One, which is the final recommendations of the Water

Study Committee, I have received over the last several months various drafts of this.

May we know what exact date you're referring to in this exhibit?

A Yes. There's been problems with -- we redrafted several times and the last time we did, and I thought we had it right, the word processor ate part of it, and I figured that they clarified.

So this would be dated 1-18-85:1410a. That would be on the last page.

The title of it is Recommendations of the Water Study Committee.

Q All right, sir, I have picked up one off the table in the back that's dated February 20th, '85. Am I looking at the same one?

A No, to make sure you -- it's handwritten or is it typed?

Q Handwritten.

A The proper date would be on the very last page about one-third of the way down the page.

Q All right, sir.

Mr. Buys, I'm interested in whether or not there was a consensus by the Study Committee with regards to the mapping of a vulnerable area.

For purposes of my question can I assume that the committee came to consensus that the area contained, or described, in the vulnerable area is one that is being contaminated? Is that correct?

A Ask me that question again.

Q All right.

A Within the vulnerable area the committee --

Q All right, I'm interested in the methodology and the explanations of the definitions you've used to describe a vulnerable area.

Am I correct in understanding that the vulnerable area does not mean that the Committee has come to a conclusion that within that area they established evidence of contamination by allowing produced water to be deposited in unlined surface pits.

A I think you can say that the vulnerable area represents that area within the study area, the whole study area, that we believe is most likely to be polluted, but I don't know that the committee as a whole agrees that this is an area that has been polluted.

Q All right, there is no consensus by the committee that this area has been polluted but it's one that is at high risk, or at risk, within the San Juan Basin.

A That's right.

Q Would you describe for me again, sir, what the difference is when we talk about a definition for the vulnerable area as opposed to those areas outside a vulnerable area?

How do I distinguish between the two?

A That are special areas, you mean?

Q No, sir, between an area that's a vulnerable area and one that is not, excluding for a moment the special areas.

A The vulnerable areas have been -- have been, you know, the work has been done, the definitions have been arrived at and agreed to by the committee, consensus by the committee, and a map has been prepared and presented as an exhibit.

Any area outside of the vulnerable area at this time is not part of the short term study group's responsibility. That's not to say it will not be studied later on by the long term committee.

Q Using the definition agreed upon by the study committee, how do you exclude the nonvulnerable area?

A From the short term study group's work?

Q Yes, sir.

A We had just so much time and so much energy and we had to put it where best we thought, and that's how we worked it going after that, the -- the vulnerable area.

Q Does -- does the area outside the vulnerable area fail to meet the definition agreed upon by the study committee in that you had ground water deeper than the agreed upon definition, or an absence of ground water that had been documented?

A There's various reasons why an area

that's not in the vulnerable area is not.

One is, I guess you'd say one is that there is no known pollution in -- in areas outside the vulnerable area.

Secondly, there is no -- we don't know that there's shallow ground water there; shallow, 50-foot or shallower.

In some of the areas there's no production; there might have been ground water, just was no production, oil and gas production.

I think many of the people on the committee, I will say people on the mapping committee were aware that a lot of the area that is not in the vulnerable area is also underlaid by geologic conditions that make it -- you would -- you would think it would be a lot harder for pollution to -- to have an effect on ground water there, or to have -- oil and gas to have an effect on ground water there. I'm not saying it won't, but a lot less difficult.

Q Is it fair to characterize the committee's consensus about the vulnerable area as one that has a rational basis upon which the Commission could then enter an order?

A I think it is a rational, logical approach there. That is, I think we've done enough work to show why they came about, and why this is the area that should be first looked at by the Commission for some sort of no pit order.

Q When we look at the map, which I think is Exhibit Number Two --

A That's it, yeah.

Q -- is that intended to be simply an illustration of the area affected by the definition?

A That's exactly right, the way the committee envisioned the program, an order would require each operator to determine, using the definition of a vulnerable area, whether his well's in that area or not, so that map is -- is just an illustration of what we think the vulnerable area is with our going through it with a couple of maps.

It, itself, would not be -- you would not use that to determine if your well is in or out of the program. The Commission would want to have definition and some sort of certification from the operator that his wells are or aren't in that area.

Q Is there a consensus by the committee that the definition as agreed upon is one that is convenient to administer and to understand, not only by the Commission but by operators faced with drilling wells in the vulnerable area?

A I think that's -- do think that's the case.

Specifically with new operations you determine, when you do your survey of your site, the information would come about at that time to determine if this is a site within this vulnerable area or not.

Within that vulnerable area I believe you've told us that there are identified some 1200 oil and gas wells that currently exist and approximately 300 water wells in this area.

A That's right.

Q When we look at the committee report on the page that shows the compliance schedule, second to last page, it has a paragraph that begins, "After eighteen months", if you'll look at the third line of that paragraph and find the phrase "prohibited except by permit", would it be fair, Mr. Buys, to insert after the word "permit" the words "or exemption" in the event the Commission approves some small volume exemption on a blanket basis in the unlined pits?

A That would -- that would seem logical to me to include there. Yes.

Q Let me discuss with you what was the thinking of the committee in terms of providing an eighteen month compliance schedule. Could you give us a little more detail about whether the committee thought that was reasonable, how that was arrived at, and what the committee was trying to accomplish?

A Well, I feel -- I feel that the committee agreed, my feeling is that the committee agreed that eighteen months was a reasonable time period.

The way it came about, I think, is we originally said a year, or a year was said, and we said that represents a couple problems to the industry.

One is planning for budgets for the capital expense that this would require; and secondly, while a year sounds good, most of the kind of work that we're talking about here, or we envision would have to be done, would not be able -- would not lend itself to being done in winter months. So a year would, in fact, not be a true year of working.

So that's how we came out with eighteen months.

Q I'd like to go through with you, Mr. Buys, the conclusion section of the report and have you explain for us the basis upon which various statements have been made in the conclusion section.

A Okay.

Q All right, let me find the ones that were of interest to me.

To return to an earlier discussion we've had in terms of what the vulnerable area means, it is simply an area where there is shallow ground water that is potentially at risk from contamination.

A That's right.

Q When we discuss the committee's work essential -- working essentially with limited data available in the records of various agencies, could you describe for us what is meant when we've added that portion of the next sentence?

A Well, the first thing that comes to mind is a lot of the data reported would not really be considered complete information about that water well. As an example, you might know how deep the well is, where the perforations, but it doesn't list exactly where the table, water table is. That's where we made some assumptions.

It's information like that we're saying is not -- was limited.

On the other hand, some people's opinion was that there are more water wells in this area, or in the Basin, than we had records of; therefore, we didn't -- if we didn't have a record of it we couldn't include it in our preliminary review to decide whether it would be applicable to this study or not.

And I guess that's what we're saying. There could be more water wells out there and some of the information that we did have could have been more complete. What we had is, I think, you know, gave us a pretty good shot at defining the vulnerable area.

Q The last portion of that sentence says that to date only limited evidence of contamination of these waters was found.

Could you amplify upon what evidence or basis that statement is made in the conclusions?

A Well, that particular statement was -- there was a lot of discussion in the committee, and I guess the only thing to say is that at this time there is one incidence of ground water contamination that is being -- is attributed to oil and gas production, and that that, the way I understand it, is that we don't know that that's exact -- that that is a true statement or not.

We know there is some pollution at one well in that vulnerable area but we don't know that it's been proven proof positive that that is linked to an unlined pit or produced water pit.

Q Can you identify for us in some descriptive words what well or area was involved when the committee identified one well within the vulnerable area that might be a source of contamination?

A This -- this well is in the Flora Vista area and I believe it's Mary Willer (sic) -- I forget the number on it.

Q It's the Manana Gas Well in Flora --

A Gas well --

Q -- Vista?

A -- right, and we did see this well on our -- on the field trip that we had in October of '84.

Q Has the committee attempted to make any type of calculations or other studies with regards to the hydrologic conditions around these unlined pits?

A No, we haven't, and that refers back to one of the four goals, was to attempt to determine the probability unlined pits have in contaminating the vulnerable aquifers, and that was something we did not have time to get to.

Q Can you describe for us, Mr. Buys, what your understanding is of those items that you anticipate would be the subject of a long term study?

A The first thing, I believe, would be some sort of approach to what impacts small volumes of produced water would have going into unlined pits in the vulnerable area.

The second thing on a long term committee would be look at other areas in the Basin to determine if any of these conditions we've described in the short term exist other places in the four county area.

Other than that I don't really have any other tasks for them right at this point in time.

Q Let me go through with you and see if I understand those major elements upon which there was consensus by the Water Study Committee.

When I use the word "consensus" I mean unanimous agreement by the various members of the study committee, so that the end product came to a resolution that everyone agreed upon.

With regards to mapping and defining and identifying the vulnerable area was there consensus on that point?

A Yes, there was.

Q When it came to the issue within the vulnerable area of providing a recommendation to the Division on precluding high volume discharges into unlined pits, was there any consensus on that point?

A High volume discharges.

Q Yes, volumes in excess of, say, twenty barrels a day.

A Yes, I think there's -- you can say there's consensus on that.

Q And what is that consensus?

A Pits, using the Federal standard, pits of five barrels or higher a day in all likelihood should not be allowed to go into -- pits that receive five barrels or greater, unlined pits in that vulnerable area, probably shouldn't be allowed to exist after the order is -- should be handled by the order; in other words, taken out of service.

Q Can you articulate for us the basis upon which the committee has a consensus about high volume discharges into unlined pits?

A Just that, I guess nothing more than logic. There's a certain amount of logic that I think most people can see that a large volume of water going into a pit day in and day out could have an effect in this small -- in this vulnerable area, and so I think from that most people are willing to concede that these large volumes going into these unlined pits probably shouldn't happen in a vulnerable area.

Q And that again is based upon the opinions of the study committee, their analysis, calculations, what not, but it is not based upon documented evidence of contamination by unlined pits, even at large volumes.

A Not in the San -- not in the vulnerable area, no, and not by calculation or any study. It was just, you know, certain -- certain definitions and certain logic, it seems like they should not exist any longer.

Q When we look at whether or not the Commission should allow a small volume exemption, which I have understood to be five barrels a day or less, then there was no consensus by the committee about that issue.

A That's right. There was a consensus to not agree to it.

Q When we talk about the pits, and with your permission, I'd like to mark the drawing as Study Committee's Exhibit Number Three, Mr. Buys, when we talk about the pits around a wellsite that are unlined, you've identified for us those pits.

Was there any consensus or agreement by the committee with regards to how to handle the unlined pits?

A By that do you mean how -- should they be lined or should be taken out of service, or --

Q Yes. Let's start with each one of the pits. When we look at the blowdown pit, was there a consensus about whether that pit ought to be lined or taken out of service?

A I don't think that there's any consensus on how it should be handled because we really didn't address that, other than we identified several pits that are common to operations in the San Juan Basin, and looked at -- had a consensus on definition to describe that pit.

But how a pit should be taken out of service was never -- I won't say it wasn't discussed, but it was never -- it was never made a goal of the short term committee.

Q Would you describe for the record, Mr. Buys, the understanding of you and the committee with regards to the order or frequency in which the various pits that you would commonly see at a wellsite are subject to having water placed in them?

I realize that you've gone through that earlier, but I'd like to have you do it again so that I'm clear on what the committee had available to it and its understanding of the pits that were subject to having water placed in them.

A Just that the primary -- the produced water pit, that water that receives -- that pit that receives water from primary separation is a pit that any given day when the well's on would in all likelihood receive water.

The other pits that are on the diagram do not routinely receive water every day, on average.

Q Where is the dehy pit in relation to the produced water pit on a typical well, sir? Is that the same pit or is that different?

A On average it's a different pit. Generally it's a different pit in the San Juan Basin.

MR. KELLAHIN: Thank you, Mr. Chairman.

MR. STAMETS: Are there any other questions of the witness? Mr. Shuey.

QUESTIONS BY MR. SHUEY:

Q Just a couple questions, Mr. Buys.

You said that there were approximately 1200 oil and gas wells in the vulnerable area that the committee described, and then you -- you've got your drawing here and you discussed some of the pits.

Is it safe to say that at each oil and gas well there are at least two and sometimes three pits?

A At a gas -- at a gas well there's -- there's, on average, there's -- will be the produced water pit and the dehydrator pit.

Q Okay, by the "produced water pit" you mean what?

A That pit that primarily receives water and any day would probably receive some water from the primary separation.

Q Okay. The pit that's associated with a condensate tank, does that sometimes receive water from the tank?

A Yes, it does, yes. No, not all wells in the San Juan Basin have condensate tanks. The San Juan -- many of the formations of the San Juan basin are very dry, both from water and from hydrocarbons.

Q Okay. When you discussed the Flora Vista case, you said that, if I can be accurate in describing what you said, that was a case in which a water well had been contaminated and that the possible culprit was a nearby pitted gas well.

A That's the way it's been described to me.

Q Okay. If we do some multiplication and find that at the 1200 oil and gas, or gas sites, in this vulnerable area, there's approximately 2400 pits, of the 2399 other pits besides this one in Flora Vista, have you or has anyone else evolved any information on that in terms of their -- in terms of whether they had contaminated ground water or not?

A I, well, from working on the committee, I don't know. I don't know that they have, and I have not seen any information. I'm trying to think -- I don't think we've seen any information.

Q In your capacity as the committee chairman, is it your opinion that the committee would have had time to go and get that information?

A Get --

Q To do some other site specific studies on other pits outside of that in Flora Vista?

A Not in a six months time frame.

Q Okay. Thank you.

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

MR. WRIGHT: Mr. Chairman, I'm Tom Wright, representing El Paso Natural Gas Company. I just have a few questions.

CROSS EXAMINATION

BY MR. WRIGHT:

Q Mr. Buys, during the committee deliberations, what were the ranges of small volume exemptions that the committee -- committee considered?

A A range of volumes anywhere from zero to five barrels.

Q So generally everyone on the committee agreed that there probably should not be exemption in the vulnerable area for more than five barrels.

A I think that's a fair statement.

Q But there was some support for both ends of the range on the short term committee, is that correct? Both for no exemption and for exemption of five barrels.

A Within the committee itself, yes, there was disagreement and some people believed both ends of that zero and five barrel range, right.

Q In the -- from what -- from the evidence that the committee considered, is there evidence that there are at well locations some pits that are normally dry?

A From the -- I believe that the committee would agree with that, yes.

Q And from what the -- from the evidence that the committee -- committee considered, there is some evidence that there are -- are pits that receive less than five barrels of produced water per day.

A Yes, I think that there's agreement on that, too.

Q And some of these numbers we've gone over before, but I'm not still clear on it, how many wells are we talking about in the vulnerable area?

A We've counted the wells as best we could off of -- using a particular listing system available in the San Juan Basin, and we feel that 1200 is a good representative number of how many wells are in that vulnerable and special areas.

Q In the vulnerable and --

A Oil and gas wells that are in production today.

Q And did the committee -- from the evidence the committee considered, do you have any idea about how many pits there are per well?

A I don't -- the committee did not -- I don't think it's -- I can't say the committee has an opinion on how many pits there are, but I think most people agreed, I think it's agreed, that the diagram on average is a fair representation.

Many wells will not have the blowdown pits.

Q So some wells have one pit and some wells have as many pits as there on this diagram?

A That's right, and some might even have another pit, but --

Q But the average would be about five pits per well?

A No. The average -- now, in my opinion the average will be about three pits per well.

Q Three pits per well and 1200 wells?

A Right.

Q Does the committee have any idea how much it would cost to line each pit?

A No. There's no consensus on the committee about that. That really wasn't discussed.

It was discussed at times but there was not any agreement and we had no need for an agreement from what we decided were our tasks.

Q Is there a list of the committee members, the short term committee members, entered into the record yet?

A No, but I -- I intended to do that.

Q That will be done.

A That will be done before I leave testifying.

Q Thank you, Mr. Buys.

MR. STAMETS: Mr. Paulson.

MR. PAULSON: Mr. Chairman, may I ask one question from here without going out?

MR. STAMETS: Only if the reporter can hear you.

MR. PAULSON: I'll speak loudly. Thank you.

Gary Paulson with Amoco Production Company.

CROSS EXAMINATION

BY MR. PAULSON:

Q Mr. Buys, the vulnerable area includes, according to your report, areas where the depth of ground water is less than 50 feet, and where the water is presently being used, or could reasonably be presumed to be used for certain purposes.

Did the committee attempt to investigate the quality of the water existing within the vulnerable area?

A The committee as a whole did not. Now, OCD has done some analysis and they will testify, they will be talking about that in a little while.

Q But the designation of the vulnerable area didn't take into account the quality of the water, ground water, that exists presently.

A No, it didn't.

Q So that it might be possible that if the recommendation that the committee is adopted, that under, I guess it's Section C-a), their quality permit, it's indicated that if the operator can demonstrate that the quality of the existing uncontaminated ground water is such that the introduction of produced water will not cause degradation of ground water, that you would then be able to get a permit.

It's certainly possible, is it not, that some of the water in there, within the vulnerable area, would facilitate --

A Be below quality; that's possible.

Q No, further questions.

MR. PAULSON: Thank you, Mr. Stamets.

MR. STAMETS: Are there other questions?

MR. KELLAHIN: Mr. Chairman, I have one last question based upon what Mr. Paulson asked.

RECROSS EXAMINATION

BY MR. KELLAHIN:

Q I think it's very clear, Mr. Buys, but let me ask you again to make sure I know, pollution was not a criteria to distinguish between the vulnerable and the nonvulnerable area.

A No, it was not.

Q The distinction is that the vulnerable area is an area that's at greater risk than the nonvulnerable area.

A That's right.

MR. STAMETS: Mr. Buys, I've got a --

MR. TAYLOR: Mr. Chairman, if I could just have one more question.

MR. STAMETS: Okay.

MR. TAYLOR: I just want to have Mr. Buys clarify the exemption they're talking about.

REDIRECT EXAMINATION

BY MR. TAYLOR:

Q Mr. Buys, you stated that there was no consensus on the committee about granting exemption for small -- what do I want to say -- for small water production, and that there is a feeling by some that zero was -- was what it should be, and others thought there should be an exemption for up to five wells.

A Five barrels.

Q Five barrels, excuse me.

A Yes.

Q Was the -- was the feeling of the committee, other than those people who thought there should be no exemption at all, that the exemption should be on a well by well basis where they would have to apply for that, or was there some other method by which they thought these exemptions could be granted?

A Well, the way -- the way we wrote this document, there would -- the way it was written, and I said it has not been agreed to in volume or in depth of ground water, that there be two ways to go at it.

One would be certain types of pits would essentially get a carte blanche exemption, which would allow them to dispose of small volumes of water into unlined pits.

Then the other way of going about it was if an operator on a well to well basis could demonstrate certain things, which are, you know, the quality of the water being produced, or the quality of the ground water underneath the pit, or soil and geologic and other considerations, which would show that it would be unlikely for water in the pit to get to ground water, then they could get a permit to dispose of, you know, an unstated volume of water at that pit, but that would be well to well, the way this is written now.

Q Well, I assume because there were some members of the committee that thought there should be no small volume of discharge exemption that there was not really consensus as to the fact that there shouldn't even be exemption to those, is that correct? The majority of the committee members felt there should be exemptions but there was no agreement because of the fact that some felt there should be no exemptions granted.

A That's right. I believe if you go a lit tle further, I believe you can say that there's -- I believe the people on the committee as a whole agreed that some sort of permitting -- if somebody could prove that they would not be impacting ground water, then there should be a mechanism for them to allow them to try to do that.

So I think as a whole the committee agreed that some sort of permitting process would be -- should be allowed.

Q So there more or less was a consensus on that issue if they could prove that there was no -- could be no harm to ground water.

A Yeah. What there was not a consensus on was how much water could go underground if you met these criteria.

Q You said you had a list of the members of the committee.

A Yeah, I was going to read that, yeah.

Q Okay, would you do that, please?

A Now, these are the -- these are the people on the committee, on the initial full committee, as I think that they participated in the short term, so here we go.

Chris Shuey of Southwest Research and Information Center.

Edith Pierpont from the League of Women

Voters here in Santa Fe.

Tom Chandler from Texaco.

Joe Rush from Milestone/El Paso.

Lori Komatar from Northwest Pipeline.

Dale Shoemaker of Amoco Production and Chuck Boyce of Amoco Production.

Masud Zaman of the Water Resources Division of the Navajo Indian Tribe.

Bill Lorang of El Paso Natural Gas.

Dave Boyer from the Oil Conservation Division.

A. R. Kendrick, representing Four Corners Gas Producers Association.

Anthony Drypolcher and other members of the Environmental Improvement Division.

John Calder of ARCO.

Mike Herrington of Union Texas.

And Albert Gutierrez of GeoScience Consultants, representing at the time Giant Industries, were probably the members as I -- as I remember who did the most work on the short term committee and had an impact on the results of the work.

Q Mr. Buys, our Exhibit One was the recommendations of the committee.

Exhibit Two is the map, and Exhibit Three are the drawings.

A The drawing.

Q Each of those were prepared under your supervision, was it not?

A Definitely, yes. Had to think about that. Yes.

MR. TAYLOR: I'd like to move the admission of Exhibits One, Two, and Three.

MR. STAMETS: These exhibits will be admitted.

CROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Buys, I've got a few questions.

If the Commission prohibits the disposal of produced water in the vulnerable area, what will the operators do with the water?

A If there's a total prohibition, you're going to have a volume of water that no longer an go into an unlined pit.

There's verious options available, but the fact of the matter remains that there's going to be some water that has to be disposed of that is not going to evaporate, and at this time in the San Juan Basin, it is my opinion there is just no mechanism to handle that.

That's not to say that there couldn't be and there won't be, but at this time there isn't.

Q What would the options be, though?

A The options would be deep well injection under the UIC program.

Another option would be building solar evaporation ponds either at each site or a central facility.

Various physical chemical treatments and then disposal. The disposal could be, you know, I'm not saying it would be, but through NPDS permits through a river or other water body if it was a high enough quality water used from any number of uses.

But those would be the general options.

MR. TAYLOR: Mr. Chairman, we'll have some testimony on options for disposal later on.

Q Your testimony was that none of these facilities are available at the present time to serve the volume of water which would be affected.

A To serve the volume of water, yes. I mean some of this is going on there but is not -- it does not exist to the scale that I think we'd need with a complete ban in the vulnerable area.

Q Okay. In Exhibit Number One, in Special Areas in Part b), you've identified the areas which lie between the rivers and the ditches mentioned below, and I presume that means that no pits or only the permitted pits would be allowed between that ditch and the appropriate river.

A That's right.

Q Now, are these ditches defined on your Exhibit Number Two or are they defined on the U. S. Coast and Geodetic Surveys? How would an operator determine whether or not he lay between one of those ditches and the river?

A They are not on our map, that I know, at least not all of them are, and I don't really have an answer for you.

The ditches, the irrigation ditches, were -- that was worked out between other committee members and all I know was -- what I know I can talk about is just that they exist and we felt that artificial water levels might exist between these ditches close to the river and the river, and we thought that that would make those areas vulnerable, also.

But other committee members could answer that question better.

Q Okay. Before this hearing is concluded we do need to be able to tell people how they can determine whether or not they are affected.

Mr. Buys, if the Commission goes along with the recommendation of this vulnerable area and, let's say, that a new ditch is put in or new wells are drilled and find water less than 50 feet deep, do you believe that the area should be expanded, say, at a public hearing, like we do our nomenclature?

A If information became available that would further identify some, you know, areas that could be -- that would meet the definition of vulnerable, yes, I think that would be the way to go with it, then, make an announcement and have a hearing.

Q Okay. On the next page relative to the prohibitions and exemptions, I presume that the volumes of water which would be disposed of would vary from well to well in the area.

A Vary in what way?

Q In volume. You might have one well making five barrels of water; another well making two barrels; another well making half a barrel.

A That's what, you know, the wells -- the San Juan Basin in it's gas operations is a low water producer in the first place, and it varies within -- within the Basin, and the wells do vary, so you'd have to identify a well and decide what kind of water volume is being produced.

Q And even if each -- in each well you could have a different volume at a separator drain line, say, from the dehy drain line, you might have, what, two barrels a day at the separator, half a barrel, or less, at the dehy?

A Yes. You -- the only pit that continually receives water on average is that produced water primary pit, the produced water pit from the primary separation.

Dehydrator pit does not receive water routinely at all, and as a matter of fact, the water that it does handle through its dehydration, much of it leaves as water vapor; it never does drop down into the pit, although I'm not saying -- why would you want a pit?

Q Based on water volumes alone, then, would you believe that there would be different levels of hazard in the vulnerable area from well to well and from pit to pit at individual wells?

A Yeah, in theory, yes.

Q Is it possible that the Commission should consider some sort of a phase-out by volume? Let's just say, for example, everything over five barrels a day would have to be phased out in twelve months, and everything from five barrels down to a half a barrel, in eighteen months and everything from, well, half a barrel and lower, in twenty-four months, would that be a logical way to phase out the produced water and provide protection in local areas?

A That, to me that seems like a logical way. I'm not necessarily agreeing to the compliance time but the concept, yes.

MR. STAMETS: Any other questions of this witness?

He may be excused.

We'll take about a fifteen minute recess.

(Thereupon a recess was taken.)

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

Mr. Taylor, you have some other witnesses?

MR. TAYLOR: Mr. Chairman, our next witness will be Mr. 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:

Q Would you please state your name, by whom you're employed, and your position for the record?

A Yes. My name is David Boyer. I'm employed the New Mexico Oil Conservation Division. I'm Chief of the Environmental Bureau and my position with the agency is a Geologist 4.

Q And you're appearing here today on behalf of the Division, is that right?

A Yes, that's correct.

Q Did you sit in on the meetings of the produced water committee? Were you a member of that committee?

A Yes, I was.

Q Have you ever appeared before the New Mexico Oil Conservation Commission before?

A No, I have not.

Q Would you then please state your educational experience and your work background for the Commission?

A Yes. I have a Bachelor of Science in hydrology and water resources from the University of Arizona.

I also have a Master of Science in hydrology from the University Arizona at Tucson.

My work experience, prior to New Mexico, was involved with various water resources development studies on Arizona Indian reservations through the Office of Arid Land Studies.

In 1978 I came to New Mexico and took a position as a geohydrologist with the New Mexico Environmental Improvement Division.

In that capacity I was in charge of the New Mexico Surface Impoundment Assessment and the New Mexico -- development of the non-oil and gas portion of the Underground Injection Control Program.

I also reviewed and made recommendations for approval and disapproval of ground water discharge plans under the Water Quality Control Commission regulations.

Last July I came to work for the Oil Conservation Commission.

Q And as part of your employment with the Oil Conservation Commission, you have been studying produced water for some time?

A Yes, that's correct.

MR. TAYLOR: Mr. Chairman, are the witness' credentials acceptable?

MR. STAMETS: They are.

Q Mr. Boyer, would you explain to us why the Commission proposed a rule prohibiting unlined pits, or proposed a study of this matter?

A Yes. The Commission is charged by New Mexico Legislative Statutes to protect fresh waters in the state as designated by the State Engineer. The reference to this statute is 70-2-12 B(15) of the New Mexico Code.

As part of that study we wanted to take a look at some of the different types of produced waters in the San Juan Basin and determine their characteristics and the potential for vulnerable -- for contamination, for aquifer contamination.

I have several exhibits that I would like to introduce and at this time I'd like to introduce Figure 1, or have Figure 1 introduced.

Q Let's see.

A Figure 1 is simply a schematic drawn by one of the OCD staff people of the possible sources of produced water in the field.

Now earlier Mr. Buys talked about a number of pits associated with individual wells and production facilities.

This shows quite a few different pits that -- at different facilities, both at the wellsite and further on down the pipeline.

These names are defined in the committee recommendations, ancillary pits, primary pits, the definitions are in there.

But this is the type of pit that we are talking about regulating in the San Juan Basin.

If we go to the areas that we're talking about today, Lee Wilson in a 1979 report, he listed that area as a highly vulnerable area to contamination and his reasons for listing the -- listing this area up in the San Juan Basin was because of the shallow water table and none, or very limited, protection from discharges to the vadose zone.

The soils up in that area are generally permeable and generally have no caliche in the valleys to overlie and protect them; therefore, there's a high potential to contaminate ground water from improper disposal practices in this area.

We need to take a look at, besides the vulnerable areas, which Mr. -- besides the definitions of vulnerable areas which Mr. Buys has already described in his testimony, we have to take a look at some of the characteristics of what we're talking about as far as the waste products that may go into these produced water pits, and these are products that are produced along with the oil and gas and it's usually called produced water.

Now, this water has a number of characteristics that we have looked at over the past -- over the past year.

I have some sampling results and I would like to introduce a table listing those sampling results and it's at the back there. This was a table that was compiled by the EID.

This, this table shows the results of sampling that were conducted in September of 1984 by this Division, myself, and David Catanach. An earlier sampling that was conducted back in April of 1984 of these particular, of several selected wells.

Additionally, sampling was conducted in January of this year and those analyses came in last night and they haven't been -- not all of them were complete and so I didn't try to compile them; however, that data will be available in the next few days and includes about another fifteen wells and pits.

Based on what I've seen in preliminary data, the hydrocarbon content of those samples is quite high. The TDS, or the total dissolved solids, is lower, but those will be available in a few days and I will gladly make them available to whoever wishes to make -- make copies.

In any event, I want to discuss some of the -- what we looked -- what we found with regards to some of the characteristics of these produced waters and why we believe that it is important that they be regulated to protect ground water.

First off the table shows that you have a wide variation of total dissolved solids. You have a variation from about 50 milligrams per liter at one particular well, the Florence 37 A, to over 24,000 at a Chacra -- Chacra well up in the San Juan Basin.

The average for the sample, these nine samples, was about 10,900. The limit which we protect ground water according to the statute that I referenced earlier, is 10,000 milligrams per liter, so these waters are at least on the average, are quite poor quality with total dissolved solids-wise.

Some of the other inorganic constituents that exceed standards that have been promulgated under the New Mexico Water Quality Control Commission regulations, just for an example, of standards in ground water, some of these other constituents include chloride, sulfate, some heavy metals, arsenic, barium, boron, iron, manganese, cadmium, chromium, lead, selenium. All of these inorganic materials that I've mentioned, especially the arsenic and selenium and lead, cadmium, have health effects that are toxic to humans at concentrations, at excessive concentrations.

These concentrations that I'm comparing them against were set after regulatory hearing by the New Mexico -- before the New Mexico Water Quality Commission several years ago when ground water standards were adopted based on health effects at that time.

If so desired, I can go into individual health effects from every -- from every parameter, if you wish, but I think that it's -- that at least right now I would just like to sum up as far as inorganic constituents are concerned by saying that the produced waters exceed those -- those numbers in a number of cases, and therefore that these waters should be -- should be disposed of in a proper way so as to prevent ground water pollution.

I also want to discuss what I think is the more important constituent now, is benzene and other associated hydrocarbons which are found dissolved in the waters that are released as the well -- as the water is -- as the natural gas comes up the water comes up and there is natural gas in those waters -- excuse me, there is dissolved hydrocarbon gas in that -- in those waters and that goes onto the surface of the ground.

To give you some idea of the comparisons, again with just using benzene, the health limit for benzene set in the regulations is .01 milligrams per liter.

The nine samples that are on this table have a range from 3.2 milligrams per liter to almost 30 milligrams per liter, and so there is, let's see, that would be ten, hundred, thousand, about a 10,000 difference, exceeding over the health standards. Is that right? Between 1000 and 10,000 exceeding over the health standards.

So benzene is an extremely important constituent and one that needs to be looked at in any type of a discharge to these unlined pits.

I'd like to just mention some of the

toxic effects of benzene.

It has been documented that benzene causes leukemias, in other words, cancer. There is good data indicating that health levels, that show that good health levels can be determined. It isn't a type of parameter where you've doing a lot of guesswork. There's a lot of good health data.

So benzene is probably the most important of -- of the constituents that we know of right now that we want to protect from getting into the ground water. There may be additional constituents that we haven't looked at. I've heard about them but I haven't looked at them, such things as polynuclear aromatic hydrocarbons and other exotic type names like that, but for purposes of this hearing I'm just mainly concentrating on the benzene and toluene and some of the other numbers that are in the -- that we have ground water standards, State ground water standards set for, and based on my review of this information, the produced waters exceed that -- those standards.

Now there are a number of things that are found in ground water naturally; benzene, however, is not one of them.

A lot of the inorganic constituents that I mentioned are found at different concentrations but benzene is not found in ground water naturally.

The State EID last summer published a study of volatile organic sampling results for statewide but

I'm going to concentrate on the system, on the San Juan County systems. I'm just going to concentrate on the ground water systems because of the surface water systems get it from the river and treat it.

The City of Aztec, they had no volatile organic hydrocarbons detected.

Flora Vista Water Users, none, none detected.

Lee Acres Water Users, none detected.

The West Hammond Water Users, none detected.

The ground waters, ones that were sampled, didn't detect any of these and earlier reference was made to Flora Vista. There was contamination detected several years ago in one well and that well was shut off line, but today none of the wells tested by the -- community wells tested by the State Environmental Improvement Division showed any detectable levels of these type of chemicals, so these are not normal constituents of ground water, at least not in the type of ground water we're looking at. They may be associated with oil and gas deposits.

Regarding the inorganic constituents, the one that is used most rapidly for comparison is total dissolved solids.

In 1980 the State EID made a -- compiled a list of chemical quality of New Mexico community water supplies. The total dissolved solids for the San Juan

Basin, wells, the ground water areas were from about 300 TDS up to about 7-or-800 TDS. There may be some individual variations beyond that but there are -- most of the water is of good quality. The State limit for total dissolved solids is 1000 milligrams per liter, so that is below that for the ground water standard.

So here again, the types of waters that are introduced do have characteristics that are -- that are both health effects and esthetic effects that need to be avoided in any type of disposal.

The one documented case we do have, again, was that of contamination in a well, is the Flora Vista, and as Mr. Buys said, the exact cause of that has not been proven, which -- which -- what might have been the cause. There was an oil and gas well in the neighborhood that was producing those types of hydrocarbons, but that's -- right now it hasn't been proven one way or the other.

Q So if I could summarize what you've said there, the Commission is delegated the responsibility of, under the Water Quality Control Commission, of prohibiting pollution of water or protecting fresh water resources.

A Well, that is not a delegation. That is a separate prohibition or separate charge that is given in the statutes under the Oil and Gas Act.

I was just using the Water Quality Control Commission regulations or not regulations but standards as examples, because those standards were set for New Mexico conditions and they differ a little bit from the Public Health standars for drinking water, for example, in a couple of constituents.

Again, it's useful to look at those as a comparison against what -- as some sort of a number to start from to compare how bad the discharges are.

Q And essentially the Commission's determination to study produced water flows from its duty to protect the fresh water resources.

A Yes, that is correct.

Q Okay. Could you please explain for us, Mr. Buys was talking about the fact that the committee had decided that the immediate vulnerable areas in the northwest part of the state were those aquifers or areas along rivers where there is water at less than -- at 50 feet or less. Could you explain the rationale for that determination?

A Yes. As I was getting to a little bit further in my techinal testimony a little bit later, the reason for this is that the shallower water is clearly at risk in -- from this disposal. I'm going to elaborate on some of these, but it goes back to what I mentioned before in the Lee Wilson report, too, that this area has shallow water which means that travel times are shortened for the materials getting to water. It has a characteristic, it does not have in general low permeability materials. It doesn't have the caliche like you see down in the southeastern corner of the state. It has sands and gravels in the vadose zone, or the unsaturated zone, as it's also called.

All of these give -- give rise to having a --looking at that area first. Many of the wells in the San Juan Basin are at that depth, or thereabouts, so this first cut at protecting these vulnerable aquifers used -- used 50 feet as a working number so that we could look at these wells individually, and again, that was based on the fact that it is the most vulnerable, area most vulnerable to contamination from percolation downward.

Q So essentially there's been no determination that water deeper than that is not vulnerable, but in the short term for the committee to work on, 50 feet or less was most vulnerable --

A Yes.

Q -- and something needed to be done?

A Yes, and I think that it's important to emphasize that in the definition of vulnerable aquifer, the definition of 50 feet was -- was also followed by a definition of unconsolidated, or aquifers existing in unconsolidated materials.

So there are additional safeguards, but again, 50 feet is a good number for working from this information.

Q Okay. Mr. Buys stated that the committee had been unable to come to a consensus as to small volume discharges; that generally many people on the committee felt that small volume discharges should be allowed but they were unable to agree on the amount of discharge or specifically how they might be handled other than on a well-by-well basis.

Does the Division have any recommendations to make in this regard?

A Yes. I feel, as Chief of the Environmental Bureau, that -- that there should be no small blanket exemption for small volume discharges, and I'm going to present some technical testimony as to why I feel that way.

In general you may have -- there are a number of problems, and I'll just discuss some of those briefly, but -- and then I'll discuss the technical reasons.

Aside from technical reasons, the type of discharge that goes from both the primary separator and the dehydrator contains hydrocarbons that are -- that have high levels of toxic materials, as I testified just a few minutes ago, arsenic and benzene, and so on and so forth.

The difference is mainly in volume but you still may have a drip that comes out a relatively small volume but it has very high concentrations.

So small volume along does not provide for much protection.

There are also some administrative reasons. If we wanted to do a permitting program from a standpoint of taking a look at individual unlined pits within the vulnerable area, I think that it would take a large quantity of staff time and also it would take a -- it would take a lot more information from the operator to give us the type of information as to how much is actually going into the pit, what is the quality, and so on and so forth.

Those are briefly my views, and I'd like to go on to the technical testimony, give you some technical back-up for why I believe that small quantity discharges pose a risk, as well as large quantity discharges.

I'd like to introduce another figure. It's labeled Figure 2. It's a general soil map of the San Juan Basin and it -- Figure 2 is from the Soil Conservation Service, the Department of Agriculture Soil Survey, and I just want to briefly discuss that the figure, if you take a look at the area labeled 2, you'll see it goes along the river areas from Farmington up towards Bloomfield and Blanco and up to Aztec and up to Cedar Hill.

If you take a look at the map units down below, you will take a look at the association, the soil associations that are called the Fruitland-Riverwash-Stumble. Deep, nearly level to moderately steep, well drained to somewhat excessively drained soils that formed in alluvium and Riverwash, on fans and in valleys.

The next page of Figure 2 gives a little bit better explanation of what is meant by that definition.

I think the key word there is -- is drained and excessively drained. In that particular case it gives a rather qualitative indication of permeability. In other words, if you add water to the soil it moves into the soil. It doesn't stand and pond like you'd have if you had a clay -- clay layer or something like that. It actually moves into it.

And they say it's deep and well drained, which means that it's well developed and throughout that well developed stage it is drained and is drainable.

That is sort of a general soils map and I have additional discussion that I'd like to get into that will discuss the individual characteristics within the area.

The area shown on that soil map, that Area 2, follows very closely along with the area, the vulnerable area that we're talking about in this exhibit over here. Which exhibit is that?

Q Two.

A That's Committee Exhibit Number Two.

So I feel that it's very good justification to discuss in detail the individual soils within this particular area, and the general statement I made is that the vadose zone, or unsaturated zone, provides little protection for small quantities or large quantities, for that matter, of discharge to the subsurface.

Consequently, I'd like to enter into the record Table 1, which is entitled Properties of Soils in the San Juan River Valleys.

Q Okay, and let's list this as Exhibit Four.

A I will discuss briefly this table. It is five pages of different types of soils on it, and the sixth page is interpretive information. The soil name and map symbol are given and the acreage in the soil survey area, and that's the entire soil survey area, so it's possible there are additional areas outside the vulnerable area that are included in this numbers of acreages, but generally my review of the San Juan Basin, or San Juan County Soil Survey Manual, shows that most of this acreage is indeed inside the vulnerable area.

A listing of the depth and the texture, and I see one mistake right up at the top there, that should be zero to 5 inches for the Ap soil instead of zero of 51.

The texture in that particular soil is a clayloam.

The permeabilities are given from the tests that the Soil Conservation made and are listed in tabular form in the manual, so those are the vertical permeabilities and it also can be called the infiltration rate of those particular soils.

And as a hydrologic soil group, C, which is defined on page six of the table, and it tells what the infiltration rate is, or qualitatively describes the infiltration rate, and some other qualitative information about the particular soil.

The soil location is also given on that page six, and that's listed, for example, that first soil, it's a floodplain and low river terrace, and there are some limitations listed in the soil survey for the particular use of different things.

Now in this case unlined pit suitability, meaning unlined sewage pits, but it wouldn't matter, it has a severe limitation to the wetness and floods. In other words, it has a real shallow water table, 24 to 60 inches seasonal water table.

If you go through and take a look at these individual soils, you'll see that for the most part once you get below the top, what's called the A horizon, you get into more permeable materials, sand, loamy sands, gravelly sands, I can just go through, sandy loams, but permeabilities are -- increase also, 4-to-12 feet per day permeabilities and they have severe limitation because of seepage. Unlined pits have severe limitations because of seepage.

So what the bottom line of the summary of this particular table shows is that the soild in the vulnerable area are indeed, for the most part, coarse grained and do have limitations for controlling infiltration into the subsurface; in other words, infiltration is very rapid.

At this time I'd like to introduce this Table 2.

Q Let's designate that as Exhibit Five.

A Table 2 is entitled <u>Application Rates for Pits of Various Diameters and Variable Discharge Rates.</u>

What I did here was, it's time to explain how -- what my thought process is -- was on making some of these calculations.

Based on what I've seen up in the San Juan Basin, a lot of the fluid that comes out of the separators, before -- it just doesn't go into the pit from the end of the pipe. It has something called a swirl pot that decreases the amount of pressure and essentially sprays the fluids over a certain area.

It depends on -- I'm sure it depends on the pressure and the design of the swirl pot as to how far it goes, what that area is.

So I took a diameter under the swirl pot of 2 feet, 3 feet, and 4 feet, for purposes of calculations.

Then I also took estimations of the rate of discharge into the pit. In other words, it dumps 5 barrels per day, 1 barrel per day, 1/2 barrel per day, or maybe 2-1/2 barrel -- gallons once a day and that might be based on the volume inside the separator and only dumps once a day, so it dumps 2-1/2 gallons.

If you make a calculation over that volume over that area, it tells you, if you had an impermeable pit, what the depth of the water would be on that -- on that area; in other words, how much water at the end of a day would you have.

If it dumps 5 barrels per day to an area of 2 square -- to an area with a diameter of 2 feet, you'd have a depth of 8.9 feet if you had no -- if you had a liner or something like that.

Now, you can compare that rate of application to the permeability rates that I gave in Table 1, and the conclusion I draw from doing that is that at depths beneath 6 to 24 inches most permeabilities or most infiltration rates exceed, and in some cases greatly exceed, the application rates; therefore ponding will not occur under natural conditions, and I'm just talking here about the reason why you see pits so dry is one, you may indeed have a lack of water, but two, your infiltration rates are so -- so large that the water soaks right in, and this is -- I'm just talking about the water phase here and if you get oil you can have other -- other complications, but if we just talk about the separator is working properly and you're disposing of your disposed water.

So that's why you see dry pits, is those two reasons. One, small volumes. Two, high infiltration rates.

I'd like to introduce another table and that's Table Number 3.

Q Which we'll designate as Exhibit Number Six.

A Before I read the title I just want to make one additional comment about Table 3.

There was some speculation aboaut evaporation and flash-off playing a role in removing some of these materials before it reaches into the -- gets into the ground, and Phil Baca, the Environmental Engineer for the Division will address some of those issues in his own testimony later on.

Anyway, getting back to Table 3, the title of Table 3 is Days to Complete Saturation of Material Beneath Pits (Assuming storage and No Movement.)

Now, this is sort of just a table that I put together just to -- in one way it a rule because we know that ground water is moving downward, we know that ground water isn't being stored at the bottom of this pit, at the top of the water table, and so on and so forth, but just to get an idea of how long it would take to complete some saturation beneath the pit at the rates we're talking about.

And given some basic information I made a little table using these different diameters, again 2, 3, and 4 feet; depth of the water table, H, is 10, 25, and 50 feet; the volume of the discharge, or the volume of the actual -- the volume of the storage area, in this case it's the volume, cylindrical volume of material times the depth of material times your velocity, and in this type of materials we're assuming a porosity of .25. You could assume .20 or .30 and it wouldn't make much of a difference.

Your porosities in this type of material range right around 15 to 35 percent and so it's ballpark figures, anyway.

But what it shows is if you had no movement out of this imaginary cylinder that goes from the bottom of your pit to the top of the water table, at 5 barrels per day you fill up that cylinder in .3 days for a 2-foot diameter pit.

Even for small quantities over a small diameter, if you had one dump per day and you had no movement out of the -- that imaginary cylinder, it was take 117 days to fill up.

My conclusion on all of this is that even if you did have some sort of storage in the vadose zone due to capillary storage and so on and so forth, it would fill up, and it's just -- this table is more an illustrative table to show that this storage is very finite in this unsaturated zone.

I have three more tables and they're all stapled together so I don't know if you want to label them one exhibit or not.

Q Yeah, we'll label that next exhibit, Exhibit Seven, and why don't you explain those for us and what's contained in them?

A All right. Tables 4, 5, and 6 give some basic hydrology, or hydrogeology for the river valleys up here and the reason for that is once it moves to the water table, you've got to know something about the hydrology to make some estimates of where it will be moving, and so on.

Table 4 is entitled Ranges of K for Alluvial Material in River Valleys, and it's just a straightforward compilation of different permeabilities and I got it out of several textbooks.

One of the interesting things was that there was a pump test done that was reported in a recent publication, Hydrologica Report 6 by the Bureau of Mines, and it was done in the vicinity of the Farmington on a coarse-grained portion of the Animas, and it had a very high permeability, permeability on the order of 2500 feet per day of -- of movement.

The actual values of permeability can range from 25 to about 2500, so for purposes of illustration in the next couple of tables, as I discussed, I used a permeability of 25, permeability of 250, and a permeability of 2500 feet per day.

To actually get the actual water movement you have to multiply the permeability times your hydraulic gradient, and hydraulic gradients are given in Table 5, which is entitled Examples of River Gradients, Farmington and Vicinity. This is all a part of the same exhibit.

And in the absence of additional information, you would just -- you just make an assumption that ground water flow gradient is the same as the river gradient in the shallow ground water area near the river. In other words, the ground water flow will be sub-parallel to the -- to the river bottom and you will end up with a gradient that is approximate to the ground -- to the river gradient.

And I just made some calculations from some topo maps and came up with a gradient of about .0023 average for the San Juan and about .0041 average for the Animas and .059 for the La Plata. That was only one measurement, only had one map.

And Table 6 just shows you some of the rates of ground water movement, the average linear velocity in some of these river valleys based on the information that I've just -- just mentioned, and again the actual average linear velocity is your permeability times your gradient divided by your porosity.

If you just wanted the average flux or the average volume going through it, you wouldn't use porosity, but the -- you use porosity to get an average linear velocity of your -- of your travel.

And using those values of permeability that I mentioned, 25, 250, and 2500, you come up with average linear velocities of .24 feet per day, 2.4 feet per day, and 24 feet per day.

So if you use a range from .24 feet per day to 24 feet per day, you can probably come up with some idea of ground water, rate of flow of ground water movement in the San Juan River.

For the Animas River it's a little higher, .41 feet per day to 41 feet per day.

And those values are as good a ballpark estimates as you're going to get based on the available hydrological data and certainly their order of magnitude, and when you're dealing with the different composition of the subsurface down there, it -- it certainly is well within the reported literature values for this type of material.

In other words, you have three orders of magnitude that you have to take a look at just to get a range of what happens with this stuff.

Anyway, that's Table 6.

The last table -- the last table is Table 7 and it's titled Estimation of Ground Water Concentrations.

Q And for the record we'll denominate this as Exhibit Eight.

A Now, just to get a quantitative estimate of concentrations of this stuff might be in ground water, you had to make some assumptions, and some of them we can discuss later. I will discuss later some of the assumptions, but I'll just lay them out to start with.

First off, you have this imaginary cylinder going from the bottom of this pit, whatever diameter you choose, 2 to 4 feet, going down to the top of the water table.

At the bottom of the water table this imaginary cylinder discharges into the ground water.

Now, for purposes of , again for very simplistic model, you assume that the ground water mixes with the pollutants that are coming down and comes up with -- you come up with final, some final rate of concentration, some final dilution. You're just talking about dilution here. It's called a mixing model. You're not addressing some of the other types of character -- attenuations that the subsurface may undergo. It's a simple -- just a simple mixing model giving you a firsthand glance as to what may be happening down there.

And the first page of the table shows you the basic mixing equation. I won't go through all the terms except that the first term, the $C_i Q_i$, C_i is the initial concentration of your contaminant. In this case it is zero in the ground water for benzene. In other words, I'm assuming benzene is not an actual constituent, so therefore you have zero concentraton for that particular term.

The other types of things are self-explained in the table.

I used an average effluent of -- concentration for benzene of 14 milligrams per liter based on the average of the nine produced water samples.

I used an estimated concentration of 10,900 milligrams per liter total dissolved solids for the estimated concentration of TDS.

I ran the simple model at 5 barrels per day discharged to ground water, 1 barrel per day, 1/2 barrel per day, and 2.5 gallons per day.

And the results are given on pages two and three of this table.

For different pit diameters of 2, 3, and 4 feet, different permeabilities that I already mentioned of the ground water of 25, 250, and 2500 feet per day, the bottom line is that the concentration of benzene in the ground water for a pit of 2 feet in diameter in a -- discharging into a ground water having a permeability of 2500 feet per day, still exceeds the ground water standard, not by much, but it still exceeds the standard.

So you -- this -- this shows that at least using the 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 -- of fluid containing benzene at 13 milligrams per liter will cause ground water to exceed ground water standard at -- at the boundary of this imaginary cylinder.

By the way, for purposes of calculation, I used a depth of 25 feet of contaminated -- for mixing of the contaminated zone. That 25 feet is based on information from the Environmental Improvement Division that indicates that on some recent product spills they have found gasoline contamination, and I'm talking about dissolved constituents in the ground water at depths up to 25 feet.

Even though hydrocarbons are quite light and usually float on top of the water, dissolved hydrocarbons move with the ground water and mixing and dispersion can occur.

For total dissolved solids it's a little better, little better situation.

I used an average of 740 TDS and that was based on the samples of the ground water on a study done on the Aztec area, and in any event smaller quantity discharges or larger quantity discharges do not appreciably affect the total dissolved solids in some of these areas.

Again you can take a look at your numbers for your different effluent concentrations in gallons per day and you can come up with some numbers here.

The same holds true for pits of 3 feet diameter and 4 feet in diameter. That 4 feet in diameter discharging 2.5 gallons per day, in other words one separator dump per day, using this imaginary model, even at a very high conductivity of the aquifer, you -- you just come under the ground water standard. You come down to 0.008 milligrams per liter benzene.

So the bottom line, as far as I'm concerned, is that small quantity discharges have the potential to pollute ground water using this -- this -- these assumptions that I have made here.

I think that you could go out and do studies elsewhere and maybe come up with some harder numbers and use some more sophisticated models. This committee did not have time to do all that. I think if you did do a site specific study you'd probably end up with a site specific number, which may or may not be applicable to a site a mile away or even a half mile away.

I'd like to make a few points here, a few additional points, before I close this -- this portion of my technical testimony, and one o the things that was mentioned or was asked earlier of Marty was what contamination have we seen. What has -- what's out there? And we have the one case where there's a limited case and we suspect it could be from this particular gas well out in the area.

And while there are a number of characteristics of the unsaturated and saturated zones that could delay seeing some of this stuff, and I'd like to introduce at this time Figure Number 3.

Q Which wse'll call, refer to, as Exhibit Number Nine.

A Figure Number 3 is from an API publication, Number 4149, and it just talks about oil spills, in this particular case they're actually talking about spills, but it's illustrative in a couple of ways.

If you have -- if you have a combination of water and oil coming out of the dehydrator and going into a pit, it will theoretically form sort of a type of a diagram or type of a characteristic shape as shown in the top part of that Figure Number 3, where you have some fluid hydrocarbon floating on the water table. This is especially true if your separator or whatever, it may not be working at top efficiency and you are getting some oil spill over into the pit.

The dissolved or soluble materials, the soluble materials will dissolve into the ground water and that is illustrated by the cross hatched or the shaded area beneath the water table showing the zone of ground water contaminated by soluble compounds, and that more or less goes along with what I was saying that -- about EID finding 25 feet or contamination at 25 feet beneath a spill or product leak.

Beneath the top figure you can see the effect of stratified soil with varying permeabilities, what sort of effect that has on your -- on your waste. If you have a fine grained material you're going to have it spread further out before it starts moving down. If you have a coarse grained, it's going to go down.

The imaginary cylinder I talked about just had one homogeneous material in it and you didn't have any stratification; however, if you look at Table No. 1 you'll see that some of the soils do have stratification at depth and stratified layers, so you can expect that there will be some movement aside from straight downward.

Well, given all that, you know, why didn't we see more contamination. I've already said that you've got, at least by just strict mathematics, you should have lots of contamination down there.

You know, why not? And the questions is that we may not have looked for it enough. We have -- we have a case here in Flora Vista that we're going to try to go out and do some work here in a couple weeks and do a little more looking around that particular well area.

But, you know, there may be -- this is a case of where you have a water supply system with a large drawdown or a large flow, and a cone of depression intersecting a flume of contamination. You may have -- you may have domestic water wells out there that are close by a contamination flume but the flume may not have reached it because you don't have a pumping rate that's great enough to expand your cone of depression and draw the contaminants into your water.

So that may be one reason we haven't seen any.

Another reason is that the model I was talking about assumed complete mixing and this occurs only after some distance traveled and after some time. It depends on the various types of -- of geologic material before you can actually make the determination.

But you may actually have areas, very localized areas of higher contamination that -- that you wouldn't be able to pick up using such a -- such a method.

The contaminant flume could be moving faster or slower due to the geology. I mentioned that you have some -- may have some high rates of movement. The stuff may be moved out away from a particular zone and even though you may put monitor wells around it you may -- you may not catch some of the dissolved constituents, especially if you're out of the influence of the -- of any residual hydrocarbon areas.

There are some mechanisms in the subsurface for containment and attenuation of these things. I'm going to discuss those briefly and -- and give you my view as to why they are not important in this particular area, but they need to be mentioned because I think that, again, people need to know what type of things are going to be acting on this stuff to try to make it less toxic once it gets into the waste environment.

And by the way, a good reference for this, in case anybody's interested is Groundwater Monitoring Review, Fall, 1983, an article entitled Organic Compounds and Groundwater Pollution. It talks not only about hydrocarbons but also about organic, other types of organics.

Anyway, the major mechanisms for attenuation of this -- of these contaminants are sorption, volatilization, degradation and dilution.

Now, in sorption your subsurface solids of organic matter, your clay materials and amorphous hydroxides absorb your organic solutes.

As some examples, PCB's and DDT, and those type of nasty stuff, are absorbed a lot quicker than the type of thing that we're looking at as far as benzene. So benzene has a relatively low absorption compared to some of the other typs of toxic organics that you sometimes worry about in the subsurface; however, in addition to that, especially in a sandy oil -- sany soil with low organic matter, you would even have less absorption than you would have normally.

Now the area that we're talking about

here, especially on the Animas River, is a high -- is an area where there's been high energy deposition of boulders and a lot of stuff like that from the San Juan Mountains, and you may not have as much of a developed clay and other types of materials as you might, say, along some parts of the San Juan River, where you have the washes dumping in from the south.

In any event, yeah, how this all affects absorption is unknown, except that in the sandy zones you have less absorption than where you have high clay and high organic matter; therefore, based on what I've seen on some of this area, I would expect less sorption than I would in other areas, say, in the southern part of the San Juan Basin.

The statement we were talking about, the second one is volatilization. This particular article mentions that loss due to volatilization is considered insignificant in ground water, so if there's any volatilization loss, it's lost before it gets into the ground water rather than after and Phil's going to discuss some of that a little later on regarding the volatilization of the stuff.

Degradation, bugs, in other words, usually, bacteria can act on this stuff in an aerobic environment. Some of the oil companies are using land farming as -- to break down some of these organics.

In an anaerobic environment it's a different story and degradation only occurs slowly in anaerobic environments.

So if you have an anaerobic environment down there you probably don't have very much in the way of degradation.

And that really leaves the last one, which is dilution. If you have a generally low ground water velocity mixing and dust dilution is not very common, and where you have areas of coarse material and higher velocities of ground water flow, then dilution can be an important constituent towards removing these materials to below levels that are toxic, but again, you can't always count on it because of the wide range of permeabilities you may have. Indeed, high permeabilities but you go over a short distance away and you get low permeabilities.

I'd like to conclude this portion of the technical testimony by reading a statement into the record from a textbook, Freeze and Cherry's Grondwater, and it states here:

Problems of groundwater quality degradation are difficult to overcome. Because of the heterogeneities inherent in subsurface systems, zones of degraded groundwater can be very difficult to detect.

The United States Environmental Protection Agency has reported that almost every known instance of aquifer contamination has been discovered only after a water supply well has been affected. Often by the time subsurface pollution is conclusively identified, it is too late to apply remedial measures that would be of much benefit.

From a water quality viewpoint, degradation of ground water often requires long periods of time before the true extent of the problem is readily detectable. Long periods of groundwater flow are often required for pollutants to be flushed from contaminated aquifers. Groundwater pollution often results in aquifers or parts of aquifers being damaged beyond repair.

And I think that that will conclude that technical portion.

Q Okay, thank you, Mr. Boyer.

You testified that you recommend that no small volume exemption would be permitted at this time.

Could you explain for us, if the Commission would decide that some small volume exemption is needed, what guidelines you would recommend for such exemptions, even though you've stated yourself that you're not in favor os such exemptions?

A Well, I believe that a small quantity blanket exemption wouldn't work, just based on the fact that the conclusions itself of the committee is that you have the -- site specific conditions must be looked at. Let me get that conclusion.

It says a determination of the probability an unlined pit may have in contaminating vulnerable aquifers depend on the hydrological, geological, soil and geochemical conditions at individual pit sites, and I stressed the words "individual pit sites" there.

So as far as a blanket exemption, I wouldn't, you know, again that -- I feel that is not the way to go.

However, if they are to be considered by the Commission, we want to look at the same things that we looked at in the permitting aspects.

We want to take a look at the soil and geologic characteristics, texture infiltration, soil types, drainage, so on and so forth. We want to take a look at water quality of both the receiving water and the discharged water, and we want to take a look at the TDS and the organics, as I've discussed here.

I think that we need to know what types of things go into the pit and how often they go into the pit. In other words, the information we have now may not be adequate. In fact, I'd say I don't think those figures are adequate to base a small volume on; just saying zero on the report when there may be actually a very small quantity dumped. I think we need to know what that quantity is and how often it occurs.

So I think that that means any type of a blanket exemption, we need to have some sort of an accurate methodology for measuring flow and how often. What is it going to be based on,a month or a maximum daily discharge or how is it going to be measured and how frequently. I don't have answers for that right now but they're considerations that need to be addressed in any blanket exemption.

I think you also need to ask your -- if you get a blanket exemption, I think there would have to be some demonstration that you're right in giving the demonstration -- in giving the exemption. Would they have to perform groundwater monitoring, as an example? I don't have an answer for that, but I mean how do we know if we're right or wrong in giving a small quantity blanket exemption?

Groundwater monitoring is one way of doing it. You put in a monitoring well and take a sample and on some sort of routine basis have it analyzed; submit the reports to the Division for analysis.

I'm not recommending that one way or the other. I'm just saying that is one way to make sure that if you give an exemption, that you actually don't screw up the groundwater.

I think we're talking about things that are going to need increased staff consideration. You're going to need people to review what's -- what's happening out there. You're going to need inspectors, these type of things, and I think that staff constraints and time and budget constraints are pretty thin right now, so the Commission would have to take a look at, you know, how much more money would they want to put into this type of -- of program to make sure that we actually did the right thing by giving a small quantity blanket exemption.

Q So essentially you're saying that if an exemption procedure is set up, that it has to be balanced against the amount of staff time that would be needed to monitor it.

A Right, that's one of the things that would have to be balanced, right.

Q Okay, thank you.

I just have one other question to clarify what you said earlier.

At the beginning of your testimony you stated the Oil Conservation Commission was obligated to protect fresh water sources. I assume from the fact that the committee has recommended that for the time being, at least, only the so-called vulnerable areas would be subject to the no-pit rules, that in reality this is not a recommendation which would absolutely protect fresh water resources, but it is one meant to protect those resources which are being used most by communities and by individuals and that if they pollute it, it would cause the most damage in the sense of having to come up with alternative sources.

It's not a blanket method of protecting fresh water resources.

A Right. It is not the end of it. One of the things that we want to take a look at is the, you know, the disposal in the other areas of the Basin; that's what the long term committee is going to do and maybe the long term committee should also be charged with taking a look at some of the alternatives, too, to this type of thing. Do you want me to discuss some of those?

MR. TAYLOR: Would the Committee like to hear that?

MR. STAMETS: I'm not sure we'd like to hear that before lunch.

A Well, actually, it's relatively short and not too, you know, five minutes at the most.

MR. STAMETS: Let me ask a question at this point.

Are there going to be questions of this witness?

MR. KELLAHIN: Are you suggesting we should let him go?

MR. STAMETS: Just trying to be certain that there are going to be questions.

I think at this --

MR. KELLAHIN: Mr. Chairman, I think we might take a break so we can decide in the lunch hour to what extent we need to ask Mr. Boyer additional questions.

MR. STAMETS: This would be an outstanding time to take a break. Do you think 1:15 will do it today?

MR. TAYLOR: Could I get my exhibits submitted first?

MR. STAMETS: Yes, before we take the break, the exhibits will be admitted.

(Thereupon the noon recess was taken.)

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

I believe your witness had a few more things he wanted to say.

Q Mr. Boyer, you said you wanted to talk for a moment, I believe, about the alternatives to --

A To the unlined pits.

Q -- the unlined pits.

A Yes. Just wanted to let you briefly go over the types of things that the Division has been looking at as alternatives.

Number one is the, when you talk about unlined pits, you can only think of lined pits and that type of installation. We do have some current specifications for lined pits and current specs are used mainly down in the southeastern part of the state for any lined pits in the area that's under Rule 3221.

In general those pit specifications aren't going to be changed much with the revision, but the significant thing about that is there will need to be some sort of a leak detection system so that we can make sure that the pit actually is not leaking and is actually performing as designed.

Phil is going to talk a little bit more

about some of the pits later on.

Another alternative that some of the companies are already using up there is -- is tanks of one type or another. I know Amoco has been putting in some fiberglass reinforced tanks and some of the other folks have other types of installations.

The tanks will have to demonstrate integrity to -- to the satisfaction of the Division and the Division hasn't set up standards as of yet for that, but the type of thing we're looking at is some sort of test, integrity test, dipstick test, I suppose it could also include a double liner, double lined tank, and stuff like that.

Careful metering for in or out flow is another possibility.

One of the questions that I was a little worried about regarding any of the tanks up in that area, buried tanks, was an inclusion under the new, what's called by EPA the LUST program, Leaky Underground Storage Tank Program, and EPA has just promulgated some initial regulations and one of the exemptions listed in the regulations is as follows. Quote:

> Exemptions. Liquid trap or associated gathering lines directly related to oil and gas production or gathering operations. Unquote.

I don't represent myself as a lawyer, but common sense indicates to me that that would possibly -- that would likely put those type of tanks we're talking about under the LUST program.

That's all the comments I have on it and all the testimony I have.

Q Okay.

MR. TAYLOR: And that's all the questions I have.

MR. STAMETS: Are there questions of this witness?

Mr. Carr.

CROSS EXAMINATION

BY MR. CARR:

Q Mr. Boyer, I don't know what exhibit this is. It's the exhibit that has the water analysis on six wells.

A Yes, sir.

Q Could you tell me on each of these wells where the sample was actually taken? Is it from a separator or a pit, and if so, what kind of pit?

A Okay. I have those notes. I have those notes in my field book and up in the office. I don't have them right with me, but I can provide you with that information.

Q And we'd like to know not only where the sample was taken but as to a pit, if it is other than a produced water pit, you might note that.

A Right.

Q I suspect they all are.

A Right. I think that what I want to do before the next hearing, hopefully in the next week when I get the samples from the January sample analyses back, I want to put it all together and that would be in part of it, including where the sample was taken and the situations.

Q If we go to the second page of this exhibit, does that depict sampling from four individual wells? Is that what that's intended to indicate, or a common site from another well?

The sampling station, I don't know if you meant an individual well or what.

A Right. Based on -- based on what I read, it would be individual -- locations at individual wells because each one of the sections is different.

Again, I can get that information --

Q Now, on the fifteen wells that you've just recently received the data on --

A Right.

Q -- again would you be able to give us information on whether or not those -- where those samples were taken?

A Certainly.

Q Do you happen to know offhand whether any of the samples were taken from pits other than produced water pits?

A They were pits which produced water went into. There were some other samples taken up there that wouldn't be included with this that I was -- that I took -- took a sample from one of the landfills up in that area.

Q Have you any samples on, you know, in-line drips, pits at that type of location?

A Yes, I have one sample up there.

Q Can you make that available also?

A Yes.

Q Will we have those prior to the next hearing?

A Yes. Again, I would hope to get them to you within the next week, as soon as I receive the remainder of the data from the Scientific Laboratory Division.

Q As to this exhibit, could you tell us how these individual wells were selected?

A Well, the -- I was not involved in the April 6th, 1984, sampling; however, the other wells were selected in September and the ones in January, what I wanted to do, my methodology here was to get different wells from different formations and compare the different formation water so that we've have the characteristics of the different types of waters that would be expected to be produced with the oil and gas.

To that extent we worked with the company and with our District Supervisor in Aztec in trying to identify some of those wells.

Q Did you individually select these?

A Did I individually select them? No. I had the opportunity as we visited wells to sample, the first sampling in September I didn't have enough bottles, so I didn't sample every single well we visited.

I tried to get a wide range of formations.

Q If we looked at the first page of this exhibit and look at the Valdez A-1-E Well, you have the Chacra formation under that.

A Yeah.

Q Is that the only sample that you have studied so far on the Chacra formation?

A I'm not -- don't recall whether one of the ones we got in January was from that formation also or not. Up until that time this is the only information I have.

Q If we go back to the samples that were taken in April, you indicated that you did not -- it was not your decision to -- you did not select the individual wells, is that correct?

A In April, right.

Q Do you in fact know who made that selection?

A I believe the representative of the OCD at that time did.

Q And who would that have been?

A That would have been Oscar Simpson.

Q Now on the fifteen samples that you're going to make available to us, the data for which you've just received, did you witness the taking of the samples on each of those wells?

A Yes, I took them myself in each one of those wells.

Q All of the fifteen?

A Yes.

Q Thank you.

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

MR. KELLAHIN: Yes, Mr. Chairman.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Mr. Boyer, I'd like to ask you some questions following up on Mr. Carr's questions on the Exhibit Three document.

I guess I was confused earlier this morning. I thought these samples represented on Exhibit Three were samples that were taken under your direction or specifically by you, and I guess only those on the first page --

A That's right.

Q -- were samples under your control. All right, sir.

When we look at the samples from the six wells on the first page, am I correct in understanding that those samples were all taken directly from the separator flow?

A Again, I would have to get my notes. That was my intention.

There may have been one, and I think it was the Amoco Gallegos one that we actually either took it from the pit or had to somehow get it out from the end of the swirl pot, whereas Tenneco ones we actually were able to open a little stopcock on the -- on the separator itself.

Q On the Gallegos Well, if it was taken from the production pit, it was taken from the pit immediately after we dumped the separator into that pit.

A Right. My recollection is that we were struggling to get a barrel or a bucket under it so we could get a sample. In fact, it may have been just -- just above the pit.

Q When we look at the tabulation on that page one and we look at the station, am I correct in understanding that the "D" refers to a Dakota producer?

A Yes.

Q And the Chacra is obvious. The Kmv is a Mesaverde producer?

A Uh-huh, that's correct.

Q Would you describe for the record, Mr. Boyer, what is the process of taking an acceptable sample as a hydrologist?

A Okay. When we are taking a water sample we have several steps that we have to go through.

First off is that you have separate sampling containers for organic and inorganic materials, and in fact in the inorganics you actually have additional separate containers.

The items of interest that we sampled here were general water chemistry and your heavy metals and your purgeable aromatic hydrocarbons.

The process used for the general water chemistry was to take a clean cubitainer, about a quart size, rinse it out, rinse out the cap, take the sample, cap the sample. No preservatives are added at that point. The sample is labeled and shipped to the laboratory with a data sheet so that they can make the appropriate analyses.

The heavy metals are preserved, taken the same way with a separate cubitainer and preserved with 5 milliliters of nitric acid, concentrated nitric acid to prevent precipitation of the metals into the -- into the cubitainer.

The third item we're looking at is the hydrocarbon concentrations. We use duplicate 40 milliliter glass vials with Teflon caps. The glass vials are cleaned in between sampling by the State Laboratory Division and also they throw away the Teflon caps and put new ones on.

Those are filled up to the top as -- as

close as possible so there's no head space and cap is screwed down so you don't have any air bubbles. There may be some air entrapment that comes out later that does produce an air bubble, but when we close the sample we make sure that there's no air entrapment.

Now, the different -- there are different -- we take these, we keep the hydrocarbon samples cooled down to about 4 degrees Centigrade with ice bath, or something like that, and ship it to the lab.

The other samples we generally try to keep cool but there's -- the general water chemistry is not very sensitive to temperature changes at those concentrations we're looking at, several thousand TDS, and the other one we try to keep cool, but most of the stuff comes out of -- stays in solution by the addition of the -- of the acid.

So that is the general procedure for taking these samples.

Q Once the -- and were all the six samples depicted on the first page of Exhibit Three taken in the acceptable manner you've just described?

A Yes.

Q After the samples are taken, then, what then did you do with those samples?

A I hand carried them to the laboratory in Albuquerque.

Q All right, which laboratory would that have been?

A I should say that's the Scientific Laboratory Division of the State Health and Environment Department.

Q And in your opinion as an expert, is that an acceptable laboratory from which to obtain accurate and reliable analysis of those waters?

A Yes, it is.

Q With regards to the fifteen samples that you took in January of this year, did you follow the same procedure that you've outlined for us that you conducted in September of '84 on the first six samples?

A Yes, I did.

Q Is the sampling of the next fifteen in January samples that were taken from the separator or from the production pit directly after the separator was dumped?

A I tried to get a sample from the pit and a sample from the separator to compare what changes may be between the pit and the separator.

Q And you will give us indications of which ones --

A Again, all the data, right.

Q All right.

A And I will try to get indications of this on this Table 21b also, what the situation was with those samples, because I have some notes on that.

Q When we turn to the second page of Exhibit Three, these, as I understand, are samples that were not taken under your control or direction. They were taken by Mr. Simpson?

A Right.

Q Are you able, sir, to testify based upon your experience as an expert that the samples taken by Mr. Simpson were subject to the same kind of stringent controls that you took the first samples?

A I do not know the controls or conditions under which Mr. Simpson sampled. I would, if I may add, however, he was -- he had been trained in the particular -- particulars of sampling, so I presume he would have done it correctly, but I have no direct knowledge of that.

Q None of those samples on Mr. Simpson's list were taken under your direction and control?

A That's correct.

Q All right. When we look at Exhibit Number Seven --

A Okay.

Q --halfway down on the page on the left side of the diagram you've shown for the average benzene value that you've taken nine San Juan Basin produced water samples.

A Uh-huh.

Q Which of the nine from Exhibit Three go into the calculation?

A All of the -- all of the benzene samples listed for produced waters, the one that was excluded is the benzene that's listed for condensate, 20 North, 12 West, Section 29.

The other nine were included.

Q All right. On the first page under the benzene for the Cornell Well there was no test for benzene.

A There was no test because I ran out of sampling vials. That was the last one we tested.

Q All right, so we've got five on the first page and then we have four of Mr. Simpson's on the second page.

A Right.

Q To make the nine.

A Uh-huh.

MR. STAMETS: Mr. Kellahin, in your last question you were referring to Table 7?

MR. KELLAHIN: I'm sorry, Exhibit Three is the samples. Table 7 is Exhibit --

MR. STAMETS: Eight?

MR. KELLAHIN: Yes, sir.

Q When we look at the average value used in the calculation on Exhibit Eight, which is Table 7, the average value of seven San Juan Basin produced water samples for the TDS value, which seven were used to make the average?

A All of the samples on the first page of that exhibit plus the one that is listed on the second page.

Q All right, sir.

A I would like to emphasize that any number could be put in the equation as far as -- to come up with a final concentration. These were just a methodology to take a look at some averages and that's why I averaged them all together, realizing that I have one that is quite high, one that is quite low.

Q I understand. When we look at the calculation, then, the K value, which is the permeability value --

A Right.

Q You have for purposes of the calculation used a K value of 25 feet, another one of 250 feet, and a last one of 2500 feet.

A Right.

Q You gave us a reference, I think, in Exhibit Seven, which is Table 4, about how you came up with the K value or the permeability value.

A Uh-huh.

Q And if I --

A The range.

Q Say again?

A The range of values.

Q The range of values, yes, sir.

And when I -- when I look at Table 4, am I correct in understanding that the only aquifer test we have from a well is this pump test on the McMahon No. 1 Well.

A That is correct.

Q Based upon the only actual aquifer test value from this McMahon Well, which of the values on the tables for Exhibit Eight represents those that closely approximate the reality of that permeability value?

A Well, I would have to say that I chose a range because based on my experience in hydrology, you would have a range, depending on the particular fluvial depositional patterns in the -- in the Basin area.

I think the range of 2500 feet per day is adequate for a well that is probably very close to the river. In fact, one of the notations on the aquifer test was that after several hours the boundary effect of recharge from the river was noted in the aquifer test, which indicates that it had a very direct connection with the river.

So that K is probably very representative of that area.

Q Could you tell us where the McMahon Well is, Mr. Boyer?

A The township and range and location is on there. I'm -- I didn't have the quadrangle for the Farmington section when I put this up and I wasn't able to plot, you know, whether it's two miles east of town or north of town or whatever.

Q Your note on the exhibit shows somewhere in the vicinity of Farmington?

A Right.

Q Have you actually visited that well?

A Oh, no.

Q All right.

A That was reported in Hydrologic Report Number Six.

Q You gave us a reference earlier this morning to, I believe, an EID study or some data about analyzing water well samples to see if there was benzene present in those water samples.

Could you give us a more complete reference to that source?

A Well, unfortunately the thing I have from EID says simply Volatile Organic Sampling Results, and I know the thing that -- about it is that even though there is no specific date on it, I know it was done last spring, the results published last summer, and what they did was they went out and tested all the water systems in the State, all the community water systems in the state, to take a look for trihalomethanes (sic) and also for volatile organic hydrocarbons.

Q I wonder, sir, if you could also make a copy of that available to us so that we'll be using the same reference material that you are.

A Certainly.

Q Apart from that EID study are you aware, sir, of any other studies or surveys that have been made in the San Juan Basin about hydrocarbon contamination of ground water?

A The Environmental Improvement Division has been doing two different types of hydrocarbon studies.

One is the study of petroleum product contamination of groundwater by petroleum product hydrocarbons, and the other one is organic contamination other than hydrocarbon contamination.

Q Do either of those studies include the examination or study of produced water into unlined surface pits?

A That would be in the organic contamination study and that is not available yet. It's still undergoing in-house review.

Q In looking at Exhibit Eight and calculation, does the calculation take into consideration the diameter of the pit?

A Just a second let me get my -- yes, it does.

Q And for purposes of making the calculation, then, you assumed a pit diameter of 2, 3, or 4 feet.

A That's correct.

Q I assume, sir, that you're estimating that area of an unlined pit that would be saturated by the dumping of the produced water from the separator.

A That's correct.

Q All right. Have you measured the area that you would believe to be effected in the pits when you went around and took your samples?

A Not specifically measured. I did notice which of the -- how much of the area was wetted or appeared to be wetted and it appeared to me that the -- dependent on where the position of the swirl pot is, but it appeared to me that the area that was wetted was directly beneath this swirl pot and that would probably on a diameter of several feet.

Q I'm trying to understand the basis of using 2, 3, or 4 feet, and what is that?

A That is just essentially, if you have a separator that dumps into a swirl pot to reduce the pressure and the stuff sort of sprays out over the area, wets an area, it doesn't, you know, wets more than six inches and it probably doesn't go much more than 4 feet across, and so in between there you have a range of values that may be wet, depending on how much water is coming out, the pressure, and how far off the ground the swirl pot is.

Q In taking your samples did you develop data by measuring the area of saturation on the surface for each of those pits?

A No, we did not.

Q We were talking, or you were talking this morning about the rate at which water would flow vertically into the ground.

Could you explain, sir, the relationship, if any, with the rate that water will flow vertically in the ground as opposed to the horizontal migration?

A All right. Yes. The vertical rates that I talked about here were from the soil survey. They -- they developed them, they presented them, and I'm not sure of all the specifics of how they -- how they got them. I presume they did them through some sort of percolation test or infiltration test, and that may be buried somewhere in the report, but I'm not sure about that.

However, in general, your horizontal permeability of your unconsolidates sediments like this are an order of magnitude or about ten times higher than your vertical permeabilities, so your groundwater flow would be faster horizontally than downward.

Q What portion of your calculation takes that fact into consideration?

A That is not taken into consideration in the -- in the calculation because I used the figures given by the Soil Conservation Service, and again, those figures were actually numerical numbers that they developed and I would presume that would be the actual rate, or the range of actual rates of permeabilities, vertical permeabilities.

Q You told me earlier that we have the EID samples of water from water wells that have not shown benzene levels in excess of the standard.

A In excess -- they have not shown benzene levels at all from the water levels -- I mean from the water wells. Not detected.

Q Based upon your experience, what or how many samples would you consider representative with respect to analyzing the existence of quality of the groundwater when we're looking at a vulnerable area that has approximately 300 water wells in it?

A I think you want to look at what you're analyzing for. I think that -- I think that in this particular case as far as to hydrocarbons is concerned, benzene is not a natural constituent that is found in ground water.

The -- so I think that it should be enough to demonstrate that point.

Regarding TDS and some of the other --

Q Excuse me, but I didn't understand your answer. If I'm interested in hydrocarbon contamination or benzene levels, how many wells would I sample to have a representative group in a vulnerable area?

A I don't know if you would actually need to sample any wells, because it is not a natural constituent of groundwater.

Q All right, let's take that one step further. If I wanted to have a representative sampling of the water wells to see if they were contaminated, or subject --

A Okay.

Q -- to contamination from unlined pit use, what would be a representative sampling?

A I can't answer that right off the top of my head.

Q How would you go about arriving at a number? You said you couldn't do it off the top of your head. What method would you use to come up with a percentage?

A Oh, I think you'd probably want to decide what sort of a confidence interval you'd want to choose; maybe do some statistical testing, some (not clearly understood) testing, to see if you have -- take a control sample, or something, and maybe compare that with the number of wells that you might have to sample to make some sort of a statistical determination.

That is something that I'd have to look into. It's been a little while since I've done any statistical stuff like that.

Q Let's talk about a period of time. If we're going to sample water wells to see if they've been contaminated for hydrocarbons, can you give us the length of time it would take, approximately, to come up with a plan?

A Come up with a plan of sampling?

Q Yes, sir.

A Statistical, that would be statistically valid?

Q Yes, sir.

A Oh, several weeks, thirty days. I mean it wouldn't take too long, I don't think, to come up with -- formulate a plan based on the information. There's literature information as to what is -- what sort of statistical samples, statistically valid sample you'd want to choose, and all that type of stuff.

Q Once we came up with a plan within, say, thirty days, for that process, how long then would it take to actually conduct the sampling so that you were comfortable that you would have representative samples?

A Depend on the sample size you chose, obviously. It would depend on that and the access that you'd be able to get, whether you could get to all those wells, and everything else.

I presume it would probably take some -- some time and staff effort.

Q Have you gone through that process yourself?

A No, I have not statistically gone through that process.

Q In order to have a representative sampling from the oil and gas wells in the vulnerable area, we've got 1200 of them, I guess, is an approximation.

A Uh-huh.

Q What would, in your opinion, be a representative sample for the chemical analysis of water produced from those wells in order to have a representative group of -- for those well?

A More than one. I am not --

Q Would you need all 20 -- there's 12, 1200 wells?

A No, we wouldn't need all 1200 wells.

It's the same type of statistical calculations that you would make. What are you trying to determine, at what confidence limit -- intervals, and then you can come up with some sort of a number N that you want to use; random selection, and so on and so forth.

Q We tried to talk about a representative sampling for hydrocarbons or benzene levels. Are your answers the same if we're testing for TDS? Or can you give us what you think would be representative samplings for TDS?

A I think that we already have a large number of TDS samples from individual wells at water supply systems. They're on record.

We would have to do less of an effort to get TDS than the other type of constituents because they have already been documented.

We'd probably want to hit domestic wells and so you'd be reducing by some percentage the total number of wells that actually would have to be sampled.

Q Can you give us some estimate of a range of numbers of wells or percentages that you would want to have in your data base?

A Not, not right off the top of my head. I feel that as far as TDS is concerned we do have quite a few representative, you know, several dozen analyses in this Chemical Quality of New Mexico Community Water Supplies for the San Juan County and around the Farmington area.

You could go through this and make a, you know, an analysis as far as average and standard deviation and see. You may already have enough information there after you look through that.

Q Okay. You have not yet done that, have you, sir?

A No, I have not. I did not attempt to go through and try to make a determination of how many wells I would need to determine on, to get TDS. I do know that of all the wells that I have seen in the shallow alluvium, it is -- the TDS is less than 1000, and that is the ground water standard.

If you wanted to use 1000 as a limit, as an upper limit, then you could -- could proceed from there and you wouldn't have to test any more wells.

Q You indicated this morning that you were going to undertake further study and testing at the Flora Vista well. Would you describe for us what you propose to do?

A Well, the actual, specific details aren't all in place yet, but we would like to try to delineate the extent of contamination, existing contamination, out there; put in some monitor wells, if possible, to get some sample values, and somehow try to get an estimate of not only chemical quality but also the hydraulic gradient; pump the existing contaminated well, the well that is thought to be contaminated, to see if it is still contaminated. If we can get some aquifer parameters we can do some time of travel type things, and generally do a hydrologica investigation that might tell us whether or not either the remainder of the water supply wells are in danger or whether any nearby domestic wells are in danger.

Q Do you know, sir, what the current status is of the Manana Gas Well?

A I don't know what the current status is, no.

Q When do you propose to undertake that additional study of the Flora Vista well?

A The best tentative date that I have now is the last week in March.

Q That is not information, then, that we will have available either to you or us prior to the next hearing in this case?

A Yes, that is correct, it will not be available.

Q To make sure I'm clear on the Flora Vista study, is that a project that you are undertaking by the Oil Division or is that to be made a part of the study of the Commission's Water Study Committee?

A No, this is a joint cooperative project that the Division's going to undertake with the Environmental Improvement Division.

Q All right, sir.

A And it is separate from the Committee's Water Study Group; however, the results of any study will be, of course, made available.

Q Apart from the EPA and the OCD, who else will participate in that study?

A The EID.

Q I'm sorry, the EID. Who else?

A The Water Users Association.

Q Could you describe for us what type of contaminants were found in that Flora Vista well?

A The information I have is a copy of a table that I received from the Environmental Improvement Division listing a sample date of August, 1983, and at that time the biggest contamination was 32 milligrams per liter, almost 33 milligrams per liter, of oil and grease.

It had a concentration of 0.4 phenols and a detected aromatic purgeables, but there's no quantification limit given. It's less than .01 for aromatics.

Q Did they analyze for oil or grease or phenols in any of those water samples?

A In the other samples?

Q Yes.

A No, they just --

Q Produced water samples?

A Oh, in the produced water samples. No, phenols were not analyzed for and neither was oil and grease.

The oil and grease, usually when to took the sample there was a -- it could come out as sort of a two phase, and we tried to distill off the two phase part of it, and the lab, when they took their samples, went and got the actual dissolved phase versus any residual oil that may have been in the top of the area, the top part of the water vial.

Q One final question, Mr. Boyer. Were two phases visible in the samples in the produced water data?

A Were two phases visible?

Q Yes, sir.

A No. As I said, there was -- we tried to keep them, we tried to keep them separate. There may be a little, a little oil globule entrapped in the -- in the 40 milliliter vial, but we try to keep -- get the water phase and discard the condensate or any -- or any oil phase. In fact they have a name for that type of oil phase, and to the -- we did our best to eliminate that, and most of the samples that we got, with the exception of a little bit that may have been entrained were free of any two phase, distinct two phase separation.

Q All right, sir. Thank you very much.

MR. STAMETS: Are there other questions of the witness? Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Boyer, were company representatives available and present or allowed, invited to be present, for samplings that were taken in September and in January?

A Yes.

Q Did any of them object to the sampling procedure that was used?

A No. They were all very cooperative.

Q Was there water standing in any of the pits that were sampled?

A Yes, there was.

Q Could we then presume that water that was standing was not pit water that had been freshly dumped but perhaps had accumulated over a certain period of time?

A Yes.

Q From the previous question, was there free oil, then, that you got in your samples that you took out of the separators initially?

A Initially there was free oil. If we gather from the separator we attempted to make sure that the water would overflow and the oil would go out and we still had some little globules, but we tried to get as much oil as possible away from any sampling that we did, and in fact, to that end, something I might want to mention about the sampling itself, is that for each one of the wells that we sampled in, in January, we took a clean Mason jar, a clean glass jar, and used that to actually collect a sample from the end of the swirl pot or if need be, from the pit itself, so that we didn't have any cross contamination between a sample from one pit and another; each sampling device was cleaned individually.

Q And therefore you analyzed only the

hydrocarbons that were dissolved in the water.

A Yes.

Q That would seem to indicate that the hydrocarbons that were actually dumped in the pit were in a larger quantity than the amount that was sampled because of the free oil that was removed from the sample, is that correct?

A You want to run that by one more time? I'm not sure I understand it.

Q Would that indicate, then, that there was more free oil, or more oil dumped with the water that went to the pit than was indicated by the sample?

A Oh, yes, the samples, again, were designed to sample produced water and not the -- not the oil, and there was -- there was oil, free oil, standing in some of the pits.

Q Would that then indicate that there was more benzene in the fluid that was in the pits than was contained by the dissolved -- that was contained in the water?

A It would depend. It would depend to some extent. One of the things that I mentioned earlier is volatilization. It doesn't occur in the groundwater, as such, but there may be some movement of benzene and such out of that oil scum at some time.

If you just have pure drip, though, it is -- it is very high in benzene and it would be higher than the water, but as far as what the composition of the scum itself is, I am not real sure.

Q Are you familiar with any other instances of groundwater pollution in the San Juan Basin, aside from probably oil and gas? This would be from any processes, mining, or whatever?

A There's a whole slew of potential and existing problems up there from different types of waste disposal, improper waste disposal. It goes everywhere from septic tanks and nitrate problems to uranium tailings and improper disposal of those types of waste, and there's a lot of -- there's a lot of different types of improper waste disposal.

Q Therefore we're addressing only pollution that might occur from oil and gas activities as a preventative measure, is that correct?

A That is right.

MR. CHAVEZ: That's all the questions I have.

MR. STAMETS: Any other questions of Mr. Boyer?

Mr. Shuey.

MR. SHUEY: Thank you, Mr. Chairman.

QUESTIONS BY MR. SHUEY:

Q Mr. Boyer, in reference to sampling procedure for the hydrocarbons on January 11th, you talked about 40 milliliter glass vials.

A Uh-huh.

Q Could you explain to the hearing record precisely what, how you put the sample into those vials, starting with the water that you took from the separator into the Mason jar and then into the vial?

A All right. It's easiest when it comes directly from the separator, when you have a little stopcock that, at least on some of the Tenneco ones that we used, you can just open it up like a little valve and just let it drain into the vial.

What you do is you let it drain into the 40 milliliter vial until it overflows, and then just turn it down to essentially just to a drip and that lets the air that's in the sample that went in first sort of come to the surface, and you let that just sort of sit there for about 30 seconds, or so, until most of the air has -- has popped out, the entrapped air, and then you just let another drip or two go and put -- put the top on so you don't have any -- so you won't introduce any air bubbles, screw it down and put it in the bag.

Q Why is it important in these particular samples not to have any air in it?

A We don't have any free -- you don't want to have any free spaced because then one of the things that can happen is that you can get movement out of the sample into the free space of some of the dissolved constituents in other words. If you let something on the surface equalibriate (sic) with the air that doesn't contain it, it will tend to move from that surface into the air.

Q Does that have to do with why we call some of these hydrocarbons volatile?

A Uh-huh.

Q When you took these samples in the 40 milliliter glass vials, and -- well, did you notice at any point in time that you had what appeared to be an oil/water or a hydrocarbon and water phase in the vial, and if you did notice that, what did you do with that particular sample?

A Well, to the extent possible, and it happened a couple of times when we tried -- especially when you get it out of the swirl pot, or something, we just kept pouring the sample, say, from the Mason jar into the vial and very slowly, and what happens is that the -- the stuff that's flowed in on top of the oil is sitting on top and will eventually just sort of flow over the side of the bottle and you're left mostly with your produced water versus any scum or anything like that.

As I said, there was always a little bit that may be stuck to the bottom of the, just little droplets here and there, but to the extent possible, we tried to remove all of that.

Q Thank you. Those little droplets that might have clung to the side of the bottle, do those significantly affect the hydro -- the dissolved hydrocarbon or purgeable aromatic content of that particular sample, or a particular sample?

A I have not seen any data on that.

Q To the best of your knowledge?

A To the best of my knowledge it would not significantly affect it. We are dealing with numbers here that are in the range of 8 to 20, or so, milligrams per liter benzene and that would -- I would find it hard to believe that a little droplet would have that much of a significant effect on it.

And I'm not sure we're dealing with -- we're not dealing with droplets that drip here, we're dealing with some droplets of paraffin and other types of things that have longer and different types of organic molecules than the volatiles.

Q Okay. Thank you. To then summarize that, correct if I'm wrong, but to summarize that, what you're saying is that in these 40 milliliter glass vials for the hydrocarbon samples, you try your best to get nothing but produced water in this vial, correct?

A That is correct.

Q Okay, thank you. In your Exhibit Number Three, the produced water sample table, (not clearly audible) you'll notice in the column, the last column, for the Florence 37A, on the first page --

A Uh-huh.

Q -- there's a value of 50 across from the parameter TDS.

A Uh-huh.

Q TDS is total dissolved solids, is that correct?

A Right.

Q Is the measurement of total dissolved solids supposed to be representative of all the dissolved constituents that are in a given water sample?

Well, what does TDS mean? What does total dissolved solids mean?

A All right. The actual -- TDS is sort of a misnomer these days. It's actually total filterable residue. Okay, and the way they do that is they evaporate off the water, or liquid, and then they weigh the residue and that, they calculate from that what is the -- what is the residue, and in this particular case, in this particular case, if they heat it up to, oh, I think 180 degrees Centigrade, you'll lose your organic fraction, so what you're left with, your inorganic things, your heavy metals, your major cations and anions and salts, as your TDS.

Q Okay, your cations and anions and salts.

A Right.

Q Calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, those are what you would describe as major ions?

A Right.

Q Okay. Is it -- if you had not done these tests, okay, or even if you had done them, which you said you have, to verify the reliability of them, would you simply add together some of the dissolved -- some of the milligrams per liter values for the individual parameters and see if they come close to equaling the TDS?

A Right. You can -- you can get TDS from two -- two methods. You can add the major constituents, as you just labeled, or else you can do it by the evaporation and residue method. Okay.

Now, there's another check you'd make and you just -- you do your actual mole fractions or equivalent fractions and balance those plus or minus.

Q Okay, thank you, and just looking at this column, if you were to add up the parameters bicarbonate, lead, benzene, toluene, already would those not equal more than 50 parts per million or milligrams per liter?

A Yes. But I've already said that the TDS is not representative of your benzene and toluene, because they would -- they would go off.

Q They would go off. Okay.

A The measured value of TDS.

Q Right. Did you have that particular sample analyzed once or more than once?

A Well, it was only analyzed once but there were two different determinations of calcium and magnesium and both of them were extremely low, which indicates that the sample as a whole, the number as a whole is correct.

Q Okay, so then given all that, do you have any reason to believe that there is anything wrong with -- with the data or the values there were given for any of those parameters in that particular sample?

A I have no reason to doubt any of the numbers.

Q Well, good thinking. We've heard you testify, I think you used the word "suspected" in this Flora Vista water well problem.

A Uh-huh.

Q We heard you testify that you and the Environmental Improvement Division and the Flora Vista Water Users Association would be conducting a hydrologic study of the site in a month or so. I'm interested in knowing why -- what basis you and the EID have had throughout this time to call this, the contamination of this one water well "suspect", or even remotely related to any of the facilities related to the Manana Gas Well next door.

Could you explain that for the record, why is it that -- why is that gas well even remotely connected to the contamination of that water?

A Well, I'll make several comments and I would possibly ask that you direct some questions to our District people, because they're more familiar with the particular situation up there; however, to my knowledge, that's the only oil and gas well, or natural gas well that close by the system. In fact, it's only yards from that particular well, I forget exactly how many, and the unlined pits were even closer than the wells, and, of course, the fact that they found oil and grease on top of the -- on top of the water in an area where there's no other activity, there's no dumping, there's no landfills, there's no illegal type of disposal out in that area.

Q By activity you mean not only general waste level activity but hydrocarbon activity --

A Well, that's --

Q -- or what?

A They are the only well close by. I don't know what the next well is, how close the next well, but I didn't see another well when I was out there, just that one.

Again, I'd suggest that if you need something more specific you might want to talk to the Aztec field people.

Q Okay, I think there is one more question that you may have personal knowledge of.

Do you know, based on either conversation with the folks in Flora Vista who use that well or through conversations with other people who are familiar with the case, how this particular contamination incidence of the water well first came to light?

MR. KELLAHIN: We object, Mr. Chairman. That calls for a hearsay answer from this witness as to what he's been told by others.

MR. SHUEY: Well, I asked him

from his personal knowledge. Isn't that okay?

MR. STAMETS: Mr. Boyer, do you have any personal knowledge of how the contamination problem was first observed in Flora Vista?

A No, sir.

Q Fine. Now, Mr. Boyer, you testified that the Flora Vista water well that was contaminated had 33 milligrams per liter oil and gas --

A Oil and grease.

Q -- or oil and grease; .4 milligrams per liter phenols, and aromatic hydrocarbons were detected but there was no value given.

A It was less than .01 milligrams per liter given.

Q Less than .01 milligrams. That particular data that you have, where are you citing those from?

A This is an attachment to a letter from Anthony Drypolcher, Bureau Chief of the Groundwater Hazardous Waste Bureau, to -- oh, before I speak any further here -- it's a cc on a letter from Tony Drypolcher, Bureau Chief of the Groundwater Hazardous Waste Bureau at the Environmental Improvement Division, to Mr. Marty Buys. The date of the letter is December 7, 1984.

Q In that letter are there data for other parameters besides phenols, oil and grease, aromatics, on that piece of paper you're looking at?

A Yes, there are.

Q What would -- are there a parameter for arsenic, for instance?

A Yes, there is.

Q What would that result have been?

A 1.56 milligrams per liter.

Q Do you know what the State standard for arsenic in groundwater is, the health standard under the Water Quality Control Commission regulations?

A It's in the standard over there. I'm not sure which one it is, exhibit.

MR. KELLAHIN: Mr. Chairman, I'm going to object to that question. There's no proper foundation to establish arsenic contamination has any relationship based upon hydrocarbon contamination. It's irrelevant in this case.

MR. SHUEY: Mr. Chairmam, Mr. Boyer has testified this morning and earlier that he has sampled for numerous constituents in produced water. He has -- including all heavy metals. He has testified that -- that there are wide ranges of those kinds of constituents in produced water, and we have asked him questions about why this Flora Vista case is even being brought up, and it's precisely because of the presence of the gas well nearby.

Okay, and you know --

MR. STAMETS: Was your question as to what is the State standard for arsenic in produced water?

MR. SHUEY: Yes.

MR. STAMETS: I think that the witness can and should answer that question.

MR. SHUEY: May I hand him a copy of this?

MR. STAMETS: Yes.

A I'm impressed. My answer is that this is the groundwater standard under the -- State standard for groundwater. I believe it's the same as the drinking water standard by -- published by the USPE and adopted by the State.

Anyway, the standard is 0.1 milligrams per liter arsenic dissolved.

Q How many -- is that less -- is that less than 1.56 parts per million that you quoted from the sample for the water well?

A Well, the sample is, let's see what that was, the sample is about 15 times higher than the standard.

Q Thank you. In your -- continuing in your column of parameters from the water well, do you see a parameter for mercury?

A Yes, I do.

Q And what is -- what is its value?

A 0.63.

Q 0.63 what?

A Milligrams per liter.

Q Milligrams per liter. Again could you

tell us what the State standard is for milligrams -- for mercury?

A The State standard for total mercury is 0.002 milligrams per liter.

And the reported value is about 300 times the State standard.

Q Mr. Boyer, in your experience and longevity as a geohydrologist, have you had to deal extensively with the chemistry of various waste products, such as produced water, and generally chemistry of groundwater, both that which we drink and that which can be used for other sources?

A General water chemistry, yes.

Q General water chemistry. Have you in your experience seen drinking water with a concentration of 1.656 parts per million arsenic that was of natural causes? Or naturally occurring in the groundwater?

A Drinking water?

Q Yes.

A Or other types of water?

Q Drinking water?

A I can't recall any. This doesn't mean I haven't seen any or there might not be some in the literature, but I can't recall any.

Q Okay. Mr. Boyer, you -- I may not have heard quite correctly, but did you state in your response to a question Mr. Kellahin stated, there were or were -- that there were phenols and oil and grease in the gas well separator pit nearby?

A I didn't. I didn't speak to that at all. I said there were oil and grease and phenols in the samples that had been collected on August, 1983.

Q Okay. Well, I'll ask you the question then.

Do you know if there were phenols and oil and grease detected in waters in a pit next to the separator on the same date of that August, 1983, sample?

A I think there were some analyses made of that but I don't have them before me.

MR. SHUEY: Mr. Chairman, I'd like to show the witness a copy of a data sheet that I believe has that information. I believe that it has that information because the numbers that are -- that he has been quoting from his sheet supplied to him -- or supplied to Mr. Buys by Mr. Drypolcher, those numbers for the water well are identical to the numbers on this sheet here, and there is a column next to the column I'm reading from on the water well that is identified as oil/water separator next to the gas well.

Would you like to see this?

MR. STAMETS: I will wait for Mr. Kellahin to speak.

MR. KELLAHIN: Mr. Chairman, I am going to object to this line of questioning.

If I recall correctly, this witness has concluded if not once, on several occasions today that he cannot reach any conclusion about the source of contamination for the Flora Vista well because the data is not available to him, and that is the purpose of the continuing study.

It is pointless to ask this question to this witness about what is the status of the data when he's already concluded he's examined it and can reach no conclusion.

I think we're wasting our time.

MR. SHUEY: Well I, Mr. Chairman, I didn't ask him to make a conclusion on whether he thought the water well was contaminated by the oil and gas well or pit.

I'm just asking him some questions about the data on which he's been qualified to speak.

MR. STAMETS: What's the purpose of this line of questions, Mr. Shuey?

MR. SHUEY: Well, unless I'm mistaken, I thought that I heard in questioning by Mr. Kellahin that Mr. Boyer said that he either did not know or in fact stated that there were no parameters such as phenols, oil and grease, detected in a pit at the oil -- at the oil and gas well.

I stand corrected if that's not what I heard correctly.

MR. KELLAHIN: Mr. Chairman, what I'd asked the witness and what he'd answered earlier is those standards on produced water samples, and we shifted gears rather quickly awhile ago and maybe I lost everyone but Mr. Boyer and myself. But we shifted gears and talked about the produced water samples, if that's not correct.

MR. STAMETS: I certainly don't remember the question Mr. Shuey remembers.

MR. SHUEY: All right, well, are you saying I can't show him this?

MR. STAMETS: We will sustain the objection.

A Mr. Chairman, I would, if I had an opportunity, I would address some of the problems with analyses and comparisons between analyses, and that might help or clarify some of this, what Mr. Shuey's trying to get at, if that is so the Chairman's wish.

MR. STAMETS: Well, let's just let Mr. Shuey continue.

Q You were asked a series of questions, Mr. Boyer, about the second page of Exhibit Three and you testified that Mr. Oscar Simpson had actually taken those samples.

Do you have any reason to believe -- and then you then testified that to your knowledge he had had the same training as you, or the proper training to take those samples.

Do you have any reason to believe that the data on that second page was improperly gathered or is inaccurate in any way?

A I don't know the circumstances surrounding how it was gathered. I don't have any opinion that would indicate that it would be inaccurate.

Q Thank you.

A Or any knowledge that it would be inaccurate.

Q Thank you. And then a couple of -- you -- you participated in the Produced Water Study Committee --

A Yes.

Q -- is that correct?

A Yes.

Q And you, if my memory serves me correctly, were -- I believe attended at least two of the subcommittee on mapping sessions, correct?

A At least two.

Q Okay, and then -- so therefore you participated directly in -- in the -- arriving at the method by which the committee derives the so-called vulnerable area, correct?

A Did you say directly or indirectly?

Q Directly.

A Yes.

Q Okay. We heard Mr. Buys testify this morning that there was a considerable amount of work that had led up to the production of that map that's hanging on the wall, which is the committee's Exhibit Two, I believe, and that included in that was a series of investigations based on published literature of known water supply wells in the San Juan Basin.

Do you -- could you describe for the Commission and the record where some of that information came from, specific documents and who they were offered by?

A The two major documents we used were Hydrologic Report Number Six, which is Dr. Stone's publication from the New Mexico Bureau of Mines in Socorro.
That was published, I believe, in 1983.

The second document is a brand new open file report by the U. S. Geological Survey Water Resources Division in Albuquerque, and that tries to pick up where Bill Stone left off as far as putting together a compilation of water wells, mainly domestic wells, in the portion of the San Juan Basin in the vicinity of the Farmington San Juan-Animas River Valley, that area.

The two together have an immense amount of data.

Q In your judgment is there any other data, more recent data, than those two compilations that the committee could have relied upon to determine where known water wells and groundwater use are in the San Juan Basin?

A There may be one additional source, and that would have been the State Engineer's Office. That,

that would have picked up anything more recent than the open file report I just mentioned, and also may have -- may have picked up some additional information on well types and completions, and so on and so forth.

I also believe that the Navajo Tribe probably has some additional -- had some additional information and through the representative of the tribe on the committee that was provided to us.

In general, however, I believe that the committee used the most up-to-date data available for its work.

Q Thank you.

MR. SHUEY: I have nothing further. Thank you.

MR. STAMETS: Are there any other questions of Mr. Boyer? Mr. Paulson.

MR. PAULSON: Thank you, Mr. Chairman, I'll try and speak up.

CROSS EXAMINATION

BY MR. PAULSON:

Q Mr. Boyer, you made reference several times in response to your questions by counsel concerning your sampling of produced water to your field notes. I assume those are notes that you took at the time of this?

A Yes.

Q Could you also make those available,

copies of those, to the parties, as well, at the time you furnish the other data?

A Yes, certainly.

Q Thank you. My understanding is that the report that you've rendered did not -- the report that you've rendered makes no reference to analysis of water from water wells in the vulnerable area, is that correct?

A The report, you mean the committee report?

Q Well, all of the data that you've furnished today has a volume of data from produced water samples --

A Okay.

Q -- but my understanding is that there's no data in your report that discusses or concerns analyses of water from water wells.

A All right. There are, there are two sources here as I answered earlier. One is the volatile, organic hydrocarbon samples that the Environmental Improvement, the listing of the Environmental Improvement, which I'll make available to anybody as a copy.

The second one I referenced earlier is the Chemical Quality of New Mexico Community Water Supplies in 1980. If it is necessary, this could be introduced, or both these documents could be introduced into the record, and especially this one, I'd be able to Xerox the pertinent tables and include them in the record.

Q And are there water wells from within the vulnerable area that are identified in that document?

A Yes, there are community water systems.

Q And those would give some indication of the presence of some of the contaminants that you've discussed, such as benzene?

A Well, benzene is not, to my knowledge, is given in this 1980 report.

The benzene and the volatile organic hydrocarbons are given in this particular Environmental Improvement Division report, and additionally, there is a hydrologic sheet for the Aztec area that gives some additional information on alluvial wells in the area.

Q Where would that be available? The Aztec office?

A Well, I have -- no, no, that's available from the Bureau of Mines, but I'll be willing to Xerox the table and stick that in here too, yeah.

Q If you would, please.

Does the Division plan any further testing of water wells within the vulnerable area between the time of this hearing and the next hearing?

A The Division does not plan any testing at this time; however, it has responded here in the past several weeks and will continue to respond to individual requests when there may be a suspicion that problem in a well may have been caused by oil and gas related activities.

Q So if I understand your response, there wouldn't be any further testing done on the water wells within that area unless there were further complaints filed?

A Right, right.

Q How about beyond the time envisioned for the next hearing, do you know if the Division plans any further testing of water wells either within the vulnerable area or any place else in the San Juan Basin on some sort of systematic basis?

A No, this Division is not -- does not plan any systematic water well testing.

Q Thank you. How many complaints have been received to which you have responded in the past?

A Well, in the past two months I've received two complaints.

Q Complaints from the San Juan Basin?

A Yes.

Q Could you make copies of those complaints available to us, as well?

A I don't know their status as far as confidentiality. If they are not, I don't have any problem with that. I haven't received -- I haven't received all the data back yet.

Q Were the complaints from within this vulnerable area?

A Yes.

Q And did the complaints relate to contaminated water?

A Possibility of such contaminated water.

Q And does the Division plan on investigating those complaints?

A It plans on -- it plans on taking samples of the water to first off indicate if there's a problem and then we'll make a decision based on what we find.

Q Okay, and what's the timetable for that procedure?

A The timetable, unfortunately, is limited by the turn-around time at the State Laboratory. I would hope that I could get some samples back quicker than I have been.

We're talking here thirty days turn-around time.

Q Thirty days to get the samples back and to analyze them?

A No, no. Thirty days to -- thirty days from the time the samples were taken to get them back with analyses from the State Lab.

Q And what about a timetable for taking the samples?

A The samples, one of them -- one set of samples is already taken and the other set should be taken in the next day or two.

Q And I assume the results of those studies when they're available would be --

A We are not planning a full scale study. What we are planning to do is take a look at the samples and see if there's a problem.

By taking a look at what is in the samples, then we can try to decide whether we have a problem with a casing leak or a pit or whatever, and I can't speak on either one of them right now.

Q Referring to Exhibit Three, I think it's Exhibit Three, at the top it says Table 21a, Northwest New Mexico Produced Waters.

A Yes.

Q There are six wells represented across the top. The second well there is denominated the Gallegos Com #94E.

A Uh-huh.

Q Do you know who operates that well?

A I think that's the Amoco well we sampled that day.

Q And we can't find that well. Is it possible that that number is in error?

A Right, I --

Q Could you make a check on that?

A Okay.

Q I wonder if it could be the 194E or something like that?

A Possibly. The table was introduced here as mainly a convenience as a compilation.

I'll double check the numbers on that one.

Q Good. Thank you very much.

Lastly, Mr. Boyer, in selecting wells for the purpose of testing produced water, was the quantity of water that was produced from such wells considered?

A Not generally. Generally we wanted to get a representative sample of the different types of water produced by the different formations.

Towards the end of the last sampling trip we went down towards Kirtland area and took some wells from the Gallup that actually produced more water than some of the other wells up near the Bloomfield area produced.

Other than that we -- we just went strictly trying to get several samples from each formation.

Q Have you since the samples were taken, checked to determine whether the samples were in fact taken from wells that produced more than a nominal amount of water or less? Have you made that determination?

A Well, I don't know what you mean by nominal amount of water.

Q Well, let's say five barrels. Do you know whether these samples were drawn from wells that produced more than five barrels or less?

A I can -- I can get such information, if you so, you know, if you want to come up or made -- have it made part of the record. Such information could be provided.

MR. PAULSON: That's all I have, Mr. Chairman.

Thank you very much, Mr. Boyer.

MR. STAMETS: Any other questions of Mr. Boyer?

MR. WRIGHT: Mr. Chairman, Mr. Boyer, has mentioned some document that he had in his possession. (Next several words not understood.)

I'd just like to suggest that he make several copies of those documents (inaudible.)

MR. STAMETS: Any other questions of Mr. Boyer?

Mr. Boyer may be excused.

And, Mr. Taylor, probably at the next hearing Mr. Boyer ought to introduce the data sheets which were the subject of the final questioning as, what, Exhibit Number Nine or Ten?

We'll take a ten minute recess.

(Thereupon a recess was taken.)

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

Mr. Taylor, you have one final witness.

MR. TAYLOR: Mr. Phil Baca.

PHILIP BACA,

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

DIRECT EXAMINATION

BY MR. TAYLOR:

Q For the record could you please state your name, by whom you're employed and in what capacity?

A My name is Philip Baca. I'm an Environmental Engineer with the New Mexico Oil Conservation Division.

Q And in the course of your employment have you had occasion to -- to study produced water and look at the findings of the committee that's been looking after this?

A Yes. My particular concern was to look at a study of evaporation rates in the San Juan County area.

I prepared a model to look at the amount of surface area that would be required to evaporate a certain amount of water given the evaporation rate data for that area.

What I did for my model is I assumed that you were going to be dumping 20 gallons a day into an unlined pit and or for that matter, you could assume it to be lined, whatever you wish.

My goal was to look at how much of that

water over a period of time would be evaporated if the water was evenly distributed throughout the bottom of the pit, and I'd like to at this time submit exhibits.

Q Okay, let's see, that's your evaporation data?

A Yes.

Q Okay, and we're going to designate that as Exhibit Eleven.

Q Okay, would you please explain for the Commission the study you did and the findings?

A Yes. The important part of this exhibit is illustrated on page seven in graphical form and I've made several copies of that graph for those who desire to take a look at it.

I took evaporation data for the months of January through December. I obtained that data from the New Mexico Climatological Data compiled by W. K. Summers and Associates, and I used the evaporation rates from this book.

I also used the precipitation rates on a monthly basis from this book.

What I did is I took 20 gallons a day being deposited into a pit of a specific surface area. I took that volume, multiplied by the appropriate factor to get the cubic feet per day and then multiplied that by the number of days in a month.

Then I subtracted the monthly evaporation rate data and I added the monthly precipitation rate data.

And if you take a look a the graph, you'll see that if you have a pit with a surface area of 100 square feet, after one year's time your pit, assuming no seepage and assuming that all of your mechanisms for mass transfer are due to evaporation, you'll see that your pit would have an accumulation of water seven feet deep.

That means that if you're depositing 20 gallons per day into the pit, that translates into 7300 gallons per year.

At the end of the year, if you have seven feet of depth inside your pit full of water, that's 5200 gallons. That means that only 29 percent of your water from that pit has evaporated.

I went a little further ahead because I wanted to see at what point you would create a non-gaining situation in a pit and I finally created a non-gaining situation if I had a pit with a surface area of 400 square feet.

Non-gaining means that if my pit did not lose any water dues to seepage or anything else and my only mechanism was evaporation, non-gaining means that I would never have to worry about that pit overflowing through the course of time.

This calculation does not take into account the appearances of any hydrocarbon-like or oil films on the top of the pond. In that case, the evaporation rate would be greatly diminished because there is only a certain amount of water per period of time that is allowed to equalibriate into this film on top of the pit.

Q I assume just from a layman's point of view listening to what you have to say, if you had an unlined pit, what you're saying is that unless you have a very large pit, evaporation is not going to take care of the produced water, it's going to go into the ground, and if you have a lined pit, it's going to take a very large one in order to keep from building up more and more water every year.

A That's correct.

Q What other methods did you look at as alternatives to unlined pits?

A Well, I've been workin on revising the specifications for lined pits and our primary revision will entail the addition of a leak detection system and the addition of a second liner underneath the primary liner. Of course the upper liner will also have to be resistant to ultra violet light or else it will have to be covered in such a manner that ultra violet light will not degrade the polymer or membrane-like substance that's being applied.

I have also looked at some costs associated with the installation of pit liners and the cost based on some of the things I've seen, varies from $2.50 a square foot to $4.00 a square foot. $4.00 a square foot seems to give you a real Cadillac-type of design, too, so you could use $3.00 a square foot as an average.

Q What's -- there's another method of getting rid of these produced waters other than unlined pits. It could be flashing off. Have you looked at this potential for flashing off the organics in the water?

A Yes, I did, and at this time I'd like to submit another exhibit.

Q Would you please explain Exhibit Twelve for us?

A In this exhibit I tried to model a situation in which a highly volatile mixture would come out of a pipe and flash. Flashing means that part of your liquid is going to vaporize and go off into the atmosphere and the remainder of the liquid would fall on into the pit or whatever collection media you have.

What I did for my model was I tried to take a look at a situation where the greatest amount of flashing would occur. So I took a mixture of 50 mole percent benzene, 25 mole percent toluene, and 25 mole percent ortho-xylene.

I didn't add any water to that because that would just lower the potential for flashing. So I took the maximum situation.

I also took a temperature of 100 degrees Centigrade, which is slightly lower than the normal operating values that are experienced inside of a glycol reboiler.

So I took a very extreme condition. I

took highly volatile substances and I took a high temperature.

I went ahead and went through the calculations for flash evaporation, which are based on Raoult's Law. It's a pretty fundamental law in which you can calculate the mole fraction that will go off into the vapor form, giving certain parameters such as temperature and the pressure. This is a classical calculation that can be found in any chemical engineering mass transfer textbook.

After going through the calculation, I found that the ratio in terms of weight of liquid to vapor after it is flashed out would be one to one. That is, if two pounds of hot liquid that I have just described were to come out of the pipe, one pound would vaporize and go out to the atmosphere and another pound would fall into the pit in the liquid form and from there either seep into the ground, puddle, or evaporate due to the natural evaporation, or any combination of the above.

Q Okay. So could you briefly summarize what you think the findings are from the studies you've done as far as the committee's analysis of a no-pit order?

A With respect to evaporation of water, quantities as small as 20 gallons a day being deposited into a pit could not be evaporated without a sufficient amount of surface area, and in other words, a pit that's 10 x 10, has dimensions of 10 x 10 feet, would not be sufficient to evaporate a half a barrel a day of water being deposited into a pit.

Q Okay, thank you. I believe that's all the questions I have.

MR. CARR: Could we get a copy of Exhibit Twelve? Thank you.

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

MR. KELLAHIN: Not at this time, Mr. Stamets.

MR. STAMETS: Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Baca, based on your analysis of an extreme condition, what conclusions would you draw based on a large amount of water coming off a reboiler containing small amounts of these lighter hydrocarbons?

A The amounts of liquid would increase; that is, you would be flashing off less in the form of vapor and you would have more residual liquid leftover. It's all dependent on the vapor pressures of the substances that you're dealing with, and water, for example, has a lower vapor pressure at that temperature than benzene.

So your overall amount of fluid would increase.

MR. CHAVEZ: That's all.

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

MR. KELLAHIN: Is Mr. Baca going to be available to us at the next hearing for examination?

MR. STAMETS: Yes, he will be.

MR. KELLAHIN: We'll reserve the right to have some questions at the next hearing.

MR. STAMETS: Mr. Shuey.

MR. SHUEY: I would also reserve the right to ask Mr. Baca some questions.

MR. STAMETS: All right.

MR. SHUEY: Mr. Chairman, would this be a proper time to bring up a procedural matter or two?

MR. STAMETS: Yes, I think it is. I believe we have concluded the direct testimony for the day and unless someone out there has something they feel compelled to say at this time.

I presume you have a procedural matter you want to bring up.

MR. SHUEY: Yes, Mr. Chairman. I'd like to propose, and I don't know if it's proper for a motion or just a proposal, that the time between this hearing and the next be expanded. I"m flexible to the amount of time that is.

The hearing notice says thirty days. Knowing that, at least myself and I imagine any of the other interested parties here, will want to review the transcript of this part of the hearing. My experience is that transcripts for approximately six hours testimony, five hours of testimony, will probably take two weeks to prepare and be available.

We're looking for approximately two to three weeks additional time after March 20th for the second part of the hearing to be about the middle of April. The exact date is again flexible.

The reason being is Mr. Boyer did testify that the joint EID/OCD study of the Flora Vista would be going on and there was quite a number of questions being put to him about that study.

The Navajo Tribe will be conducting a similar investigation on tribal lands that would -- by people who were on the committee -- that would direct bearing and help to support the record or at least add to the record of the hearing.

We want to be able to have a record that puts all the available data in and unless there would be a hardship caused to any of the parties by an initial two to three weeks after March 20th, I think that the -- the additional benefits for the record would support an additional time of about two or three weeks.

That's what I'm proposing and again, I'm not proposing six months.

MR. STAMETS: You propose at least two weeks.

MR. SHUEY: Yes, sir. That's my --

MR. STAMETS: That's up to April the 3rd.

MR. KELLAHIN: Mr. Chairman, I wonder, for a point of clarification, I thought Mr. Shuey was representing himself today and he's referred to himself as "we".

Might I inquire as to whether there is more than one Mr. Shuey?

MR. SHUEY: I, Mr. Shuey, I am representing myself and I used the term "we" but it is I that I'm talking about.

MR. KELLAHIN: Mr. Chairman, the need to review the transcript, I think, is a reasonable request; however, there were no surprises here today for anyone that has participated in the last ten months of studying this process.

We have in a limbo state some 1200 wells in this vulnerable area that signify a substantial investment for a number of operators. They do not know the future of those wells and those pits within that area, and we are faced with a predicament of facing potential rules without data to show us that we pose of risk of contamination to the fresh water sources.

To say that those wells are going to be held in limbo pending the study of a Flora Vista contamination case that's been in existence for years, seems to me to get the situation backwards.

It's my understanding the study committee has virtually resolved every issue there is to resolve with the entrance of an order, except for the small question of whether or not there is small volume exemptions or not. As I said, I don't think that is a terribly complex and difficult issue. It is one that I think we can resolve quickly and that we ought to go forward as expediently as we can, realizing that we've been at this for some ten months.

My point is, I don't have any trouble with a continuance that puts this into late March or early April but I would not want to continue this case much beyond that for my client, waiting for future studies and data that continues to evolve and develop as we learn more about this area.

MR. STAMETS: Are there any other comments relative to potential continuance to, say, April the 3rd?

MR. WRIGHT: Mr. Chairman, El Paso Natural Gas Company can live with a continuance or not, basically for the same reasons that Mr. Kellahin expressed, and for the additional reason that if some of these pits are going to have to be closed, the summertime is the best time to work on that sort of thing and every time you continue this thing it's going to be pushing into that summertime period, and we might need another, instead of eighteen months, another two years to do all this.

MR. STAMETS: Any other comments?

(There followed a discussion off the record.)

MR. STAMETS: Mr. Shuey, would you represent yourself as an environmentalist?

MR. SHUEY: I would hope that several people do.

MR. STAMETS: In any event, I had personally wanted to stick to the thirty day time schedule to avoid any potential criticism of this Commission for delaying implementation of -- of this action if it is needed.

Since the identified environmentalist has requested a two week continuance, I certainly don't feel that we'd be criticized if we granted a two week continuance.

Also with any luck we can write the order two weeks quicker than we might otherwise.

So on that basis, we will grant a continuance of this hearing until April the 3rd and it will be, I am assuming, at the same location. If there's any change in the location it will posted on the doors out here.

Is there anything further.

MR. TAYLOR: Mr. Examiner, I moved to move the admission of our Exhibits Eleven and Twelve.

MR. STAMETS: Those exhibits will be admitted.

If there is nothing further today, then we will --

MR. KELLAHIN: Mr. Chairman, I wonder, just a point of inquiry, if the Chairman would want to request of those individuals that have set in the hearing today whether or not there are any unsworn statements that they might want to make.

MR. STAMETS: Yes, that's a good idea.

I have already had some representatives of the Cedar Hill area indicate that they are going to request that some expansion of the vulnerable area be made and they plan to present some testimony on that at the next hearing, to take in Amoco's big water pits out there in the Cedar Hill area.

Is there anybody here at this time who does not plan to be back next time who wishes to make a statement?

I see no such person.

With that, then, we will continue the hearing until April 3rd.

MR. KELLAHIN: Mr. Chairman,

this morning in your introductory comments you suggested that you might want the participants to try to identify those issues that they think will be the subject of discussion at the next hearing, and I remind you of that issue and ask you if you want to have us try to frame what we're going to do the next time.

MR. STAMETS: If anyone feels that they can do that, it certainly could be useful, but I'm not going to bind anybody on that.

MR. WRIGHT: Mr. Chairman, El Paso Natural Gas has a written statement that it would like to put in the record, but it's getting late so I'm not going to read it.

MR. STAMETS: All right, I'll just let you give that to the reporter.

Anyone or anything else?

The hearing then will be continued until April 3rd.

(Hearing concluded.)

CERTIFICATE

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

Statement of Qualifications

Name William F. Lorang

Employer: El Paso Natural Gas Company
P. O. Box 1492
El Paso, Texas 79978

Education: BSCE 1969 NMSU
MSCE 1972 NMSU

Subject of Thesis: The Hydraulics of Unconfined Aquifer Recharge, November, 1971.

Professional Registration: Registered by the New Mexico State Board of Registration for Professional Engineers and Land Surveyors and authorized to practice Professional Engineering; Certificate #5668.

Related Work Experience: Mr. Lorang was employed by EPNG June 15, 1969 and since then has worked on various water resource problems related to natural gas transmission, preparation of coal mining plans and environmental statements in the states of Oklahoma, Texas, New Mexico, Wyoming, North Dakota, Arizona and Utah. During this time, numerous monitoring facilities for ground and surface water were designed and operated and aquifer tests were performed and evaluated.

Disposition of Produced Waters

This is a statement for the record of the hearing called by the New Mexico Oil Conservation Commission to define the extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in conjunction with the production of oil and gas in McKinley, Rio Arriba, Sandoval and San Juan counties, New Mexico. The Oil Conservation Commission seeks to define such areas and prohibit and/or limit the disposition of such produced waters on the surface of the ground.

This statement is intended as testimony to be presented at a hearing February 20, 1985 in Santa Fe, New Mexico. The statement provides information in support of continued use of certain unlined pits in the area. The statement also urges the Commission to consider exemptions to any forthcoming order which would provide for the continued use of certain unlined earthen pits.

El Paso Natural Gas Company (EPNG) has been in business in the San Juan Basin of northwest New Mexico for some 33 years. Gas reserves have been developed through our own exploration and development, and through the purchase of gas from many other operators. EPNG operates some 5000 wells in the Basin and has tied literally thousands of others into its gathering system.

We feel that we have operated these many years in a prudent manner as good citizens and good neighbors. There are some 1966 EPNG employees in New Mexico generating about $54,000,000 combined annual income. We also pay our taxes as a good citizen must. EPNG paid in excess of $61,000,000 in taxes to New Mexico last year.

In all our 33 years of operation, we have never had a complaint of groundwater contamination from landowners or groundwater users in the San Juan Basin. This record strongly suggests that a large problem of groundwater contamination simply does not exist. If there were a problem, surely in the last three decades evidence would have appeared in one of the 300 shallow water wells in the area.

The Short Term Water Study Committee has delineated a vulnerable area which, in the committee's opinion, includes the bulk of the area now being used for shallow water supply. This vulnerable area lies principally along the river bottoms of the San Juan, Animas and La Plata Rivers. The committee also identified other "special" areas which should be protected much like the vulnerable area.

Within the vulnerable and special areas, EPNG has 547 earthen pits. These pits vary in size and purpose. Some are used for disposal of water from primary separation of water from produced hydrocarbons, others are used only for disposal of water separated and/or dehydrated from the gas stream. To replace all these pits with tankage would cost EPNG in the neighborhood of $1.8 million.

The amount of water discharged to these various pits is generally not measured. Thus, we are uncertain of the volumes of water that, over a period of time, are discharged to them. We do know, however, that many pits are normally dry while others normally contain produced water. Of the 547 pits EPNG has in the vulnerable areas, 421 of them are normally dry. We offer that if a pit has water discharged to it less than 10 days in any calendar month, it can be considered normally dry.

We feel that we have a very large stake in the protection of the State's environment and that each incident of probable contamination of the groundwwater should be checked. However, to line normally dry pits would not provide any additional protection to the State's groundwaters, but would reduce the economic benefits to our stockholders, our employees, and the State of New Mexico. Therefore, we feel that we must have a small volume exemption to the pit control order from OCD.

If water is discharged onto soil, we have all observed that the soil is wetted but after a time again dries to its original condition by evapotranspiration. Soils will dry to depths of several feet due to the high evaporation and low precipitation rates common to the San Juan Basin. If water is discharged to a pit at a frequency to allow drying between discharges, then saturated soil conditions will not exist thereby precluding the transport of contaminants.

It is our understanding that many pits in which occasional discharges containing small amounts of crude oil have been made tend to be relatively impervious due to the sealing of pit bottom and sides. In such cases, the only means available for water to leave the pit is evaporation, thus further reducing any threat to the groundwater. It is also our understanding that water in a pit must have a driving force - a hydraulic head - before significant infiltration takes place. Absence of a hydraulic head - such as in the case of a normally dry pit - would indicate that there is no threat to groundwater.

Once the water infiltrates, native soils have an affinity to adsorb various substances - crude oil being one - thus providing an attenuation of contaminant transport. If the pit lies substantially above the water table, the infiltrating water passes through a column of soil thus providing the contact for adsorption of contaminants.

In short, at least two conditions are necessary in order for a pit to be a threat to the local groundwater. First, the pit must contain enough water to maintain a hydraulic head sufficient to act as the driving force of infiltration and overcome any sealing of surface pores. Second, it must be near the groundwater table for otherwise contaminants percolating downward would be adsorbed on soil particles before reaching the water table.

We would offer that there are many pits that don't meet the aforementioned criteria for being a threat. If they lie substantially above the water table and are normally dry - receiving discharges of water less than 10 days in a calendar month, they would not contain sufficient water to effect the transport of contaminants into the groundwater. Indeed, of EPNG's 547 pits, 421 - more than 3/4 - are normally dry. Such normally dry pits should be exempt from any order of regulation.

I repeat that EPNG believes each incident of probable contamination should be checked. And, EPNG is presently inspecting all of its pits with or without a pit control order from OCD. I believe that EPNG may have pits in use today which should be lined, or replaced with a tank. But, there is the continuing problem of determining which pits are a threat and which are not. We are aware of at least three laboratories, Sandia National Laboratory, Woodward Clyde Consultants, and the Southwest Research Institute, which are working on technology to determine the leaking potential of a particular pit at a cost which the government and industry could afford. EPNG is planning to provide Sandia National Laboratories in Albuquerque with several site locations for field testing of such technologies to verify its commercial applicability.

In summary, we urge the Commission to consider the fact that there are many pits, both in the vulnerable areas and elsewhere, that are doing no harm. Those pits should be allowed to continue unlined because they meet one of two critical criteria: 1) they are substantially above the groundwater table or 2) they are normally dry.

EPNG urges the Commission to adopt as a part of any order for control of unlined pits an exemption for those pits which meet the criteria of minimal threat. By providing for such exemptions, the resources available can be utilized to address those situations where there is a real threat to groundwater and to try new technologies in detecting those situations where the threat to groundwater is not clear.

EPNG, therefore recommends that any requirement of an order to prohibit and/or limit the disposition of produced waters should contain the following language:

Exemptions: The following earthen pits are exempt from the requirements of this order.

1) Pits lying outside vulnerable or special areas;
2) Pits to which no more than 5 barrels of produced water are discharged per day except where the depth to groundwater is less than 10 feet; and
3) Pits which are normally dry, i.e. to which produced water is discharged less than 10 days in any calendar month.

Thank you for this opportunity to express our concerns with respect to the pending order.

William F. Lorang, P.E.
Manager, Environmental Engineer
Environmental Affairs Department
El Paso Natural Gas Company
P. O. Box 1492
El Paso, Texas 79978

mts

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

A P P E A R A N C E S

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

A P P E A R A N C E S

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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 dc 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

represent measurements off the instrument and not concentrations. I have chosen to report them in this fashion because of the difficulty of calibration of instrumentation. They are, however, useful for purposes of (not understood) samples.

You can see that components found in the samples included alkene, some alkanes, benzene is found in at least one sample near Archuleta at fairly high concenstrations or fairly high values relative to the others.

Toluene was found in two samples. Alkene, alkane. We have some alkalated benzene, such as xylene, another xylene isomer.

Turning over on the next page, the table continues and we find similar components, mostly hydrocarbons with aromatic hydrocarbons part of the sample, benzenes, C4 benzenes.

Down here we find napthalene. This was the first evidence that there might be polycyclic aromatic hydrocarbons in these samples.

Comparison between the non-aqueous phase the aqueous phase showed similar comparisons through the aqeous and non-aqueous phase. These are plots from the instrumentation, as well. This is benzene in the non-aqueous phase from the same sample, toluene, xylene, C4, C5, C6, C7 benzene.

What I'd like to point out here

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.

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 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 EID Sampling of Community Water Supplies 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 Chemical Quality of New Mexico Water Supplies, 1980 -- 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 EID Sampling of Community Water Samples.

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 _Chemical Quality of New Mexico Community Water Supplies, 1980_.

A Right.

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

And then there's the _Hydrology of the Aztec Quadrangle_.

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 Groundwater Monitoring Review along in the fall of 1983, entitled Organic Compounds and Groundwater Pollution. 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 Merger and Infiltration Gallery Feasibility Study for Flora Vista and South Side Water Users Associations.

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 non-homogeneous 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 tc 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 abcut 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; 1C 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.

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 un-saturated 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 ho-mogeneous soil.

Anyone who is curious about the differ-ence 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 per-centages 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 Groundwater Monitoring Review 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 para-xylene, 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 tc 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.)

CERTIFICATE

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

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

22 April 1985

COMMISSION HEARING

VOLUME I OF 2 VOLUMES

IN THE MATTER OF:

The hearing called by the Oil Conservation Commission on its own motion to define the vertical and areal extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in conjunction 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
Commissioner Ed Kelley

TRANSCRIPT OF HEARING

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I N D E X

EXHIBITS

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

We concluded last go-around with a witness for Mr. Pearce.

Mr. Pearce, do you have any additional testimony or witnesses?

MR. PEARCE: One very brief item, if I may, Mr. Chairman.

During the last hearing there were two requests made of us by additional documentation. I have that at this time, if I may.

What I have marked as Exhibit Number Two is a summary of calculations of benzene and toluene vaporization. There was some question. You may recall that Dr. Tom Schultz testified that he believed that the 50 percent flash volatilization number was a reasonable, conservative estimate, but there under some instances a higher percentage of benzene and toluene might vaporize.

We were asked to prepare a summary of calculations which led us to that opinion. Those calculations have been prepared by a professional engineer for El Paso Natural Gas Company who is not in attendance, but I have several copies of these which can be reviewed at everyone's leisure.

In addition to that, Mr. Chairman, we had a request at the last hearing for some ad ditional information about sampling done relative to organic content of soils.

What I have marked as Exhibit Number Three is a summary of those tests. These tests were performed by an EPA certified lab by the name of Raba-Kistner. The physical reports are not here but we have summarized the data which they developed.

In addition to that, I have two sets of documents which I have not marked as exhibits. They are a more detailed record of how the soil samples were taken and from what locations those samples were taken.

I do not propose to make these exhibits. They contain a number of photographs. I propose to simply deliver them to the Commission and then the Commission's files will be open for anyone who wishes to inspect them.

So those two binders are not actually being tendered as exhibits.

With those introductory matters, Mr. Chairman, if I may, I would offer Exhibits One, parts one through five, and Two and Three into evidence.

MR. STAMETS: Are there objections to the admission of these exhibits?

MR. PRUETT: Is Mr. Miller -- Dr. Miller going to testify?

MR. PEARCE: Yes, that's Part Six of this, I'm sorry.

MR. STAMETS: If there is no objection, these exhibits will be admitted with the notation that Alfred J. Wessler put Exhibit Two together for El Paso Natural Gas Company and is not actually here to testify today.

All right, who shall be the next person?

Mr. Carr.

MR. CARR: May it please the Commission, my name is William F. Carr with the Campbell Law Firm in Santa Fe.

As the Commission will recall, on April the 3rd Dr. Tom Schultz testified about five mechanisms of attenutation. The five mechanisms are set forth on the easel that's before the Commission.

Today I'm going to call Dr. Gary Miller, who is going to testify about the sixth mechanism of attenuation, which is biodegradation.

At this time I will call Dr. Miller.

Mr. Stamets, the witness needs to be sworn.

(Witness sworn.)

MR. STAMETS: Mr. Carr, you may proceed.

DR. GARY DAVID MILLER,

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

DIRECT EXAMINATION

BY MR. CARR:

Q Will you state your full name and place of residence?

A Gary David Miller. 428 Elmcrest, Norman, Oklahoma.

Q Dr. Miller, by whom are you employed and in what capacity?

A I'm employed by the University of Oklahoma as Assistant Professor in the School of Civil Engineering and Environmental Science, and today I'm here as a consultant for Northwest Pipeline Corporation.

Q Have you previously testified before this Commission and had your credentials accepted and made a matter of record?

A No, I have not.

Q Would you briefly summarize for the Commission your educational background?

A I have a Bachelor's of Science degree with a major in biology and a minor in chemistry from Oral Roberts University in 1972.

I have a Master's of Environmental Science degree with an emphasis in solid waste management from the University of Oklahoma in 1974, and a PhD in Civil Engineering and Environmental Science from the University of Oklahoma in 1980.

Q Would you review your work history for the Commission, please?

A Since 1980 I have been Assistant Professor of Civil Engineering and Environmental Science at the University of Oklahoma. I have also been Assistant Co-Director of the Natural Center for Ground Water Research at the University of Oklahoma, which is a U. S. Environmental Protection Agency established center of excellence and is a consortium of the University of Oklahoma, Oklahoma State University, and Rice University.

I teach courses at the cradute level in solid -- or in ground water quality management and in ground water pollution control, and all these positions I've held since 1981.

Q Do you belong to any professional associations?

A Yes, I belong to several professional associations, including the American Society for Microbiology, the National Waterwell Association.

I am also a member of the EPA Peer Review Panel for Environmental Chemistry and Physics, and I've been a peer reviewer for several journals, including Analytical Chemistry and Ground Water Monitoring Review.

Q What does a peer reviewer actually do?

A When an article is submitted to a journal for possible publication, it is submitted -- it is then sent to other scientists that have a similar area of expertise for their review to see it is it acceptable for publication.

Q And you review to satisfy yourself and check to be sure it's being run in a technically sound fashion, is that one of the things you check?

A Yes, that's correct.

Q Would you briefly review some of the research that you've personally participated in which relates to the subject of today's hearing?

A Overall I've participated in more than 20 research projects but two of them I'd like to highlight that relate to this hearing.

One is I was principal investigator on a research project titled Microcosm Technology for Subsurface Environments between 1980 and 1983. It was funded by the U. S. Environmental Protection Agency and the project was to develop laboratory techniques and field sampling techniques for studying ground water microbiology.

Since then I have been co-principal investigator on a research project titled Determination of Subsurface Contaminant Transport Using Microcosm Systems, also sponsored by the U. S. Environmental Protection Agency, and it is funded at the level of $850,000 for three years and we are using the laboratory and field sampling techniques developed in the previous project to further study the transport and fate of contaminants in the subsurface environment.

Q In carrying out these studies do you actually go into the field and take samples and bring them back to your lab and analyze them there?

A Right. That's exactly what we do. We go into the field, collect subsurface materials, bring them into the laboratory for analysis.

Q Have you written any books or portions of books which relate to the subject of today's hearing?

A Yes, I've been the author of three books, or co-author of three books, but one most relevant to this hearing is a book chapter with Dr. Larry Canter and myself titled "Trends in Research and Development: Implications for Managing Groundwater", which is in the book titled Groundwater Management: A Key Issue for the 80's, to be published by the American Academy for the Advancement of Science this year.

Q Have you had other papers published which relate to this subject?

A Yes. Three papers I'd like to mention.

One I co-authored with Dr. Larry Canter titled "Bio-degradation Studies of Selected Priority Pollutants".

The second one was by Dr. Joseph Suflita and myself, titled "The Microbial Metabolism of Xenobiotic Compounds in Groundwater Aquifers".

And a third, and the third paper was also co-authored with Dr. Joseph Suflita, titled "The Microbial Metabolism of Chlorophenolic Compounds in Groundwater Aquifers", which has been accepted to Environmental Toxicology and Chemistry.

Q And that will be published?

A This year in a special proceedings that will be coming out, special publication.

Q Dr. Miller, what were you asked to review and study in preparation for today's hearing?

A I was asked to review my research and related current research on microbiological degradation of organic chemicals in the subsurface.

MR. CARR: May it please the Commission, at this time we tender Dr. Miller as an expert witness in environmental biology and chemistry.

MR. STAMETS: Are there any questions as to his qualifications?

MR. TAYLOR: Mr. Chairman, I don't have an objection but I -- I'm sort of confused.

I thought that a paper that he'd written was in the exhibit from Meridian, yet he said he was testifying on behalf of Northwest Pipeline.

Can I be straightened out on that?

MR. PEARCE: Yes. The exhibit is entitled Meridian because my particular client is Meridian Oil and we combined all of the exhibits together.

MR. TAYLOR: All right.

MR. PEARCE: Dr. Miller is correct that he is retained and appearing on behalf of Northwest Pipeline.

Other than combining exhibits and keeping from paying experts to testify on the same topics, that's really what we've got going on here.

MR. STAMETS: Being no objection, the witness is considered qualified.

Q Dr. Miller, are you familiar with the five mechanisms of attenutation that Dr. Schultz presented in this case at the April 3rd hearing?

A Yes, I am familiar with those. I was -- I was present at the April 3rd hearing and in fact several of those mechanisms we also addressed in my research because we are attempting to differentiate between those mechanisms and biodegradation processes that occur in subsurface material, but my testimony today will be primarily towards the biodegradation processes in the subsurface.

Q Would you turn to the first page after Tab No. 6 in Meridian Exhibit Number One and identify this and review it for the Commission?

A Yes. This first page is titled "Main Points About Biodegradation of Organics in the Subsurface."

This material behind Tab 6 in this exhibit was prepared by me for this hearing and this first page just summarizes the six main points that I would like to make.

Q Would you now identify the second document in -- after Tab No. 6?

A Yes. The second document is titled "Biodegradation" and I believe it is about five pages in length, and it's a written narrative that summarizes my testimony today.

Q Does this report also have a bibliography attached to it?

A Yes. The attached bibliography, about two pages with twenty references, those references could be used by anybody who would like to go into this subject matter in greater depth.

Q Will you now refer to the first point you're going to present concerning biodegradation, state what it is, and review it for the Commission?

A Yes. The first point I'd like to make is that benzene and toluene are readily biodegradable by microorganisms, and as supporting documentation for this I have a paper several pages over, the first paper, titled "Biodegradability Studies with Organic Priority Pollutant Compounds", authored by Henry Tabak and others, who are researchers for the U. S. Environmental Protection Agency at their Cincinnati Laboratory.

Specifically I'd like to refer to Table 3 on Page 1509 of their paper and in that table, which is titled "Biodegradability of benzene, toluene, and their derivatives evaluated by the static screening flask test method", we see in the lefthand column, titled "Test compound" that the first compound mentioned in benzene.

The second column is "Concentration of the test compound" and benzene was tested as 5 parts per million and 10 parts per million.

And the third column is -- is a performance summary. The "D" in that column refers to significant degradation of benzene was found with rapid adaptation of the micro-organisms.

The next column is titled "Original culture" and within one week between about 40-to-50 percent of the benzene had been degraded. A subculture was then taken of that first culture and within two weeks 95-to-100 percent of the benzene was degraded.

So benzene was significantly degraded and there was rapid adaptation of the micro-organisms to it.

Then further down, third from the bottom, is toluene. The same concentrations of toluene were tested. It was also found that there was significant degradation with rapid adaptation of the micro-organisms. In fact, it was more rapidly degraded than -- than the benzene, and within one week 100 percent of the toluene was biodegraded.

So -- so this table, then, indicates that benzene and toluene are readily biodegradable in the environment.

Q Toluene degraded in one week and benzene in two.

A Within about two weeks.

Q Are the authors of this report recognized authorities in this area?

A Yes, they are. They are active researchers with the U. S. Environmental Protection Agency.

Q And in what journal was this paper published?

A This paper was published in the Journal of the Water Control Federation, which is a highly recognized journal in this area.

Q Have you utilized their work in your research?

A Yes. I utilized their work and this paper in my own research.

Q And have you confirmed their conclusions in your own independent research?

A Yes. My research would agree with what their table has shown.

Q Would you now refer to your second point and review that for the Commission?

A The second point, then, is that micro-organisms exist in the subsurface and they are metabolically active, and this, this area is -- gets us to the new area. It was, perhaps, a misconception by some people in the past that micro-organisms did not exist in the subsurface environment, and in the past about five or six years we have discovered that they do exist in the subsurface environment and they are metabolically active.

The next paper in this exhibit, which appeared in EOS, by Wilson and McNabb,

Q What is EOS?

A EOS is the title of a journal. Okay. And this article by Wilson and McNabb is titled "Biological Transformation of Organic Pollutants in Groundwater", which appeared in 1983, and in this paper they summarize what we had learned in about the four previous years about the occurrence and activity of micro-organisms in the subsurface environment.

In the first table on Page 505 of their paper, titled "Numbers of Organisms in the Subsurface Environment", we can see that there were several sites that aquifer material has been obtained. They used the same sampling technique that we used, that we developed in our previous research project, and they obtained aquifer material from two places in Oklahoma, from a place in Louisiana, from Conroe, Texas, and from a site in New York on Long Island, and there were various depths to the water table at these sites.

They sampled the subsoil. They -- they obtained material just above the water table, and they obtained aquifer material just below the water table, and in all of these sites they found that there was a surprisingly uniformity to the numbers of micro-organisms that occur in the aquifer material.

The minimum amount that they discovered was approximately 300,000 micro-organisms per gram of dry weight of aquifer material.

The maximum number they found was 170,000,000 micro-organisms per gram of dry weight of aquifer material.

So everywhere they looked they found micro-organisms and to date everywhere we've looked we've found this relative -- in this range numbers of micro-organisms in subsurface environment.

Q Are you familiar with the sampling techniques employed in preparing this paper and doing this research?

A Yes. I helped develop those sampling techniques and participated in collecting some of these samples.

Q How does this information compare with the number of micro-organisms that are found at great depths?

A Some other researchers have collected some samples from depths exceeding 100 meters and have also found about 1,000,000 micro-organisms per gram of dry weight. So even at great depths these significant levels or organisms do occur.

Q How does this compare with the number of organisms in surface soils?

A In surface soils we find about 10 to the 8, or -- or maybe about two orders of magnitude more organisms, about 10 to the 6, or a 1,000,000 micro-organisms per gram of dry weight; a still significant number of micro-organisms.

Q That's at the deeper depths.

A In the deeper depths, right.

Q And are there any differences that you've noted in these organisms?

A Yeah, the main difference we seem to have found in the subsurface micro-organisms is that they're used to what we might call a nutrient poor environment or in other words, they don't have a lot of food to eat in simple terms. They're not picky eaters and they will metabolize or eat, digest just about a wider range of chemicals that comes along than surface micro-organisms who have the luxury of, let's say, being picky eaters and can specialize in the types of things that they will metabolize.

Q At both levels do the organisms eat benzene and toluene?

A Yes. They metabolize benzene and toluene. In the subsurface environment it appears that they will metabolize benzene and toluene at lower concentrations and will metabolize them to lower concentrations below, say, levels of significant concern.

Q Are you ready now to go on to your third point?

A Yes. The third point that I would like to make for the Commission is that aerobic biodegradation of benzene and toluene and related organic chemicals does occur in the subsurface environment.

Again, this is made in the article by Wilson and McNabb.

On the next page, Page 506 of their article in Table 2 they summarize the prospect for the bio-transformaton of selected organic pollutants in water table aquifers, and if you look under the lefthand column titled "Class of Compounds" you'll see under alkylbenzenes that benzene and toluene are listed, and for the aerobic environment for benzene it is listed that it's probable that benzene will degrade at concentrations greater than 100 parts per billion or micrograms per liter, and possible that it will be degraded even at trace concentrations below 10 parts per billion.

The same thing is true of toluene, that it's probable that it degrades concentrations greater than 100 parts per billion and possible it degrades even at trace concentrations.

The reasons that these terms "probable" and "possible" were used is that everywhere we looked benzene and toluene was degradable, so we would predict that probably it would degrade at future sites.

Q On this table there is also a column for an anaerobic water and it indicates "none".

A Right. At the --

Q Can you explain that?

A Sure. At the time that this article was written, that was what was thought to be true, that benzene and toluene would not be degradable under anaerobic conditions; however, since that time it has been found by some that under certain anaerobic conditions that benzene and toluene may be degradable, and I'll address that a little bit later.

Q Have you confirmed the conclusions set forth in Table 2 with your own research?

A Yes. In fact, some of this information that's in Table 2 is from my own research.

Q Will you now go to the report by Bouwer and McCarty?

A Yes. The next paper, which supports the aerobic degradation of these types of chemicals in the subsurface environment, is titled "Modeling of Trace Organic Biotransformation in the Subsurface", and it appeared in the Groundwater Journal.

And this, what I would like to refer to first of all is Table 1 of this paper and titled "Average Utilization of Substrates Fed Continuously to Aerobic and Methanogenic Biofilm Reactors After Acclimation."

And if you looked in the lefthand column titled "Substrate", there is a category called nonchlorinated aromatics. Benzene and toluene are there. Benzene and toluene are nonchlorinated aromatic chemicals.

And you see that -- that ethylbenzene, syurene, naphthalene, were removed at a rate of 99 percent or greater within a 20 minute detention time in their treatment study under aerobic conditions. So these were rapidly degraded under aerobic conditions.

Under anaerobic, or methanogenic conditions some of the nonchlorinated aromatics were also removed but at a much slower rate.

Then the next point I would like to make from this article is on Page 439. It's Figure 3. They reviewed the general figure on the degradation of different types of organic chemicals under different types of conditions and under aerobic heterotrophic respiration conditions they indicated that chlorinated benzenes and nonchlorinated aromatics were readily degradable, and they indicated that under the anaerobic environment that there was much less known about it, as indicated by the question mark under sulfate respiration, for example.

Q Dr. Miller, are you ready to go to your graph on toluene?

A Yes. The next evidence, or next exhibit is titled "Toluene", and it's just a graph from my own research that indicates a solid line and a dashed line and the solid line is from aquifer material that's collected from well within the -- the saturated zone a couple meters below the top of the water table.

The dashed line is from right near the top of the water table but within the aquifer or within saturated material.

And we see that within about four weeks in the upper zone the toluene was completely degraded and in the lower aquifer material it was a slower rate of degradation but there was a significant degradation of toluene in my own research.

Q Dr. Miller, this information relates only -- depicts -- is information collected only below the water table.

A Yes.

Q Do you have information or could you plot information showing what happened above the water table?

A Yes. We also studied aquifer material collected in the unsaturated zone above the water table and the rate of degradation in that material was between 240 and 250 percent per week, and it would essentially coincide with the Y axis on this chart so we didn't include it, but very rapid degradation in the unsaturated material, and the rate of degradation in the saturated material was approximately 30 percent per week.

Q Would you now go to the fourth point?

A The fourth point about this is that -- that the aerobic degradation pathways of benzene and toluene lead to complete mineralization to carbon dioxide and water with the formation of no metabolites formed that are of human health or environmental concern.

And I've taken this material from a report by the name of Perry. The author is Perry. It's number seventeen on my bibliographic list, from a book titled Petroleum Microbiology and the first illustration is for the aerobic pathway utilized by bacteria for the oxidation of benzene.

It's illustrated on the poster here. We see that benzene is degraded in the presence of bacteria and oxygen. A water molecule is added to the ring structure to form a dihydrobenzene.

That is then transformed to a catechol and then that catechol either undergoes ortho or meta fission to either a muconic acid or a semialdehyde and at that -- when the ring structure is broken at that point, then they -- it is completely metabolized to carbon dioxide and water under aerobic conditions and none of these metabolites are of any known human health or environmental concern, that I'm aware of.

The next illustration is titled "Two Aerobic Pathways for Toluene Biodegradation", taken from the same book, and there are two degradation pathways for -- under aerobic conditions for toluene.

On the lefthand side toluene is degraded to a dihydrotoluene and a methylcatechol, finally the ring -- it undergoes ring fission and is completely metabolized to carbon dioxide and water.

Under the other degradation pathway on the righthand side the toluene is degraded to a benzyl alcohol, then a benzyl aldehyde, finally benzoic acid, and then also a catechol and then undergoes ring fission and complete mineralization to carbon dioxide and water.

Q And none of these intermediate compounds constitute a health or environmental hazard.

A They do not to my knowledge. That's correct.

Q Would you now go to point number five?

A Okay, the point -- the fifth point that I would like to make is that oxygen does occur at significant levels under most conditions in the subsurface, even in the deeper subsurface, and perhaps this is the second area of misconception, because many people believe that the subsurface environment is an anaerobic environment and we have found that that's -- that's generally not the case.

The subsurface environment is actually an oxygenated environment under most conditions.

It can be seen from the abstract of this paper that is given, titled "Deep Oxygenated Groundwater Anomaly or Common Occurrence?", and it's by two authors from the U. S. Geological Survey, Winograd and Robertson, in their Published in Science, which is a very reputable journal, and they indicate that significant levels of dissolved oxygen 2 to 8 milligrams per liter were present from waters from a variety of deep aquifers in Nevada, Arizona, and in the Appalachians in Arkansas, even as deep as 100 to 1000 meters in depth.

And so generally, then, it would be expected that the subsurface is commonly an aerobic environment and would be expected to be aerobic except where there are large amounts of organic contamination.

Q Will you now review point six?

A Okay, the sixth point that I would like to make, then, is that recent studies indicate that toluene and possibly benzene may degrade under anaerobic conditions of such conditions do occur in the subsurface environment.

And for that I'd like to refer to a page titled "Abstracts of the Annual Meeting of the American Society for Microbiology" which occurred in March of this year, and under the section entitled "Environmental and General Applied Microbiology" the abstract numbered Q 5, which is titled "Biotransformation of Toluene in Methanogenic Subsurface Material", by Rees, Wilson and Wilson, they found that toluene was degradable under methanogenic, which is a type of anaerobic condition, in the subsurface environment at a slower rate than aerobic conditions but they did find anaerobic degradation.

The next paper by Reinhard and Goodman, titled "Occurrence and Distribution of Organic Chemicals in Two Landfill Leachate Plumes", which just recently appeared in <u>Environmental and Science Technology</u>, also there were indications that benzene, toluene, and related compounds could be degraded under anaerobic conditions in the subsurface environment.

Thirdly, Dr. Rene Schwarzenbach from Switzerland, who works with some famous scientists over there, visited my lab last month and he indicated in his laboratory experiments he found anaerobic degradation of benzene, toluene, and related compounds under -- under anaerobic conditions given at rapid rates and especially after adaptation of the micro-organisms.

So very recent evidence does indicate that toluene and possibly benzene may degrade under anaerobic conditions in the subsurface environment.

Q And why do you think this informations has not been discovered prior to this time?

A Previously it was -- it was thought that micro-organisms did not occur in the subsurface environment so there were no biological processes down there.

We set out in the late seventies and early eighties to test that common belief and we developed sampling procedures for obtaining aquifer materials that was uncontaminated by surface micro-organisms and would only contain the indigenous micro-organisms that occur in the subsurface.

When we studied that material we also developed new laboratory techniques for identifying micro-organisms in aquifer materials and we were pleasantly surprised to find out that there were micro-organisms that exist.

In fact, one of the researchers that -- that started this expected to have a one-year research project and go on to something and better and the something bigger and better turned out to be groundwater microbiology, and so we have continued to pursue that line of research.

Once we found out that there were micro-organisms that do occur in the subsurface environment, we found that they are metabolically active, and also there weren't -- it's very difficult to sample wellwater or groundwater for -- and analyze it for dissolved oxygen without introducing dissolved oxygen into the -- into the water, so the paper by Winograd and Robertson was an innovative technique for doing that, and so by that innovative technique they were able to document that the -- that subsurface groundwater does contain dissolved oxygen.

So it's been largely due to the development of analytical and field and laboratory techniques that we've been able to make these discoveries.

Q Would you summarize now for the Commission the conclusions you've reached as a result of your studies?

A Yes. I'd like to just refer back to the first page of Subsection 6 of this exhibit, which was titled "Main Points About Biodegradation of Organics in the Subsurface".

My first point was that benzene and toluene are readily degradable by micro-organisms in the environment.

Secondly, micro-organisms do exist in the subsurface and they are metabolically active.

The third point was that aerobic biodegradation of benzene and toluene and related organic chemicals does occur in the subsurface environment.

Fourth, the aerobic degradation pathways of benzene and toluene lead to complete mineralization, to carbon dioxide and water, with no metabolized forms that are of human health or environmental concern.

Fifth, oxygen occurs at significant levels under most conditions in the subsurface, even in the deeper aquifers.

And finally, recent studies indicate that toluene and possible benzene may degrade even under anaerobic conditions if they -- if such conditions do occur in the subsurface environment.

I think that biodegradation of organics in the subsurface is one of the most exciting scientific discoveries in recent years and combined with the other loses previously described by Dr. Schultz, there are several volatilization losses. There is two or three dimensional flow in the partially saturated zone, which can result in the dilution of any remaining chemicals.

Sorption, which for the types of soils in the area of concern can result in a 5 to 50-fold delay or retardation of these chemicals.

Biodegradation results in the further disappearance and at a rate greater than 30 percent per week, and after adaptation, an even faster rate of disappearance will occur, and in fact, biodegradation and some of the dilution and and retardation mechanisms can work together to provide a greater residence time of these chemicals in the -- in the subsurface for biodegradation to occur.

And then the concentration of benzene and toluene will be reduced to less than 10 parts per billion, which is below current levels of regulatory concern.

Now most computer models that have been developed for predicting the fate of these types of chemicals in the subsurface have been formulated by hydrogeologists that originally used inorganic chemicals that do not degrade, and they used retardation factors to simulate the movement of organic chemicals, which, if the organic chemicals are biodegradable, we now know this is not an accurate way to model their transport and fate.

The U. S. Environmental Protection Agency has within the past year initiated at least two new research projects, one by myself, to develop mathematical models that will include more accurate simulation of microbiological processes in the subsurface.

When we consider that all these six retardation and removal mechanisms for benzene and toluene, it is clear why they have not shown up in water supply wells in the area of concern, and I would not expect them to threaten fresh water supplies in the San Juan Basin.

Q Dr. Miller, were materials contained in Part 6 of Meridian Exhibit Number One prepared by you and compiled under your direction and supervision?

A Yes, they were.

Q And can, from your own experience and research, you testify as to the accuracy of the materials contained therein?

A Yes.

MR. CARR: At this time, Mr. Stamets, we would offer into evidence Part 6 of Meridian Exhibit Number One.

MR. STAMETS: Any objection to the entry of this portion of the exhibit?

It will be admitted.

MR. CARR: That concludes my direct examination of Dr. Miller and I tender the witness for cross examination.

MR. STAMETS: Are there questions of Dr. Miller?

MR. KELLAHIN: Yes, Mr. Chairman.

MR. STAMETS: Mr. Kellahin.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Dr. Miller, did you attend the Oil Conservation Commission hearing in this case on February 20th of 1985?

A No, I did not.

Q You were at the hearing we had on April 3rd, 1985, in this case?

A Yes, I was.

Q So you heard Mr. Schultz' testimony about the other mechanisms of attentuation.

A Yes, I did.

Q In preparing for your testimony today, Doctor, did you review any of the information that was in the transcript for the Februrary 20th hearing?

A No, I did not.

Q Doctor, what we're trying to determine here is whether or not there ought to be small volume exemptions in a vulnerable area of the San Juan Basin so that oil and gas wells, the produced water from which, can be placed in unlined pits, and whether that process poses a reasonable probability of contamination to the groundwater.

Within that context, then, I want to ask you some questions and your professional opinion on biodegradation.

Assume, if you will, for me, sir, that the prior testimony has provided evidence that a hydrologist has made a simple dilution calculation and has assumed certain factors; that the produced water coming from the separator has been analyzed out of the separator directly and shows concentrations of benzene in the range of 20 milligrams per liter; that in addition there have been water samples taken out of the pit in which there are analyses showing that concentrations of benzene in the pit are about 3.5 milligrams per liter.

The hydrologist then does a simple dilution calculation assuming a vertical distance from the bottom of the pits to groundwater of about 25 feet and that the pit is subject to having water placed on it on a continuing basis at the rate of about five barrels a day.

It is also in the record that a number of these pits are in soil compositions that are gravel. They have big cobbles in them. They do not have fine grained soils.

Let's also assume that groundwater monitoring has occurred around this well and while it's been done appropriately, in accordance with the standards of a hydrologist, and the groundwate monitoring fails to detect benzene in concentrations in excess of the standard, my question, sir, in your opinion are there reasonable scientific explanations for the fact that benzene at 3.5 milligrams per liter is in the pit, and yet when you sample the groundwater around that pit you do not find benzene?

Do you have an opinion on that point?

A Yes. I -- I feel that our scientific evidence today would strongly indicate that these six removal mechanisms and dilution mechanisms would account for that.

Q In your opinion is it necessary for you to actually to go out to the San Juan Basin and look at these wells and study it yourself in order to reach the conclusion that the mechanisms, including the mechanism of biodegradation, is occurring in this type of soil and area?

A No, I don't think it's necessary. The preponderance of evidence everywhere we've looked is that biodegradation of these chemicals does occur in these types of materials, these types of environments, and would filly expect them to occur in the San Juan Basin.

Q Doctor, I'd like to ask your expert opinion on whether you agree or disagree with certain testimony of a prior witness, Mr. Dave Boyer, at the February 20th, 1985 hearing.

This testimony appearing on page 82 and 83 of that transcript, Mr. Boyer is discussing the mechanism of biodegradation and he concludes that it is not an important factor to consider when you're determining whether the benzene concentrations in the pit are reaching the groundwater, and he says:

"There are some mechanisms in the subsurface for containment and attenuation of these things. I'm going to discuss those briefly."

He then discusses briefly the first five and he gets down to the last, biodegradation, and defines biodegradation, and then he says:

"In an anaerobic environment it's a different story and degradation only occurs slowly in an aerobic environment, so if you have an aerobic environment down there, you probably don't have very much in the way of degradation."

That was his testimony. Do you agree or disagree with his opinion?

A I disagree. I think that that would have been commonly believed five or six years ago but the recent evidence indicates that that's not true.

Q You quoted to us awhile ago, doctor, and discussed for us the paper by Winograd and Robertson?

A Yes.

Q And it had to do with the presence of dissolved oxygen in the saturated zone?

A In groundwater is correct.

Q In the groundwater? And that that was one of the factors that allowed the biodegradation mechanism to work in this type of environment.

A Right. It would permit aerobic degradation.

Q I want to direct that kind of point to the San Juan Basin water area, doctor.

Would you anticipate that recently recharged water, which is common in the shallow, localized, recharged alluvial aquifers in the San Juan Basin, we're dealing with San Juan Basin that is continually and actively recharged. That's the type of aquifer we have. If you'll assume that, my question is whether or not in your opinion there would be higher or lower percentages of dissolved oxygen than in the deep groundwater discussed in the Winograd and Robertson reports and studies?

A They indicated a range of dissolved oxygen from 2 to 8 milligrams per liter.

I would expect the dissolved oxygen to fall within that range in the San Juan River Basin; perhaps towards the upper end of that. But 8 milligrams per liter, depending upon the temperature of water, is getting near the saturation point for dissolved oxygen, so it probably wouldn't occur much higher than that.

Q Is that range of dissolved oxygen in the water an adequate range to create an environment for the biodegradation to take place?

A The only -- the only way that it could be limiting is if it was overwhelmed by organic chemicals.

Q And when we talk about the concentrations of benzene that I described earlier, when they come out of the separator and were in that 20 milligrams per liter range, by the time we're in the pit we're down to the 3 and 4 milligram range, in your opinion would that be a concentration that would overwhelm the mechanism of biodegradation?

A In my opinion it would not be high enough to overwhelm it.

The cases where I have seen it overwhelmed have been much, much higher concentrations of benzene and toluene and related compounds.

Q Let's assume also, sir, as I discussed with you earlier, that the facts are that the pit is subject to a rate, a volume of water, produced water in the pit, of 5 barrels a day or less, would that be a volume of water in the pit that would overwhelm the mechanism of biodegradation, using a concentration in the pit of 5 -- 3.5 milligrams per liter?

A It -- it appears to me from my research and the research of others that that concentration and volume should not overwhelm the capacity of the subsurface to degrade these chemicals, although I haven't performed, you know, detailed studies of that or mathematical modeling of it, because we're still developing the mathematical model for that, but I would say that -- that there is ample opportunity for adaptation of the micro-organisms within the pit and in the subsurface immediately below the pit to rapidly degrade these chemicals, and the presence of benzene and toluene and related chemicals in the water environment provides for, you know, adequate micro-organisms to exist that can degrade those chemicals.

Q All right, let's assume that the potential contaminants in the pit, that there is some level that reaches the groundwater and they're subject in this area to rapid dilution.

Will biodegradation continue in an atmosphere where we have the contaminants diluted and we have highly oxygenated water?

A Right. Biodegradation will occur. I've studied in the -- at the -- in the neighborhood of 100 parts per billion biodegradation occurred. I've studied at about 10 to 20 parts per billion and biodegradation of these chemicals occurs at those trace levels, also, and usually when we're getting below, say, 10 parts per billion, we're getting below levels of regulatory concern.

Q In the scheme of trying to determine the effects of the different mechanisms of attenuation, can you give us a general range of magnitude of the effects of biodegradation in the fact situation I've given you? Does it play a mojor part, a minor part, or can you attempt to determine how important that factor is in relation to the other five factors that Mr. Schultz discussed?

A I think biodegradation plays a major role. I think that it works in concert with some of the other factors, like sorption, to -- to provide for what we might call a treatment zone, an area of active degradation beneath the pit that I would anticipate occurred there.

We've observed what we might call treatment zones and other sites we've investigated around the country where there was an area of active degradation that was maybe a foot or so in length, and we found significant concentrations on one side, within a foot disappearance to below measurable levels in subsurface material.

So I would -- I would -- it would be my judgment that there are this kind of a treatment zone beneath these pits.

Q At the April 3rd hearing Commissioner Stamets gave Mr. Schultz an example and asked Mr. Schultz whether that was adequate and an example characterized what is happening in the unlined pit area in relation to groundwater, and the example was this, sir: That -- the expert was asked whether or not this is like the carbon filter you might have on your tap water in the house, and that after a period of time if you did not change your filter by running the tap water through the filter the filter becomes full and eventually you're going to have a glass of water that's got contaminants or pollutants in it.

With regards to the mechanism of biodegradation and the other factors of attenuation, would that be a fair example of the type of a situation we have when we're dealing with the unlined pits in the San Juan Basin?

A I would say that would only be fair if the system was overloaded with a gross amount of contamination or deposition of pollutants, that there was kind of bulk flow of pollutants, but in this case, where we're talking about 20 parts per million concentration and, say, 5 barrels per day, or so, of liquid, I wouldn't think that that would be accurate because the system would not be overloaded and the biodegradation mechanisms would result in disappearance or complete metabolism of these chemicals.

Q I just want to make sure we're dealing with the same numbers, doctor.

A Okay.

Q The example I gave to you and the fact situation is we're dealing with 3.5 milligrams per liter.

A Right.

Q And we're dealing with 5 barrels a day in the pits.

Witnesses are continuing to change the mathematics on me and I am barely comfortable with milligrams per liter, and if you could keep in that form it would help me a lot.

A I'll try.

Q You just made reference to 20 parts per billion.

A I meant to say 20 parts per million but I was in that range.

Q I'm still not with you.

A Right.

Q 20 parts per million is --

A Is 20 milligrams per liter, approximately.

Q All right.

A Right.

Q In your opinion, then, with regards to the unlined pits, are we dealing with a statis carbon filter type environment there or do we have a dynamic regenerating system that continues to have the mechanism of attenuation work on these contaminants and not only delay them but remove them from -- from the system?

A All right. I'd say in these concentration ranges and levels of input that it is a dynamic system where there is a capacity for regeneration.

Q Up to this point, doctor, we have been talking about the unsaturated zone and the effects of biodegradation on that zone.

Let's have you shift gears now, sir, and talk about what happens, if anything happens, with regards to the treatment of contaminants in the saturated zone, or saturated environmenta.

A Our experiment, our experimentation to date indicates that biodegradation continues in the saturated zone, perhaps at a somewhat reduced rate, but still occurs there at significantly rapid rate. It would -- we estimate in the range of about 30 percent per week rate of degradation in the saturated zone. So if benzene and toluene and related chemicals reach a groundwater there would continue to be biodegradation even in a saturated zone.

Q So if in the vulnerable area of the San Juan Basin we have unsaturated zones and also saturated zones, in your opinion are the mechanism of biodegradation still active and functioning in both the saturated and unsaturated environment?

A Yes.

Q Talking again in the small volume concentrations that we've just discussed.

A That's correct.

Q Thank you, sir.

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

Ms. Pruett?

CROSS EXAMINATION

BY MS. PRUETT:

Q Sir, you were at the last hearing and you heard Mr. Pearce telling the Commission his experts were going, I believe he said, to discuss the read world geology and hydrology, and your essay is titled "Main Points About Biodegradation of Organics in the Subsurface."

And your first point is that benzene and toluene are readily biodegradable by micro-organisms and you cite the Tabak article for that proposition, but the Tabak study was not a real world study, was it?

A No, he used real world micro-organisms he collected from the environment but it was the surface environment and only indicates the potential for benzene and toluene to --

Q Right.

A -- degrade by micro-organisms.

Q That article reflects --

MR. PEARCE: Excuse me, let's don't interrupt the witness, please.

A Right, I wanted to -- and therefore I went on to the next five points and showed that first of all, you know, by the Tabak article that benzene and toluene are degradable.

Then the next points indicated that they're degradable in the subsurface environment.

Q Right, but the Tabak article was based on tests done in controlled laboratory situations, in laboratory culture samples.

A Sure, with micro-organisms from the environment.

Q And they were injected, those flasks were injected with yeast extract and settled domestic waste water.

A That's correct.

Q And produced waste water, which is the subject of this hearing, doesn't contain yeast extract or settled domestic waste.

A No, I wouldn't expect it to.

Q Okay. Now, also in the Tabak article on page 1506, the authors point out that the minimum sensitivity of the gas chromotography -- chromotographical procedures is .1 milligrams per liter and he states that. quote, the indication of 100 percent biodegradation in the tabular data should not be interpreted as zero residual of the individual priority pollutant, end quote.

So even though Tabak's charts show 100 percent degradation, that may not, in fact, be the case. There could be some residual under .1 milligrams per liter that just -- their instruments were incapable of picking up.

A Right. We can only say that there's degradation to the point of limits of detection. We can't state below that.

Q Right. And that point of detection is in fact ten times greater than the New Mexico health standard for benzene.

A In his studies, yes. In my studies, probably my limit of detection was in the about one part -- or about a tenth of a part per billion. Okay, so that would be much below the Tabak's.

Q Tabak also stated that, on page 1517, the priority pollutants that were observed not to exhibit significant degradation under the conditions of the static-culture-flask methodology cannot be presumed to be completely recalcitrant to microbial action. Unquote.

Isn't the reverse also true, just because degradation occurred in these controlled flask conditions, that one cannot presume that under environmental conditions they would necessarily degrade?

A Yes, and that's exactly why I presented evidence to show that it would occur in the subsurface environment.

Q Now, on your third point citing Wilson and McNabb and Bouwer and McCarty, they said aerobic biodegradation of benzene, toluene, and related organic chemicals, occurs in the subsurface, again in an attempt to convince us that you have looked at real world subsurface conditions, but in fact, the Bouwer and McCarty article did not study benzene and toluene in the subsurface here, did it?

A Right, they -- they studied it under methanogenic type conditions that could possibly occur in the subsurface, but in the others, all the other studies we've done, we've collected aquifer material and subsurface material from the environment and used that for all of our studies.

Q But the Bouwer and McCarty article, which you cited for this proposition, involved a situation where they actually studied ethylbenzene and styrene in a biofilm reactor again in a controlled laboratory situation.

A Yes, that's correct. In that article they were looking at that type of experimental set-up and part of the reason for that was because it's difficult to obtain those type of conditions. We now can do it, but the only way to set up those kinds of anaerobic conditions was by the technique that they used.

Since then we have found methanogenic

conditions in the environment using -- using actual aquifer material, and it confirms their results.

Q And Boywer and McCarty used acetate as their primary substrate to support bacterial growth in their biofilm reactor.

A Yes.

Q And acetate isn't usually found in produced water, is it?

A Not to my knowledge. It's just an organic substrate similar to the other organic chemicals that are in produced water.

Q And it seems to be that Wilson and McNabb's references to benzene degradation ranged in the solids. I believe they --

MR. CARR: I'm going to object. This is argumentative. If the counsel would like to make a closing statement or call a witness to testify she certainly may do that, but her opinion is not appropriate. She may cross examine the witness and reserve here comments for an appropriate time.

MS. PRUETT: Sir, this witness has made what I believe are overstatements and I'm trying to pin him down to exactly where he got his information and to point out inconsistencies within the material he himself has cited.

MR. CARR: These are argumentative questions. When counsel stands up and says, "I don't believe this ..." and starts arguing with the witness her line of questioning is inappropriate, and I'm objecting to it and requesting that you rule so that she will cease from further questions of this nature.

MS. PRUETT: I would be happy to remove my own statements and my interpretation and I will rephrase my question (inaudible.)

MR. STAMETS: Ms. Pruett, if you would rephrase your questions that certainly would help.

MS. PRUETT: All right.

Q Isn't it true that Wilson and McNabb have stated in their bulletin here that their references to benzene degradation are, quote, the authors' opinion, unquote, and were based on, quote, cautious extrapolation from the behavior of these compounds, and, quote, from the authors' admittedly limited experience with their behavior in the subsurface environment, unquote?

A Yes. They said that because we have not sampled everywhere in the world and there's only a limited number of places that we've sampled.

They cited at that time, I would say, what, one, two, three, four, five different sites throughout the country. Since then we've sampled four or five other places to confirm their -- their studies.

It -- we've only looked at a limited number of concentrations, but we've looked at concentrations that are in the range of concern for this hearing.

We also almost, I would say all of the aquifer material that they did study was similar in nature. It was all sandy, low organic carbon content, from river alluvial type deposits, very similar to the San Juan Basin here.

So they were saying that they can extrapolate this to all subsurface environments because there's -- there are many different types of subsurface materials and environments but fortunately, the types of materials that they used for their studies is very similar to the types of materials of concern here.

So it's highly extrapolative. You can extrapolate it very easily, I think.

Q Also their exact words were "cautious".

A Right.

Q In the Winograd and Robertson article they cite examples for the proposition that aerobic conditions and microbial metabolism would be expected in the unsaturated zone as well as ground levels.

Didn't they end their abstract with the caveat that these assumptions must be tested on a, quote, case-by-case basis, unquote?

A Yes, and everywhere we've looked in the shallower subsurface in our own studies, we've found dissolved oxygen concentrations at least two milligrams per liter, typically four or five milligrams per liter.

We haven't done something similar to them in the deeper subsurface but everywhere in the shallower subsurface and in alluvial type material we found similar dissolved oxygen concentrations.

Q Now the Reinhard and Goodman study, benzene wasn't observed to be biodegradable, was it?

A No, I don't believe so.

Q And in the Reinhard and Goodman study, indeed, wasn't the adsorptive capacity of the aquifer for benzene exhausted in that study?

A I don't think that he stated it was totally exhausted but that that was one possible interpretation to some of his data.

Q Didn't they state in that article that the only observable attenuation mechanism for benzene that appeared to be operating was hydrodynamic dispersion?

A I don't recall that specific statement from his article, but I recall other statements from his article that he did indicate that biodegradation of some of these chemicals was one possible interpretation of his results.

Q For the other compounds but not necessarily for benzene.

A Not necessarily. I don't recall that statement in there.

Q Now in your article on -- on the last paragraph of page 1, you state, quote, in fact, degradation of these two organic chemicals, benzene and toluene, has occurred every time they have been tested with subsurface material, close quote.

But isn't it true that one of the references you submitted (not clearly understood) showed that there was no significant biodegradation of benzene in alluvium from the flood plain of the South Canadian River?

A That -- I'll have to turn to that and look, although I'll have to say that -- that -- that Barbara Wilson is one of my students and in verbal communication from her, she has found anaerobic biodegradation of benzene but it hasn't been published yet.

MS. PRUETT: Mr. Chairman, I would suggest that that remark be stricken as hearsay.

MR. STAMETS: The Commission will recognize the remark as hearsay.

MR. KELLAHIN: Mr. Chairman, I might point that there's a well recognized exception to the hearsay rule; that an expert witness may rely upon hearsay evidence upon which he may reach a conclusion and, in fact, that's what Dr. Miller has done today. That's what all the other experts do before this Commission, because they don't go out and do all the actual research themselves.

It's a well documented exception to the hearsay rule and we believe his comment is appropriate.

MR. ELMER: Counsel, doesn't that refer to printed materials which the expert utilizes in preparing his expert testimony and not to oral statements made?

MR. KELLAHIN: I believe it's broad enough to include oral statements made to this expert. It's the custom and practice of this Commission of broaden that exception to include not only documented evidence upon which he relies but the verbal testimony or evidence he receives verbally or orally from others.

It would be a significant departure from the practice of this Commission to now exclude that type of evidence.

MR. ELMER: Well, I can only make my recommendation to the Commission that oral testimony relied upon by an expert be excluded, because the affiant is not before the Commission for examination and that the Commission should limit its admission as to the written materials which the expert relied upon in forming his testimony.

MR. KELLAHIN: That's a difference without being a significant distinction, Mr. Chairman, because the written testimony or report from someone else, that person is not here to document it, either.

MR. STAMETS: No sense in protracted legal argument here. We will allow the answer to remain in the record and we will take it for what it's worth.

Q Aside from any hearsay or oral testimony, the reason I asked that question is this quote in the Rees abstract, quote, toluene degradation was apparent after 6 weeks; after 11 months the toluene concentration was reduced at least an order of magnitude. There was no significant degradation of the other aromatic hydrocarbons. Close quote.

Benzene is an aromatic hydrocarbon.

A Right. That -- that's a good point. I was going -- intended to add to that is that's where you have to be really careful in -- in looking at information about the anaerobic degradation of these compounds because what happens when the aquifer material and the microorganisms under anaerobic conditions have been experienced and been exposed to these types of chemicals, there is a long adaptation period and typically we find the adaptation period, we would expect it to be six months, maybe a year.

So many researchers have studied these chemicals under anaerobic conditions, studied them for a month, said they didn't go away, so we give up, they don't degrade.

More recently we have been taking the approach let's study them for longer periods of time. When we initially expected it would take nine months, a year, maybe a year and a half before we'd see something happen, when degradation does occur under anaerobic conditions, it's usually very rapid, and I would say that most of the researchers I've talked to, including my (coughing, not audible) has been surprised that the period of adaptation under the anaerobic conditions was much shorter than he expected. And so when we say that benzene didn't degrade in this experiment, it only pertains to the period of time that they studied it. The next month the adaptation period for those micro-organisms may have, you know, occurred and degradation occurred rapidly.

So there are time consuming difficult experiments under anaerobic conditions, and so when degradation does occur, then that's pretty positive evidence, but when it doesn't occur, that doesn't mean it won't occur.

Q The next thing I wanted to look at was reference Figure 17, reference (17), the J. J. Perry exhibit.

A Uh-huh.

Q And I didn't find where that reference fit in your -- in your summary article. I imagine it's someplace on page 2 and I think perhaps the second full paragraph, before (16) is cited and after (17) (18) is cited.

Well, could you tell me exactly where (17) fits in there?

A Fits in there? It really fits in the paragraph "The aerobic degradation pathways. . ." that starts out that way.

Q That second full paragraph, okay.

A Yes.

Q Okay. I have a copy of this article which I'd like you to take a look at in the <u>Petroleum Microbiology</u> book.

Is this the article you were referring to?

A Yes. I believe that -- this is the book where the degradation pathways were taken from.

Q Could you read the title of that for me?

A "Microbial Metabolism of Cyclic Alkanes".

Q Are benzene and toluene cyclic alkanes?

A No, they are not. They are aromatics.

Q Can I direct your attention to the next article in that textbook, which is marked (not understood)?

Would you read the title of that one?

A "Microbial Transformation of Aromatic Hydrocarbons."

Q Would you just flip through that and take a look at it, because I've looked at both of those very carefully and I wonder if that Cerniglia (sic) article is the one that you were actually citing? I think I recognize a few of the pictures in there and the references they used having your Figures 1, 2, and 3.

A Yes, I believe you're right. You're right. It was from the Cerniglia (sic) article.

Q And not --

A And not Perry. That is a mistake, right. But the information is still the same. It's just an improper citation.

Q Yes. Well, we would correct that in the record. The author of that article is C. E. Cerniglia, C-E-R-N-I-G-L-I-A.

MR. CARR: Mr. Stamets, we'll certainly stipulate that if we've got the incorrect citation to that chart, that that can be corrected.

MR. STAMETS: We'd appreciate it if before the hearing concludes that be corrected in our copies of the exhibit.

Q And those Figures 1, 2, and 3 attached to your essay, they come from that article?

A I'm not sure which figures you're referring to.

Q Figures 1, 2, and 3, the aerobic pathways of toluene.

Figure 1 I think you said came from your own research.

A Yes, Figure 1 --

Q The other two --

A -- is my research, right.

The other two are directly from that.

Q Isn't it true, then, in Cerniglia's conclusions, he states, quote, little is known if these reactions occur under environmental conditions?

A Yes. By his research most of this information is from laboratory studies and they're well known degradation pathways, but it is another matter to extrapolate this specifically to the subsurface environment, or to the environment in general. It's very difficult because these metabolites often occur at levels that are below our capability of detection under environmental conditions. So that's why we have to do it in the laboratory.

Q With the caveat that they may or may not occur environ -- under environmental conditions.

A Right. We would -- we would expect that and we have -- we're attempting to document that but we haven't been able to document that these are the pathways that actually occur in our samples. Right, that's one of the subjects of our current research.

Q In your references (19) and (20) and the evidence for anaerobic degradation, isn't it true, however, that in both of these studies benzene was not observed to be degraded significantly, if at all?

A Yes, I believe so, in both of those studies it was not observed to be significant. Again I'd have to refer to the communication of my student and the fact that there's a long adaptation time under anaerobic conditions.

MS. PRUETT: We would make the same objection to this communication with the student.

MR. STAMETS: If you did, we'd make the same ruling.

Q In reference number (20) it was demonstrated that sometimes microbial transformation (not under stood. Isn't that true?

A Yes, that could be true.

Q Okay. In the last paragraph of your abstract you state that the rate of degradation of benzene and toluene and other organic pollutants is quite rapid, but in fact you've presented no data other than the special laboratory situations showing the rapid degradation of benzene and toluene, isn't that correct?

A Yes. I didn't present any field evidence in my studies. The rest of the, you know, I could talk about other studies that have shown rapid degradation but I didn't show -- present that in this exhibit.

Q And the authors of your only real life study, the Reinhard and Goodman study, advocated a site by site analysis of the effects of biodegradation.

A Well, I would -- I would not agree that they are the only real life study. I --

Q Do you know --

A -- think all these are real life.

Q -- I'm sorry.

A Because they all use -- well, most of these, if not all of the articles, use actual aquifer material, real environmental micro-organisms that do occur showing --

Q Yes, but the only one, the only study that was done in field conditions.

A Right. So state your question again.

Q The authors of the only field study, Reinhard and Goodman, advocated site by site analysis before predicting the effects of biodegradation.

A I would say that they're not the only one that was a field study because in many of these we go out and we -- in the field and collect material, so it's field and laboratory combined study, and theirs was probably the only one that was totally conducted in the field.

Q And did they not advocate site by site analysis? I would direct you --

A Okay.

Q -- to their --

A Before I say they did, I'd like to see it.

Q -- to their first sentence on the lateral distribution paragraph on page 955 where they state, the principal attenuating processes for an organic compound, dispersive dilution, sorption, and biological degradation cannot be evaluated individually in the absence of mass balance data, indicating both dissolved and sorbed concentration as a function of time.

On the basis of water concentrations alone, data interpretation is ambiguous...

A I still didn't see where you read that from.

Q Page 959.

A 959, I'm sorry. Okay. All right. They

indicated on the -- only in the absence of mass balance data, right, that that would be true.

Q I wanted to turn back to your comments on Dr. Rene Schwartzman.

A Schwarzenbach.

Q Schwarzenbach, thank you. I remembered Switzerland.

Did you discuss with Dr. Schwartzman the method of sampling used?

A Yes.

Q I'm a little confused about Mr. Kellahin's quotes from Dave Boyer on the aerobic, anaerobic environment. Was that from page 84? Because I want to ask -- reread that and see if you agree with his statement starting a little earlier than Mr. Kellahin started, and I'm starting at line 20.

Degradation, but, in other words, usually bacteria can act on this stuff in an aerobic environment.

A Right.

Would you agree with that?

But then at line 24 he states, in an anaerobic environment it's a different story and degradation occurs, only occurs slowly in anaerobic environment.

Would you agree with that statement?

A I would agree initially that that's true until adaptation occurs and then it's very rapid, and in this type of a case, if anaerobic conditions were to occur in the -- in the pit area, I would expect that there would be a period of acclimation certainly less than a year, I would expect, and then there would be rapid degradation of these compounds.

Q You were asked whether a concentration of 3.5 milligrams per liter I think of benzene at 5 barrels per day appeared not to be enough to overwhelm micro-organisms. Can I assume from your statement that a higher concentration might?

A The only times I've seen where it has has been much, much higher. Most of the cases I'm aware of where there has been an overwhelming, it's been a spill of gasoline or -- or large amounts of hydrocarbons, like several hundred gallons, or thousands of gallons. In that case, it would overwhelm the system.

Q Produced water contains not only benzene but many other chemicals that could work on the depletion of oxygen.

A That's true.

Q So a volume exemption without site specific information on concentration and numbers of chemicals present may not in fact provide site conditions where micro-organisms are overwhelmed.

A I would say that from what we know, that it seems that there is a reasonable level that we should be able to arrive at where there would be a volume that at the given concentrations that's low enough, and without evidence that the system has been overwhelmed, I don't see how we can, you know, it seems to me that the preponderance of the scientific information is that -- that these mechanisms do attenuate and are adequate to protect the environment.

Q But without evidence of the concentration level, you can't say that for a -- for a fact.

A Well, we do know what the concentration levels are, so I don't know exactly what you mean.

Q We do in specific cases, site studies, but we don't know every produced water pit in the San Juan Basin.

A That's true. Nobody has gone out and studied every pit, to my knowledge.

Q Thank you.

MS. PRUETT: That's all.

MR. STAMETS: Other questions? Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Dr. Miller, were the static flask tests that were used on benzene and toluene biodegradation similar to the hydrologic conditions in the San Juan Basin?

A No, not at all. They only indicate the potential for degradation of benzene and toluene but the types of studies that -- that we have conducted and were cited in the other materials would be similar to the conditions that would occur in the Basin.

Q I beg your pardon, the last part you said, what would be similar to what occurs in the San Juan Basin?

A The other types of studies that were mentioned point -- point three, mainly point three, aerobic degradation of benzene and toluene and related organic chemicals occurs in the subsurface.

Q Dr. Miller, in the type of inductive reasoning that's used when going from laboratory conditions to actual environmental conditions, isn't there a rationale that would dictate or demand that some site specific data be available before you would deduce from laboratory experimentation?

A If it was purely a laboratory study, yes. In our studies we took material from the field, brought it into the laboratory. Of course --

Q From the San Juan Basin?

A Not from the San Juan Basin, from throughout the country.

Q Do you believe that nine samples throughout the United States would be significant enough to give you a better than ninety percent chance of certainty or correlation with the San Juan Basin?

A I would say when all the studies indicate the same thing that that's pretty strong evidence. We don't have evidence to the, you know, contrary. If it was 50/50, then that would be different, but these -- these experiments are very time consuming and costly. Like I said, my own study funded at -- at $850,000 alone. So, you know, in the time that we've had.

The Tabak report, if I get the dates on it correctly, occurred in 1981, so only in 1981 were we really starting to address the question are these chemicals degradable in the environment.

So it's only been since 1981 that we've had time to go out and do these experiments, and at all the sites we've looked at since that time we found consistent results.

Q So the experiments that Tabak did, would that be more relative to, say, the single chemical, or say, benzene spills, than it would be to the continual condition of benzene in the system?

A I don't know if I'd say more relevant. How I used this paper is to indicate the potential for biodegradation of these contaminants in the environment, and then the need is to go to more, you know, the particular type of environment that you're concerned with to examine those chemicals in that environment, and that's what I tried to show in the remainder of the points that I made; that we did indicate the potential for the biodegradation of these things and then went to actual subsurface material to demonstrate that it occurs in the subsurface.

Q In a single discharge incident but not in a continual charging incident.

A We -- I used both static and column experiments and mixtures of chemicals, as well as chemicals singly experimented.

Q Would there be a point at which the stabilization would be reached that all the microbes would be eating all the benzene that they could and yet there'd be benzene bypassing them to a certain extent?

A I think that that's -- that's possible, yes.

Q Are you familiar with any incidents where there is or has been benzene and toluene or any other petroleum products polluting groundwater?

A Yes.

Q Under those situations would there be conditions existing that did not allow the biodegradation to take place over a certain period of time?

A The only cases that I'm aware of where that has occurred is when there was large volumes and rapid release of pollutants in usually pretty highly concentrated forms, much higher than anything we're talking about here.

Q We've been hearing a lot of words like "rapidly", "large amounts", and "certain periods of time", is that the study you're working right now to develop the idea of quantification of times, strengths of biodegradation of these materials?

A That's true. We're further -- further identifying the rates and the quantities, but what I mean by large amounts, I'm talking about large spills, like -- like gasoline storage tanks, thousands of gallons released in a matter of hours; most cases where the system is overwhelmed.

Other cases where gasoline storage tanks appear to be leaking pure gasoline, let's say, five or ten gallons per day of gasoline itself, then -- then the system can become overwhelmed.

Q Do you have any comments as to the biodegradation that may have taken place in shallow oil reservoirs that are located 100 feet, shallow, would they be subject to biodegradation?

A It appears that in those -- there is a potential for some biodegradation there, although it appears that in that case the concentrations are limiting and the environmental factors are limiting to biodegradation, and -- but there's a lot of discussion on that matter.

Q What happens to the oxygen that you say is in the ground once the materials start entering the ground and start the biodegradation process?

A It's one of the -- it's utilized in the biodegradation process under aerobic conditions.

Q So after a time period, then, the oxygen would be eliminated?

A I would be eliminated if there's no further addition of oxygen and the concentration of the organics is in excess of the available oxygen.

Q Are you familiar enough with the hydrology in the San Juan Basin to say whether or not there would be additions of oxygen to the system?

A I would think that, yes, the groundwater recharging the area would -- would most probably contain additional oxygen, although that recharge rate is probably fairly -- fairly slow, and then the oxygen contained, or the water from the pits would also contain oxygen and promote an aerobic environment generally.

Q Would there be conditions existing -- well, let me put it this way.

What conditions would have to exist before you would recommend that, say, Northwest Pipeline, your client, not install an unlined pit in proximity to a water well?

A Well, I haven't -- that's really not my -- my task to make that kind of recommendation here.

Q No, but what criteria would you consider should you be asked a question like that, hypothetically.

A Well, hypothetically, if you press me on it, I would say first of all there needs to be direct evidence that -- that there is contamination of water wells and secondly, that -- that the water wells are in very close proximity to the pits. I hesitate to say exactly what I mean by "close" but I would say that if the water well is more than 100 yards, I would think that that is likely to be a pretty good safety factor.

Q In your recommendation with regard to

pollution under direct examination you said you thought that small -- discharges of small amounts of produced water posed no danger to groundwater.

Is that conditioned upon your knowledge of the depth of groundwater in the San Juan Basin?

A I don't know what you mean by conditioned upon that.

Q Well, I'm trying to get --

A From what I know about it, yes.

Q I'm trying to get back to my previous question.

Before you would recommend that a pit not be installed or a well not be drilled, would you have to know how much water, produced water, was being discharged to the pit, the amount of benzene, toluene, other constituents, the depth of the groundwater, the microbiclogical analysis of the soil beneath the pit, and this type thing before you would recommend that a well be drilled or not be drilled near a pit?

MR. PEARCE: Excuse me, just a minute, I apologize, I did not understand that question.

Are we talking about him recommending whether or not to drill a water well?

MR. CHAVEZ: Drill a water well or install a pit, either one.

What type of pit?

MR. PEARCE: Well, you're asking the question. You choose.

MR. CHAVEZ: Okay.

Q If your client wanted to drill a water well in proximity to a pit, for water production, would you evaluate the distance to the depth, the distance of the well from the depth of the groundwater and the type of microbes, do a microbial analysis of the ground before you would make the recommendation to him?

A I don't think it would be necessary to evaluate the types of micro-organisms that were there.

I think if the pit was in the groundwater that might be of concern, but if -- if it's not intercepting the water table, then I don't think that that -- I think that degradation processes that occur in the unsaturated zone, that continue to occur in the saturated zone, would provide adequate safety.

Q Even if the pit was -- had 10 barrels of water a day put into it at the --

A Well, I'm talking about, yeah, again, the types of concentrations that, you know, we've been hearing about and the -- in the range of let's say 5 barrels per day.

You know, just -- not scientific opinion, but my own just personal judgment, I would say that that seems reasonable.

Q Even if the water table was one foot below the bottom of the pit?

A There would be a very active zone of degradation there that possibly might be adequate; that's difficult to say 1 foot, you know, give or take an inch.

But if it was -- I would say it would be of concern if it intercepted the pit.

Q What conclusions do you draw about the effects of biodegradation from the evidence that was presented in the last hearing by Dr. Zaman?

A You mean the excavation that he undertook?

I don't -- I don't see anything that contradicts in what he said because he didn't demonstrate that there was contamination from the pits, in my opinion.

Q But there was benzene, toluene in the groundwater a distance from the pits.

A He -- he presented -- he did not use good sampling techniques or sample handling techniques in collecting those samples and in transporting them to the laboratory and the method of excavation, the contamination could have occurred during the method of excavation, if you want to, you know, press me on that, so I -- I can't say that the benzene and toluene came from the pit. It could have come from his backhoe. It could have come from some other source in the area.

So it's difficult to draw conclusions from that.

Q If it came from any other source besides being introduced by the backhoe, what conclusion would you draw?

A I can't draw any particular conclusions because I wouldn't know the concentration that it was being introduced and from some other source, and I wouldn't know what rate it was being introduced.

MR. CHAVEZ: That's all the questions I have.

MR. STAMETS: Any other questions of the witness?

Mr. Taylor.

CROSS EXAMINATION

BY MR. TAYLOR:

Q I just have a few questions for you, Dr. Miller.

Starting out with your first page of Part 6 of the exhibit, your first paragraph says that benzene and toluene are readily biodegradable by micro-organisms.

Are they equally biodegradable?

A Well, by looking at the Tabak paper, it appears that the -- in his study, that the, as I indicated, that toluene is more readily degradable under aerobic conditions than benzene.

Q In the article by Tabak was the degradation of benzene and toluene considered aerobic type degradation?

A Yes, I believe he considered it to be aerobic.

Q Then would you consider the results to be reflective of what would occur in anaerobic conditions, especially with the rate of degradation?

A No, I didn't try to say that it would be.

Q In the article by Wilson it was maintained that aerobic degradation occurs in the groundwater. Does this degradation rely on a monod or Michaelis-Menten type of rate relationship with respect to oxygen, and given a constant nutrient source, such as benzene, and a limited supply of oxygen, would the degradation rate deline over time?

A I could ask you to explain it, but their information doesn't address kinetics.

We're -- that's the subject of our current research to define your question.

Okay, they just measured the rate of disappearance but they didn't define the kinetics and you're trying to ask which type of kinetics it was and that hasn't been defined.

Q Would you care to comment -- I don't know since your answer wasn't really yes or no -- but do you care to comment on the magnitude that aerobic degradation would have in a saturated zone where a pit would supply large amounts of benzene or toluene to the saturated zone daily but only small amounts of oxygen?

A Well, that's a hypothetical case that -- that if that were to occur, then -- then it is possible that the degradation possibly could exceed the oxygen concentration, but we must keep in mind that the transport in most subsurface environments is very slow, so there's a long residence time, and there is a consortium of micro-organisms that exist.

So -- so that's a hypothetical situation I'm not sure exists.

Q Do you know what the transport time is in the San Juan basin?

A No, I don't, haven't measured it.

Q Could it be that if the transport time in the San Juan Basin is faster than the average -- or faster than most, at least, in the example that you cited, that these models would not hold?

A We -- I studied similar type material with rapid, fairly rapid transport, and found rapid degradation within a matter of 18 inches in my laboratory columns, so essentially complete degradation within about 18 inches under fairly rapid transport rates of about 2 inches per day transport, so I -- even in the saturated zone I would expect pretty rapid degradation even under fairly rapid transport rates.

Q Would the micro-organisms have a preference for straight chain compounds over aromatic compounds, and how about a preference for phenols over benzene?

A Some micro-organisms might, but I would expect that, yeah, they would have some preferences for, like for example, phenol is very rapidly hydrolized and biodegraded in the subsurface environment.

Q Then if the produced water had large quantities of straight chain compounds or phenols the rate of benzene degradation would be decreased.

A Not necessarily because there is the process called secondary utilization or secondary metabolism where actually the combination of chemicals can -- can result in an increased rate of metabolism versus if there's only one compound that exists.

So it's not necessarily the case.

Q But it could be the case.

A I've never -- I don't think I've observed that. I'm not sure of anybody -- of any evidence of that.

More commonly there's the secondary metabolism or secondary utilization, the co-metabolism concept that occurs.

Q Have you actually done any rate modeling on discharges of 5 barrels per day with 20 parts per million benzene concentrations with respect to biodegradation, and if you have, have you compared these to actual field data or to the studies that you've cited?

A That was the last point in my testimony that I was making, is that the models do not exist to accurately do that; that we are trying to develop those.

The models that exist don't accurately account for biodegradation in the subsurface and we're trying to modify some models and incorporate accurate microbiological processes at this time.

Q You mentioned that adaptation to anaerobic conditions is required. Does this mean that during this period of adaptation biodegradation does not occur or at least is not a major contributor to attenuation?

A I would -- I would -- that's hard to say. I don't know that there's enough evidence to say one way or the other on that.

I would -- I would speculate that there would still be some small rate of degradation that would occur, but it's hard to say what that rate would be.

Q How long does this adaptation period take?

A It can take anywhere from a couple of weeks to -- to multiple months; maybe a year in some cases, although, as I said before, that we've been surprised to date that the acclimation period was less than what we would have predicted by our surface microbiological studies.

Q What happens to benzene and other organic hydrocarbons during this period of adaptation?

A Well, the other attenuation mechanisms will continue to play an effect and there may still be uptake by micro-organisms and not degraded, but we're still studying that.

Q Say we go back to our example of 5 barrels a day every day, and we're in an anaerobic environment, what's going to happen during the ten or eleven months that it takes for that environment to come around to those 5 barrels a day --

A Well, you're assuming an anaerobic environment and I'm not sure --

Q Yes, I am, and I want to know what's going to happen in that -- in that environment during that time.

A Well, I'm not sure that an anaerobic environment would exist so I don't think it's --

Q Do you think there --

A -- necessarily pertinent to this.

Q Do you think there may be no such thing as an anaerobic environment?

A Sure there is, but not under these conditions necessarily.

Q Let's see, if long adaptation times are required for anaerobic bugs to be established, what effects would changing conditions have on the time to get anaerobic organisms established to survive?

A I don't understand the question.

Q Well, let me give you an example of a changing condition to be high flow of produced waters during one part of the year and not during other parts of the year; high flow during the summer and then no flow during the winter, very small flow.

A We're studying a landfill site that exactly exhibits that and once the organisms have been adapted, they've been exposed to pollutants during one season, they've adapted, the next season comes along, they've readily adapted in a matter of days.

So their adaptation rate in subsequent seasons is very rapid under anaerobic conditions.

Q So you don't think this would have detrimental effects? I don't understand these organisms, but for instance, if there were a lot of them that adapted during the summer season and then there was no produced water coming through, or very little, during the winter season, they wouldn't die off or disappear?

A That's right. They seem to undergo maintenance, you might say, during that time, and to very rapidly reactivate their metabolism.

Q So there would be no period the next year of having to re-establish.

A It would be a much shorter period, very short period, from all the evidence we have to date.

Q Could a combination of these various conditions we've been talking about prevent degradation from occuring under the optimum conditions presented on your models?

A Under the optimum conditions presented.

Q While you're --

A It is conceivable that something could happen to --

Q Right. I mean your models seem to say that there's -- essentially you said during the last part of your direct examination that there is -- we don't have to worry.

MR. KELLAHIN: Mr. Chairman, I'm going to object to that question. I've resisted for some time and I can resist no longer.

An expert is not -- it's not appropriate to address a question that calls for this expert to speculate.

He is to be addressed questions on the reasonable probability of occurrence of some given facts or circumstances.

Mr. Taylor has asked this witness whether something might possibly happen under some conceivable set of circumstances which Mr. Taylor is unable or unwilling to describe. That calls for a speculative answer by this expert and it is not appropriate it.

We object to it.

MR. STAMETS: Mr. Taylor, will you be more specific?

MR. TAYLOR: Mr. Chairman, I don't think I was speculating. I was asking the witness if the models that he has presented to us are always going to work and whether that's speculation or not, I don't know, but he's saying that he's got this model and under various situations degradation is going to make it such that benzene and other organic hydrocarbons are not going to reach the water table, and I'm just asking him if under all situations this was going to work.

He has not told us what specific situations it is going to work under, but I'd like to know if it's always going to work.

MR. KELLAHIN: That is my exact objection. This witness does not have to testify that a model will work under all situations.

He needs to be asked the question what are the situations in which the model is tailored and what is the reasonable probability of that model working to some reasonable degree of accuracy in a given fact situation.

We're still speculating.

MR. TAYLOR: Mr. Chairman, I guess we don't need to argue about this because my whole point is that we really don't know. These models are merely laboratory models and what we want to know is about the real world in the San Juan Basin and what's going to happen, so I'll withdraw that question.

MR. ELMER: I don't think the Chair has made a ruling yet.

MR. STAMETS: Since the question was withdrawn, we won't.

MR. TAYLOR: I think that's all the questions I have.

CROSS EXAMINATION

BY MR. STAMETS:

Q Dr. Miller, you have used the words "may degrade" and I presume "may degrade" also implies may not.

A I'm not sure which exact context you're referring to.

Q Well, many, many times in here you've talked about benzene may degrade under anaerobic conditions. Toluene may degrade under anaerobic conditions.

You have not said it will degrade and I'm concerned about that, whether or not may implies that it may not.

A There is a limited implication there but what I -- the reason I've said "may" is because -- because we have had limited experience with that. The techniques have only recently been developed for studying anaerobic conditions in subsurface material.

Okay, as I said, we only started addressing this about 1980 and we've concentrated most of our efforts on the aerobic environment until about the last year, and under anaerobic conditions there is mounting, increasing evidence that these types of chemicals are degradable, but we haven't studied a wide variety of aquifer material from across the country and -- but some of the material we have studied from alluvial aquifer material in a landfill in Norman would indicate that these are degradable under hathanogenic and other anaerobic conditions, given, you know, the micro-organisms appear to be adaptable to them over actually a shorter period of time than we initially expected them to be, and so there is some indications that -- that degradation of these can occur under anaerobic conditions but there's a lot more research needs to be -- be done to say, yes, it will occur in all cases.

Q Can I paraphrase that by saying this is an area of science which is immature and there are fewer certainties?

A And there -- what was the last part?

Q Fewer certainties?

A Fewer certainties? Fewer certainties than the aerobic, yes.

Q I believe that the record does indicate that we have had one, at least one case in the Flora Vista area where a municipal well was contaminated by benzenes and other organics. There doesn't seem to be a whole lot of cases in an area as large as the San Juan Basin, but do you believe that that does indicate that it can happen?

A I don't know enough about it to say. There may be multiple sources. Maybe not at these pits, but other possible sources. In that case, I've seen cases where a person changing oil on their driveway lets the oil run off and it contaminated their own well, and so without direct evidence it was from a pit, it's hard to say, and I don't know enough about that case to say that that's evidence that these pits contaminate drinking water supply wells.

Q Conversely, do we need that degree of evidence to prove that these pits are not a problem?

A Are you saying do we need to have evidence that there's contamination before we -- or --

Q Oh, now, I think that in the case I cited that you indicated a lot of things could have happened there and we just don't have enough information to say that that is for sure the reason that this well was contaminated, and what I'm asking you is, is the reverse true? Do -- do we need some empirical demonstration that in fact in the San Juan Basin the organics that are being produced with fresh water, with the produced waters there, are being catalyzed, converted, are not a problem?

A I think that the preponderance of the scientific evidence is that when we consider all these six mechanisms, that I would, you know, not expect there to be a problem from these pits unless there was for some reason, you know, specific evidence that indicated otherwise.

Q Dr. Miller, would it be possible to take some selected sites in the San Juan Basin and do some empirical studies to determine whether or not organics are being converted, catalyzed before they could reach usable groundwater?

A What do you mean by emperical studies?

Q What I'm talking about is taking a pit and drilling a well downstream from it, taking samples, both of the produced water and then groundwater samples throughout?

A Sure, that would be possible. We have the technology to do that.

Q Would that be better than -- than the last study?

A That would be, yeah, that would be desirable to have some of that, too. It's not -- that's a major amount of effort involved, but that -- that would be additional evidence.

Q In a situation where we have groundwater occurring from depths of just a few feet, maybe four feet, perhaps even less, to fifty feet in the vulnerable area, would several such studies need to be done to sort of run the whole gamut of possibilities?

A It depends on -- I would, if I were designing this study, I guess I would design it in stages and depending on the results of the first study, might indicate whether further studies are needed.

I would investigate the -- in what we might say the worst case conditions first and then if there was any evidence of problems in the worst case condition, then we could go to the -- to the next level of concern.

Q I believe you heard Mr. Kellahin discuss the real crux of the -- of the argument at this point is this so-called small volume exemption. How much, what is the minimum amount that can be allowed to be produced and disposed of on the surface?

Do you have some recommendation as to a minimum disposal volume?

A Well, I hate to make a recommendation but I would state that from what I've studied and from my own research that it just seems reasonable in my opinion that at these concentrations and at 5 barrels per day, it seems reasonable.

In the absence of any contradictory, specific evidence showing, you know, direct contamination or widespread contamination, it seems like a reasonable small volume exemption to make.

Q Let's talk about the adaptation of the micro-organisms.

Let me ask you if this is what you're talking about. We've got a group of micro-organisms here that are used to eating McDonalds and they live on McDonalds, and some day a truck drives up and is full of -- well, let's -- Long John Silver's fish, and these micro-organisms initially don't much care for Long John Silver's but they begin to develop a taste for it, and given a length of time they will be able to eat both McDonalds and Long John Silver's?

A I think that would be, yeah, one example of a type of adaptation.

Q We keep hearing the phrase "the real world", "the real world", "the real world". What is the extent of your study of the San Juan Basin, its hydrology and formations and soil types?

A Only from reading about it. I have not ever collected a sample in the Basin or drilled a well myself in the Basin.

Q So based on your testimony, do we have in the record a real world analysis of what is happening in the San Juan Basin?

A I think we do in the sense that we studied the same types of material and same types of chemicals of similar concentrations. We used actual aquifer material. We didn't use, you know, sand or we didn't use soil material or some synthetic material. We used actual aquifer material, similar composition as would occur in the San Juan River Basin, and the same types of chemicals.

So I think it's about as real world as you can get without actually going out, you know, to the San Juan Basin and doing it, but I would expect the same types of results. I don't have any reason to believe that we wouldn't see the same thing.

Q If we had this theoretical pit out there which was receiving 5 barrels of produced water per day, let's just say that the groundwater was at 5 feet, how long a time would it take before we would have a real world demonstration that in fact the theories put forth here today are working in the San Juan Basin?

A You mean if we went out and actually collected samples and did some research?

Q Yes.

A I would -- I would say that based on my current research that it would be something like eighteen months of field and laboratory work.

Q How many dollars?

A Well, my current research, that would constitute about half my current effort, so it would be in the neighborhood of $400,000 to $500,000, for one site.

MR. STAMETS: Any other questions for this witness?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Dr. Miller, can you state that your client's wells are not introducing benzene and toluene into the groundwater in the San Juan Basin?

A I cannot state that with certainty, but what I can state, that even if some is getting to the groundwater, that degradation of those chemicals is most probably occurring even in the groundwater.

Q But you cannot say --

A With certainty that there is none anywhere, because I haven't sampled them all.

MR. CHAVEZ: I have nothing

more.

MR. STAMETS: We'll take about a fifteen minute recess.

(Thereupon a recess was taken.)

MR. STAMETS: Any other ques tions of this witness?

Mr. Shuey.

QUESTIONS BY MR. SHUEY:

Q Thank you, Mr. Chairman.

Dr. Miller, for give me if I mis-heard or let's say you mentioned during the establishment of your credentials you were calling off things you've done.

I'm interested in the studies you repeatedly said during your testimony and cross examination, you called "we" or "our" studies, and I took that to mean those which you said you had done yourself.

I'm wondering if we go to your bibliography of your testimony here, I see one reference in that list of twenty references, Number (7), that has a G. D. Miller. Is that you?

A Yes.

Q Are there any other references in your list which you apparently overtly participated in and by that I mean that which has your name in it?

A My name is not listed as the author of several of these but I participated in the research of several of these, collaborated with several of these researchers.

For example, the first one, the second one, third one, sixth one, seventh one, the eleventh one, thirteenth one, fifteenth one, sixteenth one, nineteenth one. I've worked with those researchers and collaborate with them.

Q If we were to go and obtain some of these documents, would we find any reference to you having participated in them?

A No, I didn't help write those.

Q Okay. Correct me if I'm wrong, but I believe you said in connection with the Wilson and McNabb paper that you had helped collect some of the samples?

A Yes.

Q Okay, and then I believe that on your reference (7) that was one of the references in which you say in the second paragraph of your paper that activities of subsurface micro-organisms have been detected, so I gather that you looked at some subsurface material and the little bugs inside it.

A Yes.

Q Okay. Now, on Wilson and McNabb you helped collect those samples, correct?

A Yes.

Q Okay. Did you help perform any of the analyses?

A Yes.

Q All right, now which ones did you --

A I have studied -- my work has been primarily at the Pickett, Oklahoma site and the Lula, Oklahoma site.

Q Is there any place in this article by Wilson and McNabb in which your participation in the study is documented other than where we have your name?

A No, they didn't document it in this report. Specifically I've looked at the chlorobenzenes. It was my research they used in Table 2 for the chlorobenzenes and the phenol and alkyl phenols and the chlorophenols.

The reason --

Q Your research did not include the alkylbenzenes.

A My own specific research included toluene. It hasn't included benzene. It has included styrene.

Q Thank you.

I believe you testified a couple of times that the materials that Wilson and McNabb and yourself worked with in these studies, and partacularly the Wilson - McNabb study, were similar in composition or physical characteristics to those in the aquifer that the Committee has described, is that true?

A Right, it's alluvial material of relatively shallow water table and low organic carbon contents.

Q Is there any information in the Wilson - McNabb article that indicates that composition?

A I don't recall if they did that, they included that. It may be in there.

Q If did not have your testimony here today how would I be able to tell what kind of materials those gentlemen sampled?

A It's published in some other reports that I didn't bring with me but I could furnish those.

Q Have you conducted a -- any field study of -- let me drop that.

I believe in Wilson - McNabb's article it says in the second column on the first page, talked about the core material from several shallow water-table aquifers and associated material from the vadose zone, and I just believe that you have said that you worked at the Pickett site and the Lula site.

Could you just -- could you describe what those materials actually looked like or what their composition was?

A It's a fairly uniform, sandy, brown sandy material. At the Pickett site there's a little bit of gravelly material associated with it. It's predominantly just a brown, sandy, medium-grained sand, with a small, you know, trace amounts of clay and organic carbon content, but predominantly just a sand material.

Q Now you said that you think that the material in the San Juan River Valley is similar to that material you've described.

A What I would expect in an alluvial river basin.

Q You expect; do you have any direct knowledge?

A I've never been to the river basin to see it, right.

Q Have you ever conducted a study on the properties of these bugs being able to degrade or eat benzene and toluene under a pit in the San Juan Basin?

A No.

Q I believe you testified that you -- that a foot of material under a pit, you had characterized that as the treatment zone or active zone of treatment.

How -- have you ever taken some of that material that is under, typically under the pits that we're talking about, and done the same kind of laboratory tests these authors and yourself did to determine if these bugs eat these benzenes and toluenes?

A I just said I've never done it at those pits, so I answered the question, I think.

Q Okay, so the active zone of treatment, the treatment zone, has occurred in some of the research, but you don't know if it's occurring under one of these pits.

A We have observed it at field sites, under field studies. By "we" I mean myself and my fellow researchers at the National Center for Groundwater Research.

We've observed it at field sites, okay, active zones of degradation that were the length of about a foot or maybe a foot and a half in length, where there was, you know, almost complete degradation of everything across that zone, and it was a similar type material, but I don't know of anybody that's gone out to this basin and done that.

Q Under pits, is that what you were just talking about?

A Yes, it was under a creosote pit in this case.

Q A creosote pit.

A Right, same types of compounds.

Q You were -- I believe Mr. Chavez asked you some questions about Mr. Zaman's study. You were here for --

A For his testimony, yes, on April the 3rd.

Q You said that his study to you didn't demonstrate as to any effect from the pit around which he dug the test holes or not, but there's any number of different factors that would cause you concern.

At least you mentioned the backhoe. What -- why would the backhoe have been of any concern in that study?

A Just oil and grease that could either be on the backhoe itself or leaking from the backhoe.

Q Uh-huh, did you hear Mr. Zaman's testimony regarding his inspection of the backhoe?

A I don't recall what he said. I heard his testimony.

Q You said that there could be a whole range of different sources for those kinds of materials in that area. What -- what could those have been?

A Could have been anything. Could have been somebody's gasoline tank that was leaking from their car. I mean you can speculate anything.

Q Okay. All right. Now I'm going to ask you your professional opinion. I'll do it the same way that Mr. Kellahin did.

Let's assume for instance that we have a pit that's sitting there, okay, and it does receive one to two barrels a day and the benzene concentrations are typical of those that we've seen in this hearing in the evidence, and that this particular well, oil well that received the produced water did not a reserve pit or mud pit next to it, and there are no --no cars have been in the area to be leaking gas, and that the tractors involved did not have leaking oil or leaking hydraulics, and if someone went out and dug several test pits and found benzene and styrene at distances from 45 to 235 feet from the produced water pit, if there were no other sources for those materials, where could they have come from?

A That's exactly the difficulty with doing field work, because you cannot eliminate other possible sources, and so there -- that's a hypothetical case that we can't -- can't ever say whatever occurred.

Q Then I'm puzzled about how the Commission may make a decision in this case, because I believe you testified earlier that you needed -- the field investigations would be an important way of determining the effects of this pits.

A I said that it would be added evidence.

Q Added evidence. And I believe you said that in relation to a question by Mr. Chavez, you said there may -- I quote, I wrote it down here, "There needs to be direct evidence of contamination of water wells."

With all these uncertainties involved, how could we ever obtain that direct evidence?

A It would require going out at a -- in the field, okay, and doing a series of sampling from a pit, all the way to, let's say, where there would be completely disappearance, you know, no evidence of any contamination, under very controlled conditions.

But on top of that, you know, we'd need to survey all the other possible sources in the area and indicate that if we found any evidence of benzene and toluene that was actually from that pit, not from any other pit, we'd need very good, accurate hydrogeological studies of the area to show that any contamination, if it was found there, hadn't migrated from some other source, and ideally maybe some tracer studies.

So you're talking in that case more than half a million dollars in eighteen months for a good study.

Q But you as an expert, if you conducted that study and have eliminated all other sources and did your tracer test and came -- could you come to the conclusion, all other sources had been eliminated, could you come to the conclusion that the pit was the source of contamination?

A I guess, yes, if you eliminate all other possibilities and there was contamination, but it's purely hypothetical.

Q I believe when Mr. Stamets was asking you questions you, one of you or both of you, characterized what you did describe for me as a worst case, is that correct?

A I'm talking about a worst case being something where, let's say, the pit was in the groundwater. We might start examining those first. That to me would be the worst case, and high volumes and high concentrations.

Q The type of study you described for me, though, half a million dollars, in your experience as a researcher, government contract, Federal government contract, is that a level of -- is that a level of money that involves -- well, how often is that amount of money provided to researchers such as yourself, or researchers such the experts for the industry or for the OCD?

A Very rarely. I'd say that my research project is one of the largest in this area in the country. There's only one that just started that's larger than that, and it's looking at the transport and fate of one chemical in a field monitoring study.

That's a multi-million dollar research project.

Q Would it be reasonable to, in your opinion, would it be reasonable to expect that an organization like the Oil Conservation Division could, or for that matter, any agency of State government in Mexico to be able to afford a $500,000 study?

MR. KELLAHIN: Objection, Mr. Chairman, there's no proper foundation laid to show that this witness is capable of answering that question.

MR. SHUEY: Well, Mr. Chairman, I think he has testified that that's his estimate of what it would cost. I'm asking him his experienced opinion given that he's gotten grants from the Federal government if that -- if that level of funding is capable for State government.

MR. STAMETS: I think that, Mr. Shuey, we'll allow the newspapers relative to the last Legislative session to answer that question and not require this witness to.

Q All right, thank you.

You said -- you testified earlier, as I

remember, in response to a question by Mr. Stamets that you thought that 5 barrels a day sounded like a reasonable regulatory level. Why is that reasonable?

A I think it's reasonable because of the -- all the scientific, you know, testimony that's been presented; that there are retardation, attenutation, dilution and degradation mechanisms in place that will, you know, be what we might call safety factors for these in the subsurface environment, and there hasn't been a preponderance of evidence that is an actual problem in drinking water wells.

Q Has there been evidence that those factors, contrary to your opinion, may be not as important, the retardation and biodegradation and those avenues that you and Dr. Schultz have testified to are (not understood) maybe made just like the -- just like the mechanisms that Mr. Boyer described, or (not clearly understood.)?

A I think on the contrary, that they're very well established mechanisms and widely -- well, there is wide recognition of these among the researchers in this area and the recognition of these, especially I'm referring to biodegradation is growing rapidly throughout -- throughout multiple scientific disciplines.

The geophysical -- the geohydrologists had a convention in California just recently, had a whole session devoted to this subject.

The American Society for Microbilogy just had a whole session devoted to biodegradation of these things in the subsurface environment.

So the recognition is coming very rapidly in a wide range of disciplines.

Q But there's still a large degree of uncertainty involved in all this, isn't that true?

A Well, I -- yeah, there's a large degree but there's also a large degree of certainty.

Q Okay, one final question is a hypothetical question, too.

I believe you testified that -- that, oh, yoiu thought that if a water well was 100 yards away or more that that would -- from a pit, an unlined pit, that that would not bother you.

Let's assume that this water well, let's assume that this pit is unlined that we talked to -- or talked about, and let's assume that the groundwater level was five feet below the pit and this groundwater level extends for -- over an area much greater than 100 yards from the pit.

If -- let's say someone came in and wanted to drill that water well and they could only afford a water well that was screened to take advantage of the shallow water table. They had no other source of water.

Let's further assume that that was your well that you wanted to drill and you wanted to use that water for drinking water. Would you drill that well and drink it?

A Yes, I would.

Q Thank you.

MR. STAMETS: Any other questions of this witness?

Let me ask one, Mr. Carr, before you do some redirect.

MR. CARR: Okay.

RECROSS EXAMNATION

BY MR. STAMETS:

Q Dr. Miller, it concerns me that -- that it's going to cost half a million dollars in your opinion to prove anything about this. I know it's not this simple, but if I was -- if I raised chickens and if I saw the roosters out there with the chickens and eggs and chickens come out of the eggs and I could say that's a chicken.

But the way you're talking, if I walked out in the country and saw a chicken that I had not raised, I couldn't be sure that that was a chicken.

Now I know that that's an oversimplification of the whole thing. I know lots of other things can happen in an area as complex as this. But it seems to me that you've seen some things out there in the testimony that look an awful lot like chickens and I keep hearing you tell me that you don't know all the facts and so that chicken may not really be a chicken.

It seems to me that there's got to be

some logical place between a $500,000 study and being able to accept what we have seen out in the field, and I'm not sure that I've even asked you a question.

Let me rephrase that. Aren't there things that can be done out in the field to make reasonable analysis, analysis that a reasonable man could use to make decisions in a matter of this case that are going to cost much, much less than $500,000?

A Well, I'll answer that two ways.

One is I would change your chicken analogy slightly. I didn't deny they were chickens but if you didn't personally raise them, you couldn't say who actually raised them, and that's really what I'm trying to say, is we don't know where that chicken came from; could have been, you know, any number of farmers in the area.

Q But secondly, I would say that if a coring and sampling project would -- at various distances from some of the pits would be possible, using accepted EPA guidelines for doing that, so far that hasn't been done by anybody that's been presented while I've been here, anyway, okay, so using EPA coring and sampling techniques just to look for the disappearance of benzene and toluene and these chemicals of concern with distance, could be done.

I'm -- that's not my direct area of expertise and I'd have a hard time saying what that would cost, but I would say half of that, half of a half a million, a quarter of a million or so. I would say it would be in excess of $100,000, though, to do it right. Okay.

Q That is still almost like Mission Impossible. I have a hard time -- I have a hard time dealing with that.

MR. STAMETS: Mr. Carr, you had some additional questions.

MR. CARR: Mr. Stamets, your chicken analogy has sort of thrown me. It seems to me that story would be more like someone going out and looking around and not being able to find any chickens but still deciding to shoot all the foxes. I think that's maybe more what we have before you today.

REDIRECT EXAMINATION

BY MR. CARR:

Q Dr. Miller, you've talked about some very expensive figures for some studies that might shed some light in the field on whether biodegradation is taking place under certain pits. To be sure I understand that, and in response to what I think Mr. Stamets was really going for with that, the figures you were quoting, were they not for the cost that would be incurred in doing some detailed studies of biodegradation?

A Including the field sampling and the laboratory biodegradation studies, correct.

Q So aside from the biodegradation question itself, there might be some other things that could be done at least cost.

A Right, like I said, doing the coring with distance from a pit under accepted procedures.

Q Now based on your knowledge and experience in testing and sampling water supplies, would you recommend that the Oil Conservation Division sample and analyze and study data on each pit in the San Juan Basin before prohibiting disposal of produced water in them?

A I think that would be, you know, excessive to try to do that and out of line. It's very costly to just do the analysis, much less physical sampling, but once you bring it back the analysis is very expensive for these kinds of things.

Q Do you believe there is data available in the general sense that would make that sort of testing unnecessary?

A I think so, based on the studies that we presented here.

Q Now if I understand your testimony today, biodegradation, at least as it works in the subsurface, is a relatively new area or an area now that is only being understood, is that a fair statement?

A Yes, for the subsurface environment we've only recently began addressing that, the last four or five years.

Q Now here today as part of your testimony, you've presented a number of papers. As to each of these papers are they prepared by the leading authorities in the area on each of these subjects?

A I would say, yeah, each of these are among the leading authorities in these areas, yes.

Q Are these papers that are commonly relied upon by microbiologists such as yourself?

A Yes, and as I mentioned a little bit ago, the American Society for Microbiology just held a session devoted to this subject matter and Perry McCarty, one of the authors of one of these papers presented a keynote address, specifically on his research on this before that meeting.

Q Have you personally relied upon each of these papers that you've presented?

A Yes, I rely upon them for guidance in my research.

Q As to the conclusions that you've presented here today, have you confirmed all of these conclusions in this research with your own independent work and research?

A I would say that there's nothing in my research to counter -- you know, to counter-indicate this.

Q Now, there's been quite a bit of discussion lab studies versus field studies.

Have you discovered anything in any of your work in any of your lab studies that would indicate that the conclusions that you have reached and the information you have obtained would not apply equally in the field?

A That's right. We've observed degradation and these processes in the field environment so that the things that we've observed in the laboratory do occur in the field also.

Q Why do you -- why do you conduct these studies in the lab as opposed to in the field?

A Main reason, there are several reasons. One is it's a lot cheaper to do it in the laboratory because you can bring the material into your lab and you don't have to keep running out to some remote field site and these are quite often daily samplings and daily -- daily maintenance of the material.

We can also control the conditions in the laboratory environment. We can't controll the conditions in the field environment and accidents happen; things, you know, temperature varies all over the place. We can control the conditions in the laboratory. We have readily access and once the acceptable techniques are developed it's less costly to do the laboratory work than the field work.

But we don't rely just on laboratory studies. We also try to go out in the field and confirm in the field what we observed in the laboratory.

Q Based on your research, your study of similar situations, and your understanding of the San Juan Basin, would you just state what your conclusions -- what conclusions you've reached?

A My conclusion is that based on the

mechanisms for attenuation that we've presented and it's just clear to me why these chemicals, benzene and toluene, and related ones, haven't shown up in the water supply wells in the region, and that I wouldn't expect these pits to threaten water supply wells in the region.

MR. CARR: Nothing further.

MR. STAMETS: Any other questions of this witness?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Dr. Miller, according to your testimony, then, actually an operator could dig an unlined pit that exposed groundwater and dump into that pit because the mechanism of biodegradation is available to not allow the pollutants to leave a certain area of the pit, is that correct?

A It's correct that those mechanisms would still be in place even in a pit that intercepts the water table.

Q Okay, then reasoning on further, we could actually dispose of these produced waters into a well drilled into the aquifer, couldn't we?

A You could do that. That would -- that would present a more immediate transport directly to the water table and as I indicated there's a very active degradation in the vadose zone and I would think it would be important to preserve that vadose zone between a pit and the water table where possible and the direct introduction of these into the drinking water would -- would really take away that safety margin.

Q In the time constraint that you talked about in one -- one of your statements was that in one experiment the benzene was degraded within a week. I'm sorry, I don't recall the exact test that was done but --

A You might be referring to the Tabak paper where I said two weeks for benzene and one week for toluene.

Q If the water was reached, if the produced water containing benzene and toluene reached the water table within a matter of hours because of the saturated zone, not a vadose zone, I'm talking about a saturated zone below the vadose zone, then would travel, even though these mechanisms of degradation still exist, wouldn't the benzene and toluene exist out to a certain distance from the pit?

A They could, but remember that -- that we, in the sorption testimony, Dr. Schultz said -- indicated that he expected there would be a five to fifty-fold retardation for benzene and toluene in this type of material, so being retarded it wouldn't flow as rapidly as the water itself.

Q He also said there would be some kind of saturation point experienced, also.

A There could be for sorption, but if there's biodegradation in conjunction with sorption, then -- then that, let's say, that capacity for sorption would be increased by the biodegradation.

Q How much?

A I don't know the answer to that.

MR. CHAVEZ: That's all I have.

MR. STAMETS: Ms. Pruett.

MS. PRUETT: One question.

CROSS EXAMINATION

BY MS. PRUETT:

Q I think you just said that all the things you have found in your laboratory studies you have backed up with field studies.

A We have -- we have conducted some field studies to back that up, correct.

Q Do you have any field studies which back up that toluene was 100 percent biodegraded in one week and benzene was 100 percent biodrgraded in two weeks?

A Let me think. I'd have to look at the creosote site to say for certainty that it was that rate of degradation at that field site.

Q Could you make that available to us?

A Sure. Sure.

MR. STAMETS: Any other questions of this witness? He may be excused.

We'll recess the hearing until 1:15.

(Thereupon the noon recess was taken.)

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

22 April 1985

COMMISSION HEARING

VOLUME 2 OF 2 VOLUMES

IN THE MATTER OF:

The hearing called by the Oil Conservation Commission on its own motion to define the vertical and areal extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in conjunction 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
Commissioner Ed Kelley

TRANSCRIPT OF HEARING

A P P E A R A N C E S

For the Oil Conservation Division:	Marx M. Elmer Attorney at Law Energy and Minerals Department 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

(Thereafter, at the hour of 1:15 o'clock p.m. the hearing was again called to order and the following proceedings were had, to-wit:)

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

Do you have any other witnesse, Mr. Carr?

MR. CARR: No, that concludes our direct testimony in this case, Mr. Stamets.

MR. STAMETS: Mr. Kellahin.

MR. KELLAHIN: Yes, sir.

Mr. Chairman, we'll call at this time Mr. Randy Hicks.

For the record, Mr. Chairman, Mr. Hicks was sworn as a witness at the hearing on April 3rd. He's in attendance today. Do you desire he be re-sworn?

MR. STAMETS: No, any person who's been previously sworn in any of the hearings to date in this case continue to be sworn.

RANDALL T. HICKS,

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

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Mr. Hicks, for the record would you please state your name and occupation?

A My name is Randall Thackerey Hicks and I am Vice President and Director of Technical Services for Geoscience Consultants, Limited.

Q Geoscience Consultants does business in what city, Mr. Hicks?

A Albuquerque, New Mexico.

Q Do you hold any professional degrees in geology or hydrology?

A Yes, I do.

Q Would you describe for the Commission when and where you obtained your degree and the type of degree you received?

A In 1975 I received a Bachelor of Science from Beloit College and majored in geology.

And in 1980 I received a Master's degree in geology from the University of New Mexico.

Additionally I have done some studies in hydrology beyond my Master's degree.

Q What was your Master's thesis in, Mr.

Hicks?

A My Master's thesis was in the -- it dealt with the interactions between and water in terms of the chemical reactions between the two.

Q Would you describe for us what other additional educational studies you have undertaken subsequent to receiving a Master's degree?

A While working for the Enivronmental Improvement Division I assisted with many of their studies on the impact to groundwater from discharges from various industries, as well as site specific industries or industrial facilities.

I was in a -- I took a number of different courses with respect to contaminant hydrogeology and hydrogeology in general.

Q Would you describe for us what has been your employment experience with the New Mexico Environmental Improvement Division?

A With the NMEID I was a Senior Hydrologist or a Water Resource Specialist III for several years there, and the my primary responsibilities were to evaluate the impact to groundwater from discharges from industrial facilities, agricultural facilities and municipal facilities, all sorts of discharges which may have an adverse impact to groundwater.

Q Would you describe for us what has been your experience in regulatory development and implementation?

A While with the Environmental Improvement Division, along with Mr. Boyer, I co-authored the Underground Injection Control Section of the Water Quality Control Commission Regulations, that's Section 5.

Mr. Boyer and myself spent approximately one year in regulatory development toward designing a set of regulations for underground injection control in New Mexico.

Q For what period of time were you employed by the New Mexico EID?

A From 1981 to 83.

Q What was your next work experience in the field of geology or geohydrology, Mr. Hicks, after the EID employment?

A After the EID I joined Geoscience Consultants.

Q What is it that you do for Geoscience Consultants?

A I prepare and -- I supervise and prepare regulatory or rather permits, regulatory permit documents, which evaluate the potential impacts to groundwater from discharges and also make recommendations to my clients as to how to prevent any degradation of groundwater from those discharges.

Additionally we, Geoscience Consultants will evaluate certain soil or groundwater contamination cases, or potential cases, and determine how to mitigate the situations if, in fact, they do require any sort of mitigation.

MR. KELLAHIN: Mr. Chairman, at this time we tender Mr. Hicks as an expert geohydrologist.

MR. STAMETS: Any questions as to the witness' qualifications?

He is considered qualified.

Q Mr. Hicks, you said that you were familiar with and had in fact worked in the area of administering the New Mexico Water Quality Control Commission regulations with regards to discharge plans while at EID.

A That's correct.

Q Are you familiar with the administration and implementation of those regulations concerning the levels of contamination that can be discharged onto the surface with an approved disposal or discharge plan?

A Yes, sir.

Q Would you give us a summary, sir, of how the EID Discharge Plan Approval system works with regards to the levels of contamination that a discharger might place upon the surface in relation to New Mexico Ground Water Quality Standards?

A Certainly. The bottom line of the regulation is that a discharge cannot, any kind of discharge, whether it be from an injection well or a surface impoundment, cannot cause an exceedence of the ground water standards at any place of reasonable, foreseeable future use. It is the burden of the discharger to show the Environmental Improvement Division that the activities which the discharger conducts will not result in contamination above the standards beyond their property line.

The area of reasonable foreseeable future use has been defined by policy as the property line of the facility.

Q Under the EID administration of the Water Quality Control Commission regulations is a discharger limited to discharging only distilled, uncontaminated water?

A Absolutely not. There is, in fact, the Environmental Improvement Division will allow dilution to occur between the source of input and the property line. This has been a matter of policy and also regulation.

The -- and so the level of contaminants which can enter groundwater at any given point is in fact a function of the hydrologic regime of the area or the way it's produced.

Q In terms of obtaining a discharge permit under the process, Mr. Hicks, if an applicant or a discharger has a simple dilution calculation as one approach for the application and also has a computer model done in a way that's consistent with the methods of your science and discipline, and finally has actual groundwater monitoring, would you describe as a former regulator what the significance is of each of those types of criteria of data submitted for approval of a discharge plan?

A Typically the Environmental Improvement Division will go through three levels of review with respect to a potential discharge.

The first level of review will involve a dilution calculation similar to what Mr. Boyer presented in his testimony. It's a very simplistic dilution calculation and gives the worst case scenarios for potential discharges. It involves no decay. It permits no -- no dilution or dispersion, if you will, past the point of discharge, and if, in fact, a discharge, volumes which do enter groundwater, permit or the dilution calculation shows that it meets standards, the plan will typically be approved.

The second, if the dilution calculation, the simple dilution calculation fails, oftentimes the Environmental Improvement Division will go to a more sophisticated modeling technique, using computer models, such as random walk or others which are available, and if -- and then they take into consideration dispersion and the distance to the property line.

Other factors may or may not be considered in the computer modeling.

If at the property line the computer model demonstrates that groundwater will not be contaminated, in many instances the plan will be approved at that point.

The third line of evaluation may involve the installation of groundwater monitoring wells.

Therefore, if the evaluation test fails the dilution calculation, additionally if it fails the groundwater modeling evaluation, yet groundwater monitoring wells are put in and it passes, if you will, it demonstrates that the standards are not being exceeded, then indeed the plan would be approved. This would apply specifically for discharges which had been in operation for awhile, where the groundwater conditions would be representative of -- of what is going on in the subsurface as opposed to a brand new discharge or brand new process, one that is not fully understood, may require additional evaluation, but certainly for well understood processes or where the processes have been going on for a long period of time, this has been typically the type of evaluation which has been pursued.

Q Let me direct your attention now to the vulnerable area of the San Juan Basin under consideration by the Commission, and I want to ask you whether or not you have an opinion as to what would constitute an adequate study upon which rules and regulations can be formulated in the vulnerable area under investigation by the Oil Commission concerning the potential groundwater contamination due to disposal of produced water in unlined surface pits.

Do you have such an opinion?

A Yes, I do. There are steps which should be taken for an adequate study.

Q Have you prepared those steps in the form of an exhibit?

A Yes, I have.

Q Mr. Hicks, I show you what we have marked as Tenneco Exhibit Number One and ask you if you prepared this tabulation of requirements for an adequate study?

A Yes, I did.

Q All right, sir, would you describe for us what in your opinion would constitute an adequate study in terms and for the purposes of within the vulnerable area determining the appropriateness of a small volume blanket exemption for five barrels a day, or less, of produced water into unlined pits?

A Certainly. The first step of the requirements is to inventory the water wells and the oil and gas wells in the area to determine what is actually there, how many, where they are.

The second step is to map the areas of vulnerable groundwater that are based upon the criteria which has been well established in the literature and in hydrogeologic science, looking at the depth to groundwater, the lithology of the unsaturated zone and the transmissivity and hydraulic conductivity of the aquifer. All of these are important considerations when evaluating the vulnerability of groundwater.

The third step would be to within the vulnerable area perform a statistically accurate sampling of well sites. You need to do this in order to adequately characterize the waste that is being produced, the type of waste, and the type of disposal practices, and there are a number of factors you may wish to gather, a number of data you may wish to gather with respect to this sampling.

Certainly I would evaluate each of the well sites, not only for the depth to groundwater, the lithology and the transmissivity, but I'd look at the chemistry of the produced water and the volume of water that is produced.

I would then analyze the data that was collected from this initial field study to determine if there are certain populations or certain groupings, categories which you can break out from this random sampling.

Then, as point number six illustrates, I would select several sites that are based upon these groupings to perform detailed field studies on. I would install monitor wells and what not.

The things that I would look at in this detailed study would be the history of the site. At each one of these individual sites I would want to know where the produced water pit is, where there may be buried pits, where there may be other sources of contamination other than the produced water pit, since we're trying to focus on the impact of produced water pits.

I'd want to look at some long term monitoring of the volume of water that has been produced at each one of these sites.

I'd want to look at some long term monitoring of the chemistry of produced water from these specific sites.

I would install the groundwater monitoring network that I mentioned just previously.

I would perform -- I would also install unsaturated zone monitoring network.

I would perform chemical analyses of the groundwater and any fluid from the unsaturated zone and these steps would, in fact, help me define, or they would define, the hydrogeologic site conditions in the saturated and the unsaturated zone.

And based upon the data collected from these sites and in this random sampling from which we selected these sites, I'd perform computer modeling to determine the potential impacts to groundwater and to reduce the number of field studies. What I'm trying to do here is I've selected a random sampling. I've gone out and I've visited the sites and I've collected this information. I've chosen several sites to perform some detailed investigations on, including groundwater monitoring, and then using these selected sites I would then model a larger number of sites in order to insure that we're dealing with a representative sample.

I would calibrate this computer model of many different sites with the actual field data that I had collected during my site specific studies. If the data -- if the field data permit calibration of the model, it should include the considerations of many -- the consideration of many of the aspects that we have talked about earlier in this hearing, including attenuation, volatilization, and biodegradation.

From this data base we would then have -- it would -- then it would be sufficient to produce a order.

Q Were you present on February 20th, 1985, when the Commission conducted the first hearing in this case?

A Yes, I was.

Q And you heard the testimony of Mr. Boyer?

A Yes, did.

Q Have you had an opportunity to review his exhibits and review the transcript in that case?

A Yes, I did.

Q Do you have an opinion, Mr. Hicks, as to whether or not at this point the Oil Conservation Division has conducted an adequate study, as you've outlined for us?

A No, they have not. They have not followed these -- all of the nine steps of what I consider the requirements for an adequate study, and what would be considered the requirements of an adequate study by professional hydrogeologists and regulatory -- and people in regulatory development.

They have begun. They have conducted several -- several steps in this study.

Q With reference to the Oil Conservation

Division study, what, if any, of these steps do you believe that they have completed?

A The inventory of water wells and oil and gas wells is complete.

The areas of vulnerable groundwater have been mapped to a degree that needs to be refined further.

They have not conducted a statistically accurate sampling of the well sites, although they have sampled some well sites.

The data for the chemistry of the produced water and the volume of produced water has been, from their limited sampling, has been evaluated.

And that's basically where they stopped, is in number --number four.

Q Mr. Boyer has done some simple dilution calculations that have been discussed in the prior hearing. You're aware of those, are you not, sir?

A Yes, I am.

Q Based upon those dilution calculations, Mr. Hicks, can you form an opinion as to whether or not you believe that's an adequate basis upon which the Commission can enter an order that would ban the use of unlined surface pits in the vulnerable area for small producing rates of five barrels a day or less?

A Well, as I outlined, the mechanism that the Environmental Improvement Division follows for discharge plan approval, I believe should be followed here, as well.

What Mr. Boyer has conducted is the first cut of absolute worst case scenarios using higher levels of benzene than actually occur in the pits, for example, and it does represent the absolute worst case theoretical that could possible exist, and I do not believe after my investigation in the San Juan Basin vulnerable area, that that is in fact representative of what is actually occurring.

Q Were you here at the hearing on April 3rd, 1985, when Mr. Zaman testified about his groundwater monitoring around the Duncan Oil Field and specifically I believe he monitored around the Duncan Well 6-11.

A Yes.

Q Were you here present for that hearing?

A Yes, I was.

Q All right. With regards to Mr. Zaman's work at the Duncan site, can you form an opinion as an expert hydrologist as to whether or not that study is an adequate basis upon which to form an order that would ban the use of small volume unlined surface pits of five barrels a day or less in the vulnerable area?

A It is not sufficient evidence.

Q Can you give us the reasons why you believe that that study is not sufficient?

A The data that was presented was -- had some problems with it with respect to sampling procedures and methods of sample collection, which are not standard methods. The method of sample collection with preservation with an organic is not standard methods.

The method of collection in Mason jars, I believe is what they employed, is not standard methods.

There are some discrepancies in the data, as I reviewed it, which showed that initially when they -- they did two sets of samplings, I'm sure people remember.

The first set of sampling showed some levels of benzene that were above the standards and these samples were collected in less than ideal situations, as Mr. Zaman admitted.

The second set of samples, which were collected without organic preservatives, indeed showed no detectable levels of benzene and so I'm a little bit confused as to which set of numbers or values to believe based on the evidence that was presented.

Additionally there is really -- it's difficult to imagine drawing a hydrologic gradient map or hydraulic gradient map of the water table in such a flat area where the water table is indeed relatively flat without an accurate survey by a professional surveyor, or at least someone who is very adept in surveying with instruments.

Q In your opinion is the water monitoring study data information, whatever, filed by Mr. Zaman on this one site, an adequate basis by which to determine the fate of the 1300 oil and gas wells in the vulnerable area?

A Absolutely not.

Q Mr. Hicks, you've described for us what in your opinion would constitute an adequate study. There was -- we discussed it earlier today on the Zaman study before I leave that, could you identify for us what the possible sources of contamination may have been with regards to that study, other than the potential for contamination from disposal in unlined surface pits?

A There are numerous sources that can exist at any given site.

One such source would be the reserve pit at a well site.

Another source would be surface contamination which had occurred during the testing of the well.

Another source of contamination can be pipeline leaks, the pipeline casing leaks or pipeline leaks which may occur between the storage tank and the wellhead itself or between the -- any one of the subsurface connections.

Additionally there is a potential contamination from the -- the separator itself due to surface spills, but in this particular case with Duncan, I believe that they mentioned there was a buried separator, which was -- could not observe, and that may be another source in this case.

Those would be a partial list.

Q Mr. Zaman had a photograph of a backhoe cut in which there was an obvious dark stain some feet below the surface, to which he attributed that oil stain -- attributed that stain to an oil stain and concluded that that was an indication of contamination by the use of an unlined surface pit.

Do you share that opinion?

A Well, that point is very interesting for two reasons.

First of all, I don't share that opinion. The oil stained material that Mr. Zaman showed in his slides, I would be very hard pressed as a hydrogeologist, and especially in that environment, to understand how such an apparently viscous material would be able to flow hundreds of feet from the produced water pit.

I would offer an alternative explanation for that and perhaps offer an alternative explanation for some of the high benzene readings which he may have obtained from that individual pit.

Surface contamination, as I mentioned, at well sites is not -- surface soil contamination is not uncommon due to changing of oil from the rig, the testing of the wells, and indeed, soil can become oil contaminated, not necessarily oil saturated, but stained with hydrocarbons.

This material then may be buried to prevent washing of the material, for whatever reason, and then in his excavation he may have dug through such a surface contamination and in fact contaminated his equipment on the way down and resulted in higher levels of benzene due to improper isolation of this surface contamination with that of groundwater.

Q Mr. Hicks, it has been discussed earlier that the Flora Vista site may or may not be an example of groundwater contamination from the use of an unlined surface pit and no one knows at this point.

I would like to direct your attention, sir, to the transcript of hearing on the February 20th date, and to Mr. Boyer's testimony beginning approximately on page 115, continues over 116. If you'll take a moment and review those pages of the transcript, I'd like to ask you a few questions about the Flora Vista well.

A Yes, I see that section that you're referring to and I've read it.

Q All right, sir. With regards to the information that you have reviewed, not only in the transcript but testimony of Mr. Boyer about Flora Vista, do you have an opinion as a geohydrologist as to whether or not the source of potential contamination of groundwater in this area can be attributed to an unlined surface pit from the Manana Gas Well as discussed at the prior hearing?

A The contamination of the Flora Vist well, as I understand it and as is reflected in the transcript, is -- I'll just read it again for the benefit of the audience. The information I have is a copy of a table that I received from the Environmental Improvement Division listing a sample date of August '83 and at that time the biggest contamination was 32 milligrams per liter, almost 33 milligrams per liter of oil and grease. It had a concentration of 0.4 phenols and a detected aromatic purgables, but there's no quantification limit given. It's less than .01 for aromatics and as most of the audience is probably aware, benzene is an aromatic.

Q Tell us poor little chicken farmers what that means in plain English. Is that an indication of contamination by the disposal of produced water from the Manana Well into an unlined surface pit?

A No, it is not.

Q Why not?

A It is not because the phenols and oil and grease can come from numerous sources and in fact may or may not be a constitutent in produced water at all.

Oil and grease would be a contaminant which I would look at in terms of a turbine pump if it was installed at the well initially. I would look at contamination due to how it was drilled, perhaps what it drilled through. It may have drilled through an old surface disposal pit. It may have drilled through an old reserve pit. Somebody may have been changing their oil and dumped it in the well. I mean there are numerous sources which you could attribute this kind of contamination.

Q In your studies of the San Juan Basin area, Mr. Hicks, have you come across or are you aware of any confirmed case of groundwater contamination by the use of unlined surface pits for the produced water from oil and gas wells?

A I personally know of no cases.

Q You discussed with us earlier on Exhibit One a list of requirements that you would consider be necessary to form an adequate study.

A Yes.

Q Have you and has Geoscience Consultants completed such a study with regards to the unlined surface pit use in the vulnerable area on behalf of Tenneco Oil Company?

A In terms of the requirements for this study, with the exception of the installation of groundwater monitor -- I mean unsaturated zone monitoring network, we have completed such a study.

Q Mr. Hicks, I have placed on the blackboard what is marked as Tenneco Exhibit Number Two and ask you, sir, if you'll identify the map for us before we discuss what it shows. Would you identify that, please?

A Yes. That is the map of the vulnerable area which has been displayed earlier, where the vulnerable area has been outlined along the river valleys of the San Juan, La Plata, and Animas Rivers.

Q All right, sir, would you identify for us the three sites that are indicated with the red dots?

A Those are the three sites where Geoscience Consultants and Tenneco conducted groundwater monitoring. They are the McCoy D-1 on the Animas River; the

Eaton A-1-E on the San Juan River; and the Paine A-1-E on the San Juan River.

Q In terms of evaluating the vulnerable area with regards to the continued practice of allowing small volume produced rates in unlined pits, would you give the Commission the benenfit of telling us what you've done with regards to the compiling and gathering of the data?

A Certainly. The first step that we went through with out study is we assumed that -- and I'd like to refer to the requirements for an adequate study.

We assumed that number one had been done and indeed had been completed by the OCD and the Short Term Study Committee.

Number two, map the areas of vulnerable groundwater based upon the accepted criteria, that also had been done and the results of that study are shown on that map of the vulnerable area.

Within the vulnerable area there had been a statistically accurate sample of well sites conducted and what we did initially is we went out, I went out and Geoscience went out to perform site evaluations of a number of different wells. I mean we took 21 wells initially and examined them for their hydrogeologic character -- characteristics, the characteristics of the volume of water produced, the sizes of the pit and various other parameters were investigated.

From these 21 sites we chose three for a detailed site study. These three were chosen because we felt that they were, based on the 21 sites that we had examined, were representative of the vulnerable area. They were representative of the worst case scenario that we could foresee, which was the Eaton A-1-E, and a worst case scenario again with the Paine A-1-E, and a more realistic scenario with the McCoy D-1.

After choose -- after selecting these three sites for detailed studies, we installed monitor wells at all three sites using strict EPA criteria.

We installed dry points at these sites due to our initial investigations demonstrated that drilling with a hollow stem auger, for example, or many other kinds of drilling apparatus, which are also acceptable, would be rather difficult due to the lithologic conditions of the sites, so we chose dry points.

We steam cleaned the dry points totally prior to installation.

Lithologic data were collected at each one of the sites employing a backhoe. The backhoe was used, was fully steam cleaned, as well, and used to dig trenches in areas where we could examine the unsaturated zone and in many instances the saturated zone, as well.

We collected samples from the separator and the pit for chemical analysis.

During the -- after the installation of the groundwater wells, again using -- emphasizing that I'm using strict EPA guidelines for this, we collected samples again using standard methods which applyl to hazardous waste sites or any type of discharge that EPA would be monitoring.

We used strict chain of custody, clean vials for volatile organic analysis, similar, exactly the same as those which Mr. Boyer used in collecting his samples.

Additionally, we had the results of the analyses which we received back from the laboratory verified by another independent lab, so we used two labs for verification.

The -- and that is the process that we went through to collect our data.

Incidentally, I might emphasis additionally that all of the wells -- the wells installed were supervised by a certified professional hydrogeologist -- certified professional geologist. I am a certified professional geologist and I supervised the installation of all the wells.

For all but two of the wells I was present on site during every step of the installation process and made all the decisions regarding the -- the installation.

Q In terms of the 1200 or 1300 oil and gas wells in the vulnerable area, Mr. Hicks, would you give us an approximation of the number of wells that you have seen the sites of in order to determine whether or not there is any way to categorize the types of wells we see in the vulnerable area?

A I'd like to move ahead a little bit with respect to how we conducted our study after the analyses came back from the laboratory.

We felt that as looking at 21 sites we did -- and spanning the vulnerable area in terms of a driving tour and a walking tour, we did feel that these three sites were representative of what was the actual situation in the vulnerable area.

In order to insure that that was the case, we used a -- we had a data base of approximately 300 wells from these 1300. Those are the wells of Amoco and Tenneco, where we knew the volume of produced water, the location of the wells, the elevation of the wells, and the anticipated depth to groundwater. Many other factors were known from this data base.

From that initial sample of 300 wells, using a random number generator, we selected an additional 50 wells, or rather we selected from that 50, well, 60 wells, I'm sorry. We selected 60 wells to perform on site hydrogeologic studies of each one of these 60 wells.

I personally went out and visited each one of these -- well, I take that back. I personally visited 50 of these wells. Time did not permit all -- visiting all 60. I visited 50 of these wells from this random sample.

Additionally, as people who have been in the San Juan Basin fully understand, these wells are very close together. I could go to a site where there is one, one wellhead or one numbered well, whereas there are in fact three wellheads at that given site, so I should say that I visited 50 sites that represent a minimum of 50 wells, and performed a hydrogeologic evaluation of each one of these well sites; therefore the total number of wells that I have seen is in excess of -- and that I've actually performed a hydrogeologic investigation of, is in excess of 75 well sites.

Q In your opinion have you studied an adequate number of wells and well sites from which to get a representative indication to you as a geohydologist of the varying kinds of or types of wells in the vulnerable area?

A Absolutely. In fact we called in a statistical consultant, a PhD, Dr. Francis Wall, who has a PhD in statistics and has performed numerous investigations for many companies with regards to statistical analysis of data, and I wanted to confirm with him that this random number generation, that looking at the sample of 300 was sufficient; that looking at -- that based on this -- this number of 300 and moving on down to 50 that that would in fact be an adequate sample.

We plotted out where these wells fell, these 300 wells, and indeed they were fully representative of the Animas and the San Juan River.

Q Did you and Dr. Wall -- did you and Dr. Wall as the statistician come to any agreement upon the adequacy of the sampling and the groundwater monitoring of these wells in terms of categorizing the well population in the vulnerable area?

A Yes, we did.

Q In your opinion, Mr. Hicks, is it necessary in order to either develop an exemption on a blanket basis for small volumes of produced water, 5 barrels a day or less, in unlined pits, is it necessary either to develop the exemption in those terms or in the alternative for the Division to ban entirely the use of the unlined pits in the vulnerable area?

A Based on the data that we have collected, I would --

Q My question, sir, is whether or not it's necessary for you to have site by site data at all of the 1200 wells in order to come to some hydrogeologically supported conclusions about how to handle those type of pits?

A That's not necessary.

Q What is necessary?

A What's necessary is to go and find out by a random sampling technique what types of wells exist in the vulnerable area. Then to field test these types, these populations, and calibrate these tests with actual field data; perform computer modeling on these populations to determine whether there is in fact a threat to groundwater.

Q Based upon your study, Mr. Hicks, are you able to categorize the well population in the vulnerable area into certain categories?

A Yes.

Q Would you describe for us generally what are the criteria or factors that identify the various types of well populations from a hydrologist's point of view in the vulnerable area?

A Based on my study, I have broken out the types of wells into four different categories, four different populations, with several sub-populations in two of them.

Q Before you go into detail about --

A Okay.

Q -- doing that, I'm trying to get a general feel for the types of studies you made and what conclusions you can draw from them.

A The types of studies that were made, I investigated the hydrogeologic conditions at each one of the -- at each one of the sites that I visited in order to categorize them into different populations.

I investigated the type of water produced; the type of well.

Q Mr. Hicks, I show you what is marked as Tenneco Exhibit Number Three.

All right, sir, if you'll turn to the first page of -- let me ask you to identify Exhibit Number

Three.

A Okay.

Q What is it?

A Exhibit Three is a report summarizing our field investigations of the vulnerable area in the San Juan Basin, New Mexico.

Q All right, sir, let me have you turn then to -- after the title page, if you'll turn to the first page of the exhibit and if you'll take us through the study and explain to us the exhibits as we come to them.

A Yes, sir.

Using the form that you find after the listing, where it says "Well Site Evaluation", there are certain criteria that were used in order to break down the individual wells into sub-populations. The title of the -- well, "Well Site Evaluations", those are the data that were used along with my own observations in the field as a professional geologist.

And we broke, we were able to break down the wells in the vulnerable into certain populations.

We broke them down initially into the San Juan River, or rather the river valley, river flood plain cases, which include the San Juan River, where the gradient of the -- the hydraulic gradient is equal to that of the river. In the case of the San Juan it's .002 to .003, as Mr. Boyer brought out in his earlier testimony.

We broke these out into three different

categories, high hydraulic conductivity cases, medium hydraulic conductivity cases, and low hydraulic conductivity cases. There were based on our site evaluation of the type of material which existed in the saturated zone, as well as the well testing which had been done at our sites, which we -- where we conducted a drilling program, as well as published information with regards to the hydraulic parameters and characteristics, the hydaulic characteristics of the flood plain.

The Animas River, according to our random sample, broke down into one category in that there was high hydraulic conductivity cases. We observed no medium hydraulic conductivity cases or no low hydraulic conductivity cases in the Animan River.

So the flood plains area breakdown, the flood plain population breaks down into three different categories, high, low, and medium transmissivity, or hydraulic conductivity.

The second population which exists are those of the valley side slopes and the tributaries that are away from the active flood plain of the major rivers in the system.

Those, too, broke down into three different sub-populations, high, medium, and low hydraulic conductivity cases.

The third population that we identified from our field investigations were those of bedrock mesas.

These are where the produced water pits lie on bedrock of sandstone or shale and where, in our professional opinion, produced water will not enter the groundwater system that is being used as an aquifer.

The fourth case, the fourth population that was brought out was the Pictured Cliffs wells, which in fact have no production equipment or generally have no production equipment on them. In fact, all of the wells which we investigated and that we have shown here as Pictured Cliffs did not have any production equipment on them whatsoever. They do not have produced water pits. They do not have a separator. The well flows directly into the pipeline and initially these are -- the other well sites which were not visited as far as the random sample are also listed as specific well locations that we went to in the course of our previous investigation. You'll notice that there are not 21 sites there. That's mainly -- that is because several of the 21 sites which we investigated in a random sample also are -- the sites which we visited, the 21 sites, some of them fell within our random sampling, so they are shown in the -- broken out into the different populations.

Q When you talk about the well population being placed into various categories, what type of category would typify the McCoy gas well that's indicated on Exhibit Number Two?

A That's a high transmissivity case in the flood plain.

Q Would you describe for us what the hydrogeologic characteristics are of that type of well?

A In the Animas River an examination of the riverbed itself and indeed the materials which have been deposited in the active flood plain show that it is indeed very coarse grained material, cobbles, boulders, and generally are -- well, are very high conductivity. That is also demonstrated by well tests in the area; that it is indeed high conductivity, and if you can turn to the following page after Well Site Evaluation, there is a chart which shows hydraulic conductivity values based on the type of material in unconsolidated deposits, and that's what we're talking about here, is unconsolidated deposits.

In the McCoy area we're dealing with very coarse grained gravel and very clean sand, and it falls within the range which has been tested by the McMann No. 1 Well, which has been marked on this chart. The McMann No. 1 Well was used in many of the calculations which Mr. Boyer conducted in this exhibit. This is a well which is in the Animas River Valley and correlates quite handily with the McCoy situation.

Q When we talk about the Eaton site, the A-1-E groundwater monitoring site, would you describe for us generally in hydraulic parameters what type of well will it have?

A The Eaton site falls within the valley side slopes and it is -- it is very fine grained. It was not part of our random sample.

It is a fine grained unit which has been deposited on the side of a valley slope, the side of a valley, and it's important to understand why it's fine grained in this area.

It is fine grained basically because the contribution of sediments from the tributaries of the San Juan River have caused a find grained deposition due to the materials that it's eroding. So it is a fine grained case. It is on the side slopes of the valley and the hydraulic gradient is indeed greater than .01.

Q When we look at the Paine site, Mr. Hicks, describe for us the type of site we're seeing at that well.

A The Paine site is, the Paine location was actually drilled in the river itself. It had to be swampy area on the side of the river. It had to built up so that the well equipment would be stabilized. It is on a platform which lies four to five feet above the swamp level in the side of the river, and so it is in a river valley case. It is part of the flood plain and it is in a low to medium conductivity range. It's in the -- it's in the low hydraulic conductivity case of the San Juan.

Q Would you turn now to that portion of Exhibit Number Three that has the foldouts?

A Certainly.

Q It starts with this first one. Unfolded this is part of Mr. Stamets' chicken ranch. What is this?

A This is the surficial geology map of the vulnerable area. It was -- the following pages give the full reference. It's unfortunately Xeroxed into three different sections so it would fit into the -- our exhibit here.

But it was done by Charles Hunt in 1977. It's the New Mexico Mining -- or it's a Geologic Map No. 43, GM 43 by the --

Q What's the purpose of that map?

A The purpose of the map is to show the surficial geology of the state of in this particular case, the Northwest Quadrant of the State of New Mexico, what rock units are exposed, what alluvial units are exposed, and the type of units that they are.

Q What use have you made of that map?

A I used this map to check to make certain that the cases that we investigated with respect to grouping it into these populations that we discussed before isn't -- isn't a function of chance, that there is indeed an explanation can be made why we can break this into certain populations, what geological reasoning there is.

And indeed throughout --through the careful study of this map you can -- you can tell that the Animas River, for example, and the San Juan River, share approximately the same density of side tributaries coming in.

Evaluation of the map will also show that these side tributaries erode and drain the same type of bedrock material.

You can also see from this map that the San Juan River and the Animas River have their sources in Colorado in the San Juan Mountains of Colorado. They have, then, similar sources. They have, then, a similar network of tributaries which drain into them. They have, then, a similar flux of material that is sediment from the side tributaries and also from the San Juan River itself, and as a result, you can -- and after the site investigation that I performed throughout this area, it was demonstrated to me by my site investigations that indeed we can fall into two major populations of river flood plain material and side slopes.

The river flood plain material contains the -- is dominated, the lithology of these units is dominated by that which is transported by the San Juan River.

The side slopes, or the valley slopes, is dominated -- the lithology of the material is dominated by that which is contributed by the dry -- the tributaries to the San Juan River, which indeed are the same, the same bedrock material, the same source material, whether you're looking at the Animas or the San Juan or the La Plata, for that matter.

And so we have two distinct geologic populations here. Where we have one population the material and the nature of the material is controlled by the major rivers. The other population, where the hydraulic parameters and the lithology is controlled by the side canyon contribution of sediment.

Q In your opinion is each of those well populations represented by either the McCoy Well or the Eaton Well?

A Yes, they are. The McCoy Well and the Paine Well reflect the flood plain population and indeed the Eaton A-1-E reflects the side slope population.

Q Can you give us an approximation now, sir, of the number or percentage of wells in the 12-or-1300 wells in the vulnerable area population, what portion falls either in the McCoy or the Eaton categories?

A Well, the bulk of the wells that we're looking at, it's well reflected, in fact, and the audience and the Commission can draw its own conclusions with respect to our random sampling.

We see here that we investigated a total of -- like discounting the bedrock mesa cases, because we have -- we are discounting those with this particular topic of discussion, and discounting the Pictured Cliffs, we have approximately 32, 30 sites here, of which we have the distribution as shown in this chart.

Q All right, sir, if you'll turn now to the general soil map that's in Exhibit Number Three and explain the purpose of that --

A Certainly.

Q -- portion of the exhibit.

A In addition to looking at the surficial geology map of Hunt, I looked at the soils map to determine -- to corroborate, if you will, the information upon -- is -- are we in fact looking at representative areas? Can they be broken down? Is the -- can the geology be broken down into populations?

And indeed the Soil Conservation Service has broken it down into different soil types and an investigation or evaluation of this map shows that the San Juan River Basin and the Animas River Basin show generally the same, or show exactly the same, soil types throughout in fact the vulnerable area, and indeed, if you look carefully at the sites as well, you'll see that the soils which line the vulnerable area in each case are similar between the San Juan and the -- or similar, they're exactly the same, between the San Juan and the Animas River.

Q All right, sir, let's go to that portion of Exhibit Number Three that addresses the groundwater monitoring at the Paine Well.

A Okay.

Q That's the next foldout, I think, in Exhibit Number Three.

A The Paine Well is a foldout which folds out legal size, is representative of the valley flood plain area.

This area was of most concern. The valley flood plain area was of most concern to the Commission at the initial two hearings. We investigated this site and looking at the water in the pit, we also performed chemical analyses of surface water and ground water.

And now looking at this map, where it says "Water Table Elevation in Feet", the southwest corner, or actually the westernmost extremity of the produced water pit, shows a value of 5473.2. That is the level of water in the pit. It is perched above the groundwater which is represented by the level in the -- the well point No. 1, which we installed at 5471.2, which is in fact the same level as the surface water, 5471.2, which is a survey point directly below the -- where it says "swamp area".

Q Are all these elevations surveyed in, Mr. Hicks?

A These are surveyed by a professional surveyor.

Q And the arrow indicates what, sir?

A The arrow is an indication of the groundwater gradient, how it would be moving from the pit toward areas of lower groundwater elevation. It is the direction which groundwater flows.

Q We now have the table showing the elevations, the direction of the hydraulic gradient. Did you, consistent with the disciplines of your profession, take samples and preserve them in accordance with standards the water at the different monitoring sites?

A Yes, on the next page it shows that, where we did take samples from the well point which was installed and let me emphasis that the well points were installed so that the screen was in the uppermost portion of the uppermost aquifer.

The screen of these well points, which was 36 inches in length, sampled the top 36 inches of the aquifer.

The surface water sample, which is represented here by the survey point below "swamp area" was collected pursuant to strict EPA guidelines, as was the groundwater monitoring well.

Q This next page is captioned "Benzene Concentration PPB".

A That's correct.

Q Why have you selected benzene as the contaminant or the chemical in which to test?

A There's two primary reasons for the selection of benzene.

One of the most critical areas that you can -- one of the most critical concerns that we wanted to look at was to find out what is -- what was the impact from produced water itself. Many people have brought up other parameters which may be used but benzene is a parameter which is not found naturally in groundwater and we knew that we could use it as an adequate conservative tracer for groundwater studies.

The other aspect for the reasoning why we chose benzene is because it was of particular concern to the Oil Conservation Commission and we wanted to investigate the levels of benzene further in actual field studies to determine whether there was a problem with benzene itself.

Q Were your samples taken in the method approved by the EID?

A Absolutely.

Q And who conducted the analysis of -- from those water samples?

A ASSAIGAI Analytical Laboratories in Albuquerque, New Mexico, with cross checks by Rocky Mountain Analytical Laboratories in Denver.

Q Are those laboratories recognized as being competent laboratories to conduct this type of analysis?

A Yes, they are.

Q And what were the results of the analysis, Mr. Hicks?

A The results for the analysis by ASSAIGAI Analytical Laboratories are presented in this map.

The cross check with benzene -- for benzene levels was performed on three samples and the data from Rocky Mountain Analytical corroborated the levels that ASSAIGAI produced.

And for the sake of consistency, these maps reflect the data from ASSAIGAI Analytical, and what it shows is in terms of PPB from the well, from the produced water itself, from the separator, that we have a -- we have a concentration in -- from the separator of 53,010 milligrams -- I'm sorry, PPB benzene from the separator.

In groundwater itself, it was below the limit of detection.

Q All right, sir, let's go on to the next wellsite that was the subject of your groundwater monitoring and my book shows the McCoy site as being the next one.

A That's correct.

Q All right, sir, if you'll explain to us the water table elevation method.

A Using groundwater as expressed in the swamp area, the swamp area was in fact free standing water, using the Animas River as a line source for groundwater and our three groundwater monitoring wells, in addition to the water levels in the blowdown pit and in the produced water pit, we established the configuration of groundwater shown here.

The -- all of these groundwater elevations were surveyed by a professional surveyor.

The pits at the McCoy site, both the blowdown pit and the produced water pit itself, are in fact hand-dug wells. They are constructed and excavated into groundwater and the levels in the pits themselves do in fact reflect groundwater elevations; therefore, this site has very good control with respect to the direction and the gradient of groundwater in the area and it correlates quite well with what you would expect from the Animas River. You'll remember that Mr. Boyer's general hydraulic gradient was .004. We are off the river slightly and we show .007, which is well within expected ranges.

Q In your opinion have the monitoring wells been located at appropriate places so that if there is a plume of contamination from produced water in the unlined pit it would have been detected with the groundwater monitoring at these locations?

A What we have here is a situation where we look at the gradient at a point in time and we need to understand that the gradient will vary slightly in this area, very slightly, with respect to fluctuations in the river.

We located the groundwater monitoring wells down gradient from the pit and in fact I believe that they are fully representative of material which could have entered groundwater from the pit itself.

Q Sir, if we turn now to the benzene concentration map for the McCoy Well and have you describe that for us.

A The separator from the McCoy Well discharged directly into the produced water pit which was in fact excavated into groundwater and we saw that the pit itself had a concentration of benzene of two parts per billion.

The well that was installed immediately adjacent to the pit itself, as close as the fenceline would allow, as shown by this figure, also showed two parts per billion.

And the --

Q So we're straight on our map here, what is the groundwater standard in New Mexico in PPB for benzene?

A Twenty. Ten.

Q Ten.

A Ten.

Q Ten, right?

A Ten.

Q And show us what you found in the monitor wells.

A The Monitor Well No. 1 showed a direct influence from the pit itself. Indeed, it was the exact same concentration of benzene in this well.

So we are -- we are confident that this well has been affected by the discharge from the pit, albeit significantly below standards.

The down gradient wells, the wells which are directly down gradient from Well No. 1 and the pit, show less than the limit of detection for benzene in these two wells.

Q All right, sir, let's turn now to the Eaton Well site and have you describe the groundwater monitoring at Eaton site and the water table elevation there.

A The Eaton site was also fully evaluated with respect to wells. You can see that at this site there are seven groundwater piezometers for the determination of the elevation of groundwater. All of these points again were surveyed by a professional engineer.

The groundwater levels were measured by a professional geologist.

The -- this -- this shows an interesting relationship here in that the produced water pit appears to have a mounding effect with respect to groundwater; that there has indeed been an input of ground -- of produced water into the groundwater system here, as evidenced by this mounding near the pit. The actual gradient which is exhibited away from the pit is perhaps best reflected by the contours to the north and to the west.

So we had excellent control in this area with respect to groundwater gradients.

Q All right, sir, let's turn now to the benzene concentration map that goes with the Eaton study.

A Certainly. The Eaton site was extremely interesting because it contained a high volume of produced water. There was four barrels per day entering this pit, which was larger than -- than any site that I had personally visited with the initial 21 investigations and indeed subsequent investigations, as well.

This was a large contribution of produced water into an unlined pit.

The concentration of benzene in the produced water itself from the separator, not in the pit, from the separator, was 10,800 PPB.

Immediately adjacent to the pit, again, as close to the pit as the fenceline would allow, we intalled Monitor Well No. 2. This well showed 11 parts per billion benzene, a significant reduction.

The wells which were down gradient from the source of potential contamination, if you will, the produced water pit, showed levels below the limit of detection; again, a significant reduction from the 11 PPB that was noticed in the -- that was analyzed in Well No. 2.

Q If the Oil Conservation Commission applies the EID method of approving discharge permits to the Eaton, McCoy, and Paine well sites, would those wells receive a discharge permit?

A They would all be approved.

Q Why?

A Because in terms of the excedence of groundwater standards at a place of reasonable foreseeable future use, monitoring evidence has demonstrated that excedence of standards is not occurring at these sites.

Q Let me show you what I've marked as Exhibit Number Four, Mr. Hicks.

All right, sir, would you identify Exhibit Number Four?

A This is a result -- this is a compilation of OCD data and Geoscience Consultants, Limited, data with respect to the concentration of benzene in the separators from -- rather from water that is immediately discharged from the separators, as compared to the concentration of benzene which is observed in the produced water pits themselves.

Q Do you recall how Mr. Boyer made his dilution calculation in order to come up with an average of the benzene concentration that he used in that calculation?

A Yes, I believe he used on the order between 12 and 16 miligrams per liter. The exact figure was 14.5, I believe.

Q In your opinion is it appropriate for the dilution calculation to use a benzene concentration at that level?

A Based on Oil Conservation Division data I certainly wouldn't use that. I think that's too high of a source term based on what's actually in the pits.

Q What source term concentration for benzene would you use in the calculation?

A Well, in terms of -- if I was to calculate the simple dilution method where I would actually inject, if you will, water from a produced water pit into the groundwater, I would use 3.5 milligrams per liter -- sorry, 3.5 (not understood) terms of milligrams per liter benzene. That's the number I would use.

MR. KELLAHIN: Mr. Chairman, it might be appropriate to note on Exhibit Number Four that all these values are in milligrams per liter so that we don't use something else.

Q After conducting the field studies, Mr. Hicks, what conclusions can you draw with regards to your studies of the vulnerable area in terms of a small volume blanket exemption of 5 barrels per day of produced water into unlined pits in terms, first of all, of the potential contamination of groundwater by benzene?

A First I might -- my first conclusion would be that the data presented here in Table 1 with respect to the separators and pits shows that the initial calculations that were done by NMOCD exaggerate the nature of the problem.

There is apparently and obviously, and it's demonstrated in these examples, that there are mechanisms working in the pits themselves, which significantly reduce the source term for benzene in the pits.

My second conclusion would be that we have -- we have gone out to the field. We have performed field investigations of what can be considered a worst case scenario in the terms of the Paine site; in terms of the Eaton site, and found that in areas where effluent coming from the separators is extremely high, such as in the Paine site, that -- and where groundwater is very close, such as in the Paine site, that based on this field investigation there is not a problem in these areas.

At the Eaton site we show that there is a significant reduction in benzene concentrations between the pit and groundwater and there is not a problem with benzene concentrations in groundwater from these populations and indeed the McCoy site, which is more representative of the entire vulnerable area, we find that there, again, is not a problem with respect to benzene concentrations from these populations of wells.

And my final conclusion is that we have taken a random sample of the wells in the vulnerable area. We have found that a significant number of those wells contain no production equipment. We found that a significant number of those wells lie on bedrock and pose no threat to groundwater.

We found that in the river valley scenario, that there is not a significant problem with respect to benzene concentrations in groundwater, and in the valley side slope population there is not a significant problem with respect to benzene in groundwater.

And it appears to me, based on my field observations and field studies, that indeed the evidence concerning a small volume exemption appears to be quite favorable, that indeed the volumes that we looked at show that there is not a threat to groundwater.

Q Based upon your study of the vulnerable area, Mr. Hicks, do you have an opinion as to whether the

McCoy, Eaton, and Paine groundwater monitoring studies around those types of wells have given you an adequate basis upon which to determine whether or not the balance of the well population falls into one of those categories, excluding for a moment the Pictured Cliffs wells and the wells on bedrock?

A We -- we determined from this study that in a detailed site investigation that these wells are representative of what is actually in the vulnerable area, and these wells do represent the vast majority of wells and in fact are representative of all the wells in the -- in the San Juan Basin in terms of field studies.

Q In the vulnerable area.

A In the vulnerable area, yes.

Q And for each of those three well sites the actual groundwater monitoring and the field data that you've gotten on the sites and have had evaluated for benzene concentrations leads you to what conclusion about potential benzene contamination from the use of unlined production pits?

A Based on the data, I don't see a danger to groundwater contamination based on benzene input to groundwater from these wells, from these produced water pits.

We see significant degradation of benzene in the pits and we see significant degradation of benzene in the unsaturated zone and significant degradation of benzene in the -- in the wells themselves, or rather between the wells and the unsaturated zone.

It's simply not a threat to groundwater based on these field studies.

Q How comfortable are you, Mr. Hicks, with your conclusions about these wells and the way they represent the well populations in determining whether or not the conclusions you have reached are going to apply to wells located a half mile away from these sites or in fact at the other end of the vulnerable area?

A I investigated sites from Bloomfield to Navajo Dam to within sight of the Colorado border, and the populations that we have developed here based on sound hydrogeologic data bear out in all cases.

The side slopes in the San Juan Basin near Bloomfield are equivalent to the side slope scenarios in the Animas River, are equivalent to the side slopes up near the Navajo Dam. The geology, the surficial geology map demonstrates this. The soils map demonstrates this. And the field -- my own field observations demonstrate that there are these categories -- these -- these populations and they are consistent throughout the vulnerable area.

Q In your opinion is it appropriate to limit the investigation of the water chemistry to the benzene constituent?

A I think that there are other parameters of concern. Benzene certainly is the most critical, in my opinion.

There is, in fact, as Mr. Boyer brought out in his testimony earlier, a concern with respect to TDS and I may bring out that determining the TDS content and its input to groundwater from produced water is going to be very, very difficult for several reasons.

First of all, as anybody who has examined the vulnerable area will attest to, the salt concentration, the evaporative powers, if you will, acting upon the -- in the -- in the area are such that thick salt deposits can occur along the sides of the rivers themselves, which would add considerable noise to any study of TDS.

Additionally, as in all agricultural areas, where agriculture is intensified there is a loss of water due to evapotransporation on the concentration of salts in the soils themselves. Periodically these concentrations of salts need to be flushed into groundwater in order for agriculture to continue to operate.

Therefore, throughout areas, whether you're in the Rio Grande Valley, near Las Cruces, where there is no produced water; whether up in Farmington, or whether you're anywhere in areas of intense agricultural activity, you'll find high levels of TDS, not necessarily naturally occurring, but certainly occurring as a result of agriculture.

In the case of the San Juan Basin vulnerable area, we have two processes acting upon the aquifer to raise the natural level of TDS, and that is natural evaporation, as I discussed, where the salt deposits occur along the river banks, as well as agriculture, and it's interesting to note that TDS does not appear to be a problem at all, based on actual data from published reports, which Mr. Boyer also referenced in his earlier testimony.

Q In your opinion if we are to select a good diagnostic parameter by which to judge the oil and gas operation using produced water in unlined pits, would the selection of benzene be the appropriate parameter to select?

A I believe it would be. I believe it would be because of its -- its level of concern that has been expressed by the OCC, due to the fact that it is a constituent which can be -- which is generally mobile. It's not like many other organic compounds that become fixed in a soil. It can be transported and it is indeed found in the pits themselves, and so it would be a representative indicator parameter, absolutely.

Q When we talk about benzene in the three groundwater monitoring areas, you told us that you have found low concentrations of benzene that are well within the standards for groundwater in New Mexico.

A That's correct.

Q Do you have any reason to believe that the method of groundwater monitoring that you conducted at these sites was such that you simply missed it?

A I would find that very, very difficult to believe.

We installed these wells down gradient from potential sources, immediately down gradient from the potential sources.

In the case of Eaton we had excellent control for the groundwater gradient. We screened the well within the uppermost portion of the aquifer where we would in fact see, first see, any contribution of contamination from the pit.

In the case of Eaton we actually monitored the mound, the groundwater mound which is evidenced from leakage from the pit itself.

In the case of McCoy, we demonstrated that number -- Well No. 1 was -- excuse me, let me reference that correctly, make certain it's Well No. 1 at McCoy.

The well which is immediately adjacent to the pit at McCoy, it is No. 1, that showed an influence, a direct influence from the well itself. The other two wells were directly down gradient from this area of influence, and let me emphasize the scale of these maps. One inch equals 50 feet on these scales. These maps are on the order of 25 feet, 50 feet, from the potential source of contamination and the Paine site, as well, we monitored within 15 feet, 20 feet of the potential source of contamination, again directly down gradient from the source; again in the areas of uppermost aquifers.

I find it very difficult to believe that we would miss any source of contamination.

Q Mr. Hicks, you live and work in Albuquerque. You're a New Mexico hydrologist. You consult for lots of different people, and the Commission wants your own judgment about whether or not the Commission ought to continue the practice of allowing small volumes of produced water in the range of 5 barrels a day or less being placed in unlined production pits and ancillary pits at well sites in the vulnerable area.

Do you have any reservations about that practice continuing based upon the study that you have conducted?

A Let me preface my answer by two statements.

First of all, for two and a half years I worked for the Environmental Improvement Division as an advocate, if you will, of clean water.

My role as Technical Services Director for Geoscience Consultants also puts me in an advocate role for clean water.

Water pollution is a liability for my clients. It is not something that anybody will willfully do. If discovered, it -- and if it does occur and it harms somebody, it is a tremendous liability.

It's my responsibility to my clients to minimize that liability as much as possible and if there is a liability, point that out to my clients.

I did the same thing for the Environmental Improvement Division in a different capacity. I pointed out to the dischargers by disapproving plans or asking for more information with respect to what needs to be done in order to protect groundwater; in a sense to limit the State's liability for improper disposal of produced -- of water, waste water.

In this case I would have no qualms in recommending to the OCC that based on the data that we have today, the 5 barrels per day exemption would not influence the liability of my clients nor the liability of the State in terms of -- of degrading groundwater.

I have no qualms about making that recommendation based on the field evidence that I've collected.

MR. KELLAHIN: That concludes our direct examination of Mr. Hicks.

We move the introduction of Exhibits One through Four.

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

MR. STAMETS: I've got a few questions of Mr. Hicks that I would like to ask before we take a break.

CROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Hicks, if I interpret the work that you've done shown in Exhibit Three, this does show, does it not, that water which enters the pit is migrating out of the pit into the groundwater.

A That's correct.

Q All right. I think it does two other things. Tell me if I'm correct or if I'm wrong.

It seems to me that you've demonstrated as to the benzene levels, confirmed the theories that Dr. Miller testified to earlier today.

A It certainly seems to support his -- his testimony. It seems to be the field evidence that he had talked about.

Q Now, Mr. Hicks, it also seems to me that it confirms Mr. Boyer's testimony that a potential exists for pollution from produced waters migrating into the underground waters in the area, and let me kind of go ahead and explain what I'm talking about.

Let's say that we do have a TDS water, 30,000 TDS. That water could migrate vertically into the fresh water and could cause fresh water to exceed TDS levels. Is that correct?

A That's correct.

Q Okay. Now, in discussing Mr. Zaman's work and also in talking about Flora Vista, it seems to me that you were indicating that you did not believe that produced water was the problem; that you did not believe that the levels of hydrocarbons, soluble hydrocarbons in the produced water was sufficient to have caused the problems that were observed.

A I don't think that that would be a fully accurate interpretation. I think that perhaps, if I may clarify --

Q Please do.

A -- that the study that was done at the Duncan site, as well as the potential contamination or the documented contamination at Flora Vista, the data that were presented, or the data that are known about these sites is not sufficient by any means to narrow the source to a produced water pit.

There are indeed other, numerous other sources. I'm not denying that there's a problem or that there's a potential problem at these sites. Obviously, Flora Vista, for example, has high phenols and high oil and grease. There's a problem there, but what it -- what you can tie it back to, you need to study it more, in terms of the Duncan site, as well.

Q Well, let me interrupt. I felt that I heard in your testimony that -- that you seem to believe that it was crude oil or -- or distillate which had gotten onto the surface directly as opposed to dissolved hydrocarbons in the produced water; that that was more likely the source in your own mind than any dissolved hydrocarbons in the produced water.

A Especially, yes, I would say that that is especially true for the Duncan site where they actually dug through oil stained material. That is my opinion based upon the evidence that was presented.

In terms of Flora Vista that would also be true, that based upon the evidence presented it appears to be a different kind of hydrocarbon that you expect due to oil and grease contamination, yes.

Q In the three sites that you did the investigating on at the end of Exhibit Three, if one were to go out there and put six inches of distillate in that pit, do you believe that you would see benzene levels at much higher concentrations in the -- in the test holes that you have out there?

A I think I can direct you to the table that shows that, Table 1, Benzene Concentrations in Produced Water. Also the foldout of benzene concentration for the Paine site, which is foldout number two of our exhibit, and it shows --

Q Let me -- is that foldout number two of the last series?

A Yes, it is.

Q Okay. Okay.

A Benzene concentration PPB.

Q I've got it.

A If you look at what's actually entering the pit at the Paine site, we have an extremely high level of benzene entering the pit, yet on the far edge of the pit, if you'll -- if you'll notice here, there's a dot where we took the water level elevation and the water -- it's in the westernmost corner, okay?

The analyses, and you can plot this and I would recommend that you would plot this on your map itself, the analyses that we have under the Geoscience Consultants field data from Table 1 from Paine, the .002 figure can in fact be plotted at that point.

This shows that there is a significant reduction of benzene in this pit, and I may add that the levels of benzene that were seen here for 53 PPM is extremely high in terms of answering your question directly, based on these data, and the other data that I've seen, my feeling is that the distillate entering the pit by itself would not cause a significant elevation of benzene levels in groundwater.

Q Well, I'm not clear. I think I heard your answer but I'm not sure that I understand it, and it seems to conflict with some of the points you made during the testimony, again relative to the Flora Vista and what Mr. Zaman did. I felt that I heard you say that discharges of hydrocarbons themselves could be the cause of that and my point is to say suppose you've got an upset at one of these pits and you discharge a lot of distillate to that pit, and you've got fairly high transmissivity.

A Uh-huh.

Q You've got, at least in one of these cases, you've got the pit directly in the water table. Is that the kind of situation that Dr. Miller was talking about where the microbes could be overwhelmed and benzene could be moving away from the pit and reading in much higher concentrations than you show here where you've been able to monitor and you know there's nothing going in there but produced water?

A If there is a problem at a site where condensate is entering the pit at these levels that we see, or higher, I can't testify with respect to whether that would be overwhelmed or not, but certainly it would be higher concentrations of benzene than -- than we have seen in our investigation, and if I may clarify with respect to the Duncan site, where I felt that the source of contamination at the Duncan site may be crude or surface contamination, I may refresh your memory with respect as to how those samples were obtained, where they actually dug through what appeared to be oil stain, and in fact there was a jar of material that was brought in as an exhibit for this oil stained material.

I cannot testify to the sample collection methods, as to whether this particular material that dropped into the pit itself of groundwater was the culprit or whether there was certain extenuating circumstances with regards to sampling that occurred.

Based on what we've seen in the -- in the field itself, based upon our groundwater monitoring, the discharge, the surface discharges that may exist at the Duncan site would not cause contamination of groundwater unless it was introduced to groundwater and perhaps even sampled as part of the groundwater sample.

My feeling is that maybe, and I don't know, I can't testify with respect to how exactly it was sampled, I was not there, but that would certainly be one thing that I would want to do at this site, is we have values of groundwater, or we have samples that would show that there's benzene in groundwater, I think it would be appropriate to perform a study at the site pursuant to the strict EPA guidelines to see whether that is the case or whether it indeed falls into what we have demonstrated in the field and that there is no contamination.

Q Let me ask you the question this way. I'm wondering if perhaps as to organic contamination, if the Commission should be more concerned about accidental discharges of hydrocarbons directly, to the surface than to produced water.

A Absolutely, without a doubt.

Q Now you had quite a bit of testimony in here relating to a discharge plan process.

Are you suggesting that discharge plan procedures should be adopted for discharges to produced water pits in this area?

A The discussion with respect to the Water Quality Control Commission regulations and discharge plans was used as an example to show that the cases that we have investigated here, which are fully representative of the vulnerable area, would in fact be approved under a discharge plan process.

We feel, and I believe that many, especially industries that desire to locate in New Mexico, will testify that the discharge plan process is indeed strict and does indeed consider many kinds of -- of potential contamination sources, and using this strict guideline, we applied it to these sites to see whether it would pass this strict test, these sites that are representative of the vulnerable area, and indeed it did.

So it was used for illustrative purposes only and certainly not a recommendation to the Oil Conservation Commission to move toward a discharge plan process.

Q Mr. Hicks, you probably are not the one to ask this question, but I would like to --

A Don't ask it.

Q I would like to have some indication today or shortly after this hearing if these monitor wells that have been installed would be available for a cooperative sampling effort which would involve the companies that own wells and -- and the Oil Conservation Division.

A You're fully correct, I'm not the one to answer that question.

Q Today or sometime fairly soon.

MR. STAMETS: We'll take about a fifteen minute recess.

(Thereupon a recess was taken.)

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

Are there other questions of this witness?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Hicks, in your testimony you said that the EID permits dilution of a discharge in order to meet certain requirements. Is this dilution at the surface before it's discharged or are you counting dilution in the ground after discharge?

A Dilution in the ground after discharge, between the discharge point and the property line or the place of reasonable foreseeable future use.

Q Where did you get the quantity of volume of water produced for your study?

A From Tenneco and Amoco recent records.

Q Did you monitor the volumes yourself personally at these wells to determine that these volumes are correct?

A Visually we noticed or insured that in fact the wells were -- the separators were discharging.

At the Eaton site, for example, we did in fact witness a steady discharge. I'm not saying constant but consistent.

At the Paine site while we were -- in order to take the sample from the separator we had to -- you're probably familiar with tripping the separator -- we did that, and indeed water, produced -- produced water was produced from the separator.

Q So the volumes you used on your exhibit then are not from your own measurements.

A They're not from my own measurements.

Q In your water table elevation map for the McCoy Gas Com "D" No. 1 you showed that sampling point number one is upgraded from the produced water pit yet your benzene concentration map that follows shows the similar benzene level. Would you explain that?

A Yes. As -- as you are aware, in the river valleys there are seasonal fluctuations with respect to groundwater elevations and the absolute direction of flow in groundwater will change slightly throughout the course of a year or throughout time.

With respect to the -- I might also draw your attention to the fact that the gradient is rather low in this area.

And so we could have two mechanisms working with respect to obtaining the concentrations of benzene in Well No. 1.

The first is that the water table fluctuates slightly such that during periods of the year it is in fact directly down gradient from the pit.

The second mechanism that can be operating is dilution or dispersion and mixing in the saturated zone itself. The water is moving very slowly in this -- or the gradient is rather -- relatively low, and you can get diffusion away from the pit, such that the area of influence is much larger than the pit itself, and indeed, that's what I believe we are seeing in this case, is that the area of influence is larger than the pit itself and therefore it has affected Well No. 1.

That's my explanation.

Q You heard Dr. Miller testify earlier that he thought it would take over a year and quite a bit of money to do a test on one well, yet you have done a test in a short period of time on three wells.

Do you think that your data is adequate in that case, considering Dr. Miller's testimony, to -- for the Division to make a finding or do you feel that there is still more testing that needs to be done?

A Based on the data that we have gotten to date, I would feel comfortable with a ruling.

In terms of what Dr. Miller had indicated with respect to a study, I believe he referred mainly to quantifying the biodegradation process at a site, which may involve considerably more effort than simply quantifying what the actual field data are.

And so, you know, at the present time, I feel quite comfortable with the study that we've done and feel quite comfortable with the results and not having to spend a year in doing it.

Q Was it the, for my own recollection, was it the McCoy Well that had standing groundwater?

A That's correct.

Q Then it would not be unusual to find dilution of benzene in that pit upon the separator dumping into it, would it?

A That's absolutely correct.

Q In areas where dilution may not be sufficient within a certain proximity of the pit, would you consider perhaps adding water to the produced water, say, unpolluted water to the produced water before it goes into the pit for immediate dilution?

A That is, in fact, done in cases of other industrial discharges where the contaminants are -- are diluted prior to discharge. That occurs.

Whether or not it would be recommended in the case of produced water, I don't think it's necessary.

Q But it is a recognized technique used to put discharges within certain technical limits?

A There are better mechanisms. I feel that the dilution of contaminants is -- is really a last resort.

Generally the first resort that you would look for is natural, natural protection, natural degradation. If that's not the case, industries will generally go to a treatment system. If the treatment system still cannot protect groundwater, in that case, and in those extreme cases, there would in fact be a cause for advocating dilution, but as a consultant I have never advocated dilution of effluent for any long term -- long term waste disposal practice.

Q Why is that?

A I think it's a waste of water.

Q Is it a waste of groundwater?

A Yes, sir.

Q Is it a waste of groundwater to rely on natural dilution by introducing produced water into it?

A I don't believe so, because in this particular instance we see that the natural processes, which are acting upon produced water, actually clean up or treat, as was used -- the word "treatment" was used earlier, in a treatment zone. There actually are natural treatment zones which rehabilitate the water to usable concentrations and therefore I don't see that we are degrading groundwater by the use of unlined pits.

Q I don't understand that. Are you saying that your study shows that the natural processes of degradation are at work, not dilution?

A Apparently so, especially based on the Eaton site. As -- as you'll remember from my testimony, I talked about a groundwater mound that had developed around the Eaton site, and my feeling is, based on that groundwater data, is that the Well No. 1, I'm sorry, Well No. 2, which is located immediately adjacent to the pit, is actually located in that mound of produced water or water that's generated, recharges, if you will, from the pit itself, and based on those data, I feel that there is -- there are processes acting in the unsaturated zone that reduce the level of benzene from 3.5, 3.8, that area, in the pit to .11, I believe that's the number, to the number that I see in the monitor well.

Q Do your dilution calculations indicate that there are other processes at work besides dilution that would give you these values?

A I'm sorry.

Q Do your calculations of dilution show that there are other processes at work besides dilution to give you these values of benzene?

A Yes, they do. If you were to use the dilution calculation of Mr. Boyer, which he fully explained in his exhibits earlier, where -- if you were to use the input term, if you were to crunch through, if you will, the equation for the input terms that he used for 3.5 milligrams per liter, you couldn't result -- the end result would not be 11

PPB in that well by dilution alone.

There indeed have to be other mechanisms acting upon the source to reduce the benzene concentrations. Dilution alone does not give you 11 PPB from 3500 PPB.

Q Did you do any calculations which may indicate that the absorption of benzene to the alluvium beneath the pit may or may not have reached stabilization?

A We didn't do any calculations with respect to that, but it was considered in choosing the sites.

If you'll look for Eaton, you'll see that it was -- the spud date, or the turn-on date, if you will, the number used, the turn-on date is 1981 and of course we sampled in 1985. Throughout this period of time it was producing 4 barrels of produced water a day and we felt that if ever there was going to be a case for overloading with respect to sorption, this was going to be it, because a very, very large volume of water, if, you know, neglecting evaporation, the potential for a very large volume of water could pass through this column, if you will, of unsaturated zone, and therefore we chose this location because we felt that there was sorption going on, that it would have been fully saturated with respect to sorption if there weren't other processes.

I might also bring out that the depth to groundwater in this area is on the order of 13 feet and the depth of the pit is on the order of 6 feet, which will give us 9 feet. Hopefully my in-head subtraction is correct. 9

feet of saturated -- unsaturated zone, or 9 feet of column.

So we did consider the sorption processes in our site selection, but, no, we did not do any calculations with respect to sorption.

Q So you don't know for sure then. It was just an estimate that you made as far as whether or not sorption increased degradation?

A That's correct.

MR. CHAVEZ: That's all the questions I have.

RECROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Hicks, relative to that last series of questions, I noticed that the McCoy Well dates back to 1965 and that one again seems to indicate that you've demonstrated that Dr. Miller's theories are working even on a well that's been around for, oh, about ten years.

A Well, that's -- that is, in fact, one of the primary -- twenty years.

Q My math's as good as yours.

A That's, in fact, one of the reasons why we chose this site, is because it had been around for so long and we felt that there was indeed a twenty year history of produced water disposal at this site, and if there was going to be a problem with our quote average well throughout the long term, this was going to be it.

MR. STAMETS: Other questions of this witness?

Ms. Pruett.

CROSS EXAMINATION

BY MS. PRUETT:

Q As a former regulator and co-author of the --

MR. STAMETS: Ms. Pruett, could you speak up?

MS. PRUETT: Sure.

MR. STAMETS: I can't hear you.

Q As a former regulator and a co-author of the UIC regulations, did you do a study similar to the one you discuss in your exhibit at that time?

A In that particular instance a study was not necessary because it had been conducted and numerous hearings throughout a very, very long process had been conducted by the U. S. Environmental Improvement Agency throughout the nation.

These sets of regulations were developed throughout -- by looking at case histories. A lot of -- a substantial amount of data had been collected with respect to underground injection control, and was used in the regulatory development by the U. S. EPA, using industry and governmental staff.

What Mr. Boyer and I did was use these

regulations as the basis, a basis that had been fully accepted in the nation as a standard by which industry and government had established a standard, and we used that to write the UIC regulations.

Q So those sorts of nine steps were performed by somebody, it just wasn't you.

A Although I can't testify to that specifically because I don't know which studies, but if you look at the documentation with respect to underground injection control, indeed you would find, I would say, numerous stacks of technical arguments and papers on underground injection control from which the regulations were developed.

Q Did you do any monitoring other than at the three wells you've identified here?

A Groundwater monitoring?

Q Right.

A No.

Q The hydrogeologic investigation that you did on the fifty or sixty wells, I don't remember your exact number --

A Yes.

Q -- what did each investigation entail?

A The investigation for well site evaluation is shown on -- in my exhibit here, and basically it also entailed, under comments, my own professional opinion of what the site hydrogeologic characteristics were.

It's more than -- it's certainly more

than just making little checks on this piece of paper. It is an investigation that was done by myself, a certified professional geologist, where I can take into consideration not only these individual factors but locational factors, geomorphic factors, geologic factors, which are considered in this.

Q At the site itself did you do anything other than a visual inspection or from your -- from your own experience did you decide that was not necessary?

A We took photographs. I took photographs of each one of the sites. I got into the pits in numerous sites for a grain size evaluation, which has been of the exposed -- the exposed subsurface.

There were no sieve tests performed. The grain size evaluation was visual.

All of the examination was, except for the field -- the detailed sites, all of the examinations were visual.

Q You say the grain size evaluation was in the pit itself. How -- how deep? How (inaudible)?

A That depended -- that depended upon the site, of course, and the location. If there were -- generally the pits are five or six feet deep, so you can tell what's going on in the upper portions of the -- of the subsurface. Obviously, you can tell what's going on, or I can tell what's going on on the surface just by kicking around the dirt and seeing that.

I also in the course of the evaluation, if there was some question as to whether the materials changed significantly between the surface and the groundwater, I would look in arroyos and road cuts and other areas around the particular site so that I could make a professional determination as to whether it was significantly different below what I could see.

Q Are those judgments reflected on your forms and would you make those available to us, copies of those data forms?

A I believe I can, yes.

Q Are they going to tell us anything? I mean are there things reflected there or just calculations you did in your head?

A Well, much of it was -- much of it was done in my head. Much of it was done as a -- much of it was not written down with respect to that. Much of it is, in fact, reflected in some of the other maps and things which -- which explain the situation further.

So the forms, in terms of your -- your request, forms may be of -- of limited use to you but certainly they're available.

Q How did you determine the hydraulic conductivity for the purposes of breaking down the fifty or sixty wells into this rated population?

A The next page of the exhibit shows a chart from Freeze and Cherry, which correlates grain size distribution of unconsolidated deposits with the typical values for hydraulic conductivity.

These values have been, oh, they've been corroborated in the field through the use of the pump test data from McMann No. 1, which was a pump test conducted by the U. S. Geological Survey, that showed that in the gravel lenses that we're talking about for the Animas River, we're talking about in this case 10 to the minus third meters per second.

Normally what I did is, I would look at the site. I would determine where it fell within this category, and I would reduce it by an order of magnitude to be conservative.

Q But you didn't actually do any pump tests yourself?

A On the field sites that we did, we did not do any pump tests. We did observe recovery of the wells to determine its relative hydraulic conductivity in order to determine whether our estimates based on our visual examinations would be correct, and the recovery data that we got from our own site investigations and indeed the pump test data which the U. S. Geological Survey has conducted, corroborate what we felt to be accurate hydraulic conductivity values.

Q Again, most of these corroboration mechanisms are visual.

A Well, the corroboration methods weren't.

Most of my -- most of the data that I collected in my well site investigation was visual.

The corroboration was with actual testing.

Q Do you have any field notes or well logs that you could make available to us that we could look at more specifically on what you based your (inaudible)?

A I think that the photographs, perhaps, would be useful, as would the -- in conjunction with the maps showing where these are, as well as my field points.

Q And you'll make all those -- I realize the photographs will be in the Commission's files, but will you make those --

A I believe I can make those available.

Q Thank you.

Other than benzene, you didn't look at any other constituents of produced water even (inaudible).

A That's correct.

Q Now the Eaton Well, and correct me if I'm mistaking what you said, but my recollection is that you stated that when people applied for a discharge permit from EID, one would probably be granted on the basis of the information.

A That's correct.

Q But actually EID would require data on many other components other than benzene, isn't that correct?

A Yes, that is correct.

Q They'd certainly, require some information or more information, general information.

A Absolutely.

Q Do you have any data on heavy metals in produced water and whether it -- whether heavy metals are present or were traveling?

A I haven't presented any. I've seen some, and I think I can make it available. I think Mr. Boyer took some, as well, I think. I believe that they're in NMOCD exhibits, but I didn't look at heavy metals.

Q And you can't say for certain that other components, such as heavy metals or chlorides, would behave in the same manner that benzene behaves.

A I can speak toward heavy metals to a -- to a degree. My Master's thesis dealt specifically with uranium and the relationship between heavy metals and groundwater, and in most instances they can be sorbed onto the soil relatively rapidly, in many instances, especially in the presence of some organic matter.

They may be, in this environment they may be mobile. If they're present in the produced water it would be logical to look at heavy metals. We decided to look at benzene because of the reasons I discussed earlier.

Q The statement you made about the volume going into the pits, over what period of time of these records did you study?

A I was given data from Amoco and Tenneco. I don't -- I can't verify how long they did their particular studies or made their estimates with respect to the water produced. That data can be made available to you because I am convinced that there is a time span that they've looked at it.

Q I think it would be helpful for us to see whether that's an average of what time period and what -- we'd appreciate it if you would make that available.

A Sure.

Q The three wells that you mentioned, were they dry gas wells?

A They were -- dry gas meaning no condensate produced?

Q Meaning fewer hydrocarbons in the form of liquids.

A I am not an oil -- petroleum engineer or a production person. I can testify to the fact that at each one of these sites there were production tanks to store condensate and in the cases of Paine and Eaton, where there were two tanks because there were two different formations that they were producing from, but there were tanks present, there's condensate being produced.

And I believe the OCD would have records in terms of how much condensate.

Q Did you measure the specific production from any of these wells?

A I didn't personally, no.

Q So without any specific production measurement or any quarry testing you would still recommend five barrels per day for them?

A Based on benzene, yes.

Q But you can't say --

A Now, let me -- in terms of -- based on the benzene values we've seen I would recommend the five barrel a day. We haven't done the work, or the work hasn't been done with respect to TDS and it, in fact, would be relatively straightforward to do.

Q Right, and for the fact that you haven't done that, you can't say that five barrels a day exemption would protect groundwater from TDS or chlorides.

A No, I couldn't say that.

Q And you can't say that whatever it is that was operating at the time you did your investigation will continue to operate indefinitely.

A With respect to benzene? I think that it's been operating for twenty years at the McCoy site.

I think that it's been operating for many years at the Paine and again I'm not -- I'm not the expert to talk about how long these processes go on, but based on the testimony of Dr. Miller, it seems to me that it is a -- it is a constant regenerating type of mechanism, so based on that testimony I would say it would continue to go on, but again, I need to qualify that.

Q But in the event of an accidental discharge of liquid hydrocarbons of significant volume, you can't say whether what you observed might not be completely changed.

A I can't say that.

Q Thank you.

MR. STAMETS: Other questions of this witness?

MR. TAYLOR: I have some.

CROSS EXAMINATION

BY MR. TAYLOR:

Q Mr. Hicks, excuse me if my questions don't make sense. I think Mr. Stamets' chickens may have been at work here.

You said essentially that you agreed with Dr. Miller that the effects of attenuation tend to degrade the benzene and, I suppose, other organic hydrocarbons.

To what extent do you agree with him? If I could, I'd characterize his testimony as saying really don't worry about this, or it's not a big problem.

Just how do you feel about that?

A Well, to characterize it in terms of benzene on that same level, if we -- if we make the assumption that Dr. Miller said it's not a problem, that there are natural conditions existing and don't worry about it, it appears as though the field data corroborated that, and so with respect to benzene, it appears not to be a problem.

Q If that's true, though, how do we account for those instances where we have found those contaminants in an aquifer or in other situations?

A In other situations outside of the vulnerable area, let's say --

Q Right.

A -- in the State of New Mexico?

Q Say in the southeast.

A Okay. Well, I'm not familiar with the southeast in terms of what you're speaking of, but let me -- I am familiar with several sources of benzene contamination in groundwater where product, such as gasoline, unleaded gasoline, for example, or leaded gasoline, has leaked consistently from a tank or gasoline trucks or tank cars have lost their integrity or been punctured overturned, such that a large insult to groundwater has occurred due to very, very high concentrations of benzene over a very localized period -- localized area.

Those are the cases that I'm aware of, of benzene concentration, concentrations in groundwater busting standards, where you've got either a constant source of pure product or a large insult due to on the order of tank cars being ruptured.

Q This is more or less what we might relate to a spill --

A A spill, that's correct. That's where I have been -- a spill and constant leak of product is where I am familiar with benzene contamination in groundwater.

Q Would you go into the parameters you utilized in selecting the location of your monitoring wells a little bit for me? I didn't get to look at your exhibit and I don't know if that information is contained in it. How did you actually determine what parameters to look at in terms of --

A Initially what we did is we felt that by looking at hydrogeologic maps and water table maps in any alluvial valley, you'll -- one can recognize that the water table generally follows the contours of the land surface.

We assumed that this was going to be the case and we implaced (sic) groundwater monitoring wells down slope from the produced water pit itself.

In the case of -- of Eaton, I mean that was in the case of Eaton.

In the case of McCoy and in the case of Paine, the river was within sight. There was a swampy area within sight of both and based on the gradient of the river, we chose a down gradient direction.

If a survey, then we performed a survey and did water level elevations so that we can accurately determine the gradient.

And in the case of Eaton we went back in and put in more wells so that we would insure that we were directly down gradient from the source.

And so it was a two-step process. One step involved field observations. The next step, in the case of Eaton, involved looking at the water level contours and then putting in more groundwater monitoring wells to insure that we were absolutely down gradient.

Q On the same subject, how, looking at the 1200 wells in the northwest, did you decide which -- which wells to (almost inaudible.)

A In consultation with Dr. Francis Wall, we looked at the distribution of the 1200 wells in the -- in the vulnerable area, just by looking at an API map showing the locations.

We had a sub-population of 300 wells for which we had data from Amoco and Tenneco. Those wells were located in the Animas River and in the La Plata.

So from the 1200 we had 300 in two -- two areas of the river.

We looked at those, the geographic distribution of those 300 wells with respect to the other wells that are in the area and they, from a visual observation they appeared to agree with the distribution that was shown in the API map.

So from this 300-set of -- or from this 1200-set of data, we then reduced it to 300 that we had data on that we thought were representative.

From that 300 then we went -- we numbered each one of those and using a random number generator we generated 60 sites within that 300 sub-set population and we feel, after looking at the distribution of the 1200, after looking at the distribution of the 300, and after looking at the distribution of the 60, that these 60 sites are indeed representative of the Animas and the San Juan River in terms of their distribution.

So we did a statistically valid sampling and a random selection of wells, strictly based on how the data was presented to us, which was alphabetical.

Q I don't quite understand. How did you get down to the three --

A Oh, that's how we got to the 60. For the three wells, you'll -- you'll remember that initially we went out and we looked at 21 sites and we, again using our hydrologic reasoning, we -- and based on these 21 sites, we chose 3 sites which we felt were representative of the 21 that we saw, and that's -- and we tried to choose the worst case scenarios.

We chose one case where we had low transmissivity, low hydraulic conductivity with a large volume of produced water.

We chose one that had been around for twenty years where in fact we were discharging straight into groundwater.

And we chose another location where surface water was all around it and felt that this also reflected a threat to surface water as well as groundwater.

So what we tried to do is, in our heads we chose these three sites based on what we though was the worst case scenario of the populations that we saw, which were side slopes and valley situations.

Then to insure, it was only after we put in the wells, to insure that these wells were representa-tive, that's when we did the statistical analysis.

So the statistical analysis of the 60 was done after the selection of those first 3 and indeed the statistical analysis corroborated our initial feelings, if you will, that two populations exist.

Q You were here for Mr. Boyer's testimony, weren't you?

A That's correct.

Q He talked about when he did his model for the dangers of allowing pits, he had three ranges of perme-ability --

A That's correct.

Q 25, I guess that's feet a day, I'm not sure, 25, 250, and 2500, and he said there are actual cases in the alluvial river valleys of water moving 500 feet a day.

How did your situations around your moni-tor wells compare to -- to those numbers?

Do you have any idea?

A Well, yeah, I do have an idea.

The McMann No. 1 Well, if you'll look at the exhibit, it shows the estimated the hydraulic conductivities as a relationship to grain size. You'll see the McMann Well is pointed out there as 10 to the minus 3 meters per second. That's a little bit -- that -- that is approximately, I believe, if you trot off the calculations, you'll see that that is approximately 2500 feet per day.

Mr. Boyer, for his high transmissivity zone, or Mr. Boyer, in his calculations of his high key case, or high conductivity case, again field calibrated it with actual data from McMann, which was 10 to the minus 3, which is, or actually, I guess was more approximately 10 to the minus 4 gallons per feet per day. It's in that range that you see presented there.

That is, in fact, what our -- our high hydraulic conductivities are in our -- in the data that we -- how we broke it out. The high is what Mr. Boyer used. The medium is, in fact, his medium, and the low is what his low is. They're very compatible. They correspond except for the conversion factors you're going to get are slightly different; they're not exact, but they're -- they correlate very well.

Q You said on -- I believe you said that your monitor wells, or in some cases the limited detection of benzene, benzene was not detected. What was the limit that your tests show?

A One PPB.

Q And what is the State standard?

A 10 PPB.

Q What's your experience been with regard to the amount of time for an applicant to prepare and for a staff to evaluate discharge plan applications?

A It depends upon the complexity of the plan and the nature of the discharge and where it is. It's different for each one, but I can make some broad characterizations, if you wish.

Q Sure.

A For a sewage treatment plant where the constitutents are well known, they've been around for quite awhile, and the methods of disposal are for -- for effluent are well known, my guess is that it would take on the order of three and a half to four months, or less, for such a situation.

For an injection well, for example, I'll give you the other side of the range. For an injection well for waste disposal where there are -- well, at least a year ago there weren't any fully permitted in the state, there may one or two now, but an injection well, where it is a process that is not fully familiar with the State of New Mexico, the aquifers have not been fully tested with respect to how an injection well may react, it may take as long as a year and a half to two years to get a permit for an injection well.

A uranium mill would probably be along the same -- same lines, due to the complexity of the situation and a large volume discharge.

So, basically, we vary from three to four months to perhaps as much as two years.

That's been my experience.

Q If the Commission adopts some kind of a no-pit order and allows exemptions, what were your -- what are your feelings on a discharge plan type process for allowing those?

I don't know, you were talking about discharge plans a lot and I couldn't figure out whether you were meaning that there should be something like that or --

A Okay. Well, do you want my opinion as to what I would do for exemptions or that kind of a case?

Q Sure.

A I certainly wouldn't go to the discharge plan process per se, mainly because we group these into different populations here. We know -- we can see that certain things behave similarly.

So for a site-by-site basis I certainly wouldn't say that would be required at all.

Additionally, I think the discharge plan process per se would overwhelm unnecessarily the regulatory agency and I believe that some sort of an administrative rule would be far more appropriate. Individuals have brought up -- well, my feeling is that benzene may not be a problem or benzene is not a problem in this area. There may be some other parameters that would be of concern, but they're much more easily monitored, such as TDS. There can be, just as in the same method that you can have a low volume exemption, like the BLM does, you can tie that to a certain TDS limit and you can go through the calculations to show that if you've got X volume produced and the volume is a certain TDS, that, you know, you've got to have a lined pit.

Now that wouldn't be site-by-site. That would in fact be an administrative rule, very similar to a low volume exemption.

That's the process that I would go through and in order to deal with those parameters such as TDS as opposed to a site-by-site basis.

Q Again what parameters would you consider -- do you remember Mr. Boyer's testimony when he was talking about the -- what exemptions he would -- or what he recommended for exemption, and he talked about permeability of the soil?

A Yes. Yes, I do remember that. That would be -- in fact, if you look at the, oh, let's see, Well Sites Investigated report, the first two pages, or I'm sorry, the third page, where it says Bedrock Mesa Cases? I firmly believe that these bedrock mesa cases are in fact the cases that are very similar to the cases that Mr. Boyer was talking about where we have a produced water pit located on low permeability rock, where it would not enter groundwater from these unlined pits.

Those certainly would be exempted or approved or administratively handled in an effective manner in tne same way that we can devise a nomegram (sic) or a chart or something to deal with some of the other parameters that may be of more concern now than initially benzene waS, such as TDS.

Q Are all of these wells in the bedrock mesa cases category in the vulnerable area?

A Yes, they are.

Q Now you talked about the fact that in order to make any rule on this matter there were nine steps that you thought the Committee or someone should go through.

A Yes.

Q Are you aware that when this committee was set up there was a charge to them by the Oil Conservation Commission which was --

A I'm not aware of that. I've read the -- I've read the Produced Water Committee reports in terms of The charge made as to whAt it was supposed to do. I don't -- perhaps I jumped the gun in answering my question.

I'm not aware of any step-by-step process they should have gone through in terms of this study. Maybe you'd like to direct that question to --

Q I just essentially wanted to point out that they, you know, were not mandated to go through a study process to do this.

A Oh, yeah.

Q How many of the 1200 wells in the vulnerable area produce more than 5 barrels of water a day, do you know?

A I really don't have any idea.

Q And your recommendation is for no more than a 5 barrel exemption.

A Well, my recommendation would be that based on the data that I have seen to date with respect to benzene, that 5 barrels a day entering the groundwater, which is what the BLM uses for a standard and what I'm told that other states use as a standard, would be -- would be adequate to protect the environment. It would be consistent with the rest of the nation and indeed consistent with the field data that we've shown here with respect to benzene.

Q Are you familiar with whether either the States of Texas or Oklahoma have no-pit rules, or what rules they have in regard to this?

A I don't know. I honestly don't know. I'm aware of the rule in the southeast portion of the state and I'm aware of the -- of what the BLM requires.

Q You already said, however, that your recommendation does not consider heavy metals or TDS or any other constituents in produced water and that those should affect what the determination should be on exemptions.

A That's correct. My understanding was that heavy metals and TDS were much less of a problem than benzene when we first started this investigation. That's why we chose benzene for the parameter of most concern.

But we did not investigate the mobility of -- we did not investigate the concentration of heavy metals in produced water pits, nor did we investigate the total dissolved solids content of produced water pits.

We restricted our -- our study to benzene.

Q Dr. Miller, I believe, stated that he inspected the cost of a study just on one well, I think, to be about $500,000. Could you speak to that figure? Do you have any thoughts of your own?

A Well, in reference to the kind of study that he would conduct that may be the case. If you want to quantify the types of micro-organisms, if you want to quantify where microbiological degradation is occurring, that's in a one foot zone, how much occurs in two feet, you're talking about many, many examples from a site. You're talking about expensive analyses to quantify how much biodegradation occurs at given slices.

But I don't think the Division or the Commission is really interested as to what -- how much biodegradation occurs at any given site. I think what is more appropriate is are there mechanisms that do exist that would reduce the concentration of benzene between the produced water pit and place of reasonable foreseeable future use, and if that would be a goal of the study, it would certainly cost significantly less than half a million, a quarter of million, or a tenth of a million, or certainly for one well site I couldn't give you the exact cost, but I know that -- I know that the seven wells at Eaton site, for example, you're dealing with standard stainless steel screens, and you can use Environmental Improvement Division's hollow stem auger to put it down in that particular area because there isn't the high cobbles, and -- or you could use PVC. There's a number of different methods. You could cut down that cost tremendously.

Q Could you tell us approximately what the testing portion of your -- the study you did cost to drill monitor wells and have -- not the whole part of it, just drilling the wells and have samples tested and --

A Well, let's see. Let's -- I'd have to figure it out, if you can bear with me.

Q Just a ballpark figure.

A We've got a day of rig time. If you want to contract that out, that would be $800 with a hollow stem.

You've got -- well, you better say three days for the seven wells, so multiply three times 800.

Then you'd have the price of the materials. In this case I would use, if I was interested in heavy metals, TDS, and --

MR. KELLAHIN: Mr. Chairman, I'm going to object to the costs of doing this kind of work.

I'm sure Mr. Hicks would be more than happy to put a bid out if the Oil Commission would like to hire him to prepare evidence so they could support their case.

But the question of what this cost and what was involved here I don't think is moving us along in this process.

MR. TAYLOR: It may not be moving us along but I thought it might be of interest to the Commission, but we'll move along.

Q As to the fifty or sixty wells you checked out, what levels of water were discharged, range and average?

A Oh, boy. We had, I would say that they ranged from reported to be zero, and that's not Pictured Cliffs, I mean actual Dakota cases or Chacra or Pictured -- not Pictured Cliffs -- Mesaverde wells. They were reported to be zero. We went to the pit site and in many instances, several instances where it was reported to be zero there was standing water in the pit. There obviously was a discharge there.

So it was, all I can say, it would be very low, maybe on the order of an eighth of a barrel a day or less to as much as four to six barrels a day, and I'd say that, I would feel comfortable with giving you that range.

Q On the well site evaluation form in your exhibit, which I think is this.

A Yes.

Q I've got several questions about it and the first one is were the produced water rates on that those that were reported or were they actually measured?

A Those were reported. Well, let me take that back.

That was a list that was given to me by Amoco and Tenneco. With respect to what they were measured or how they arrived at that I can't testify, but I know that many of the wells, many of the separators were in fact tested or calibrated, if you will, to the pumper's estimate. The pumper is the individual that goes around to wells to check them out. He checks out how much condensate is produced to make sure that everything is operating smoothly.

He had a -- he gave an estimate of what the produced water would be, and I believe that in several cases it was calibrated with counters, but I really can't testify fully.

Q It wasn't done as part of your --

A No, it was not.

Q -- work?

A It was not.

Q How were the hydraulic gradient values and conductivity values determined at the site?

A Again they were my visual observations, where I would correlate the -- what I believed, based on my experience as a hydrogeologist and the observations at the site, what I believed to be the lithologic material below the -- below the pit, and then I correlated that lithologic material with hydraulic conductivity values that were given on the following chart from Freeze and Cherry, and I reduced it by an order of magnitude and if I can go through an example, at the -- at the McCoy site, for example, it was entirely gravel. There was very -- there was some fine sand mixed in but the matrix, what held that site together was gravel. It was not clasts of large material floating in a sand matrix. What held that site together was gravel.

So you could categorize that in the middle of the gravel category.

Then you cross over and you see that it's 10 to the minus 2 meters per second. I would then reduce that by order of magnitude that would more correlate with the field data and also to be conservative, and I would arrive at 10 to the minus 3 meters per second or 10 to the 4th gallons per day per foot squared as hydraulic conductivity.

So it was a lithologic evaluation correlated by this chart.

Q How did you estimate the depth to groundwater? How did you determine it?

A In many cases I couldn't fill that in from my field investigation. In many of the river valleys I was able to because I could actually witness groundwater in some of the pits or in -- by the river level being close by.

In order to determine what the level of groundwater is in the valley slope cases, for example, I had to go back after I visited the site, I'd come back to the office. I would look at the Kelly elevation, or the elevation of the well site and then the elevation of the river. I would look at the slope and hopefully I would find some -- some groundwater data from some of the published sources so that I could estimate what the hydraulic gradient was and then I would give my estimate of the depth to groundwater.

I might add, that task isn't fully completed at the present time, but there are blanks in the data that can be readily filled in with respect to the depth of the groundwater.

Q Did you do any drilling other than the monitoring wells?

A No.

Q Let's see, in reference to the Bureau of Mines map, which I don't remember which it is.

A This one?

Q I think so. Let me ask the question and we'll know.

A Okay.

Q Did you use it or did you intend it to be used for soils evaluation or did you (not understood)?

A I used this map when I -- when I was out in the field I recognized that there were striking similarities between the populations based on my visual investigation and I was curious as to how the side slope environment or the side slope population could correlate so well between Bloomfield and up near the Colorado border north of Cedar

Hill.

At that time I pulled this map out and indeed found that there were reasons for that and that was, the reasons were the density of the -- the density of the drainages and the types of material that these drainages provided in terms of sediment load to the valleys.

So that's how I used this map. I used it after the fact to corroborate what I was actually seeing in the field.

In terms of the soils investigation map, I believe it's just further evidence that you can break these down and they do fall into specific -- that's it's no great surprise, in other words, that we can divide these into two populations.

Q Let me see, I don't know if I can talk about this or not, but for a monitor well site did you obtain or calculate volumes discharged, frequency of discharge, hydraulic conductivity, those other items?

A Hydraulic conductivity at the sites with the wells was estimated based on the recovery rate of the wells after sampling and my visual inspection.

In terms of the water produced, again that was Tenneco and Amoco data.

Was there a third?

Q Let's see. Let's see, years of discharge, volumes of discharge.

A Well, in terms of total volume of discharge, you could take -- for the field sites we knew what date they came on line; it would just be a matter of multiplication to determine how much water had been discharged and we did not, I haven't performed that multiplication.

Q How comfortable are you that the gradient values are accurate, not seasonally influenced?

A In the case of Eaton I feel pretty good about that. I feel real good about that, that it is -- it's a little perplexing because it -- the gradient is actually up stream from the -- it actually flows up -- up -- not uphill, but it flows to the -- well, the San Juan River flows down to the east, or west, I'm sorry, the San Juan River flows to the west, whereas at the Eaton site the groundwater flow is more toward the northeast, and that may be influenced due to some recharge contributions from the canyon. I feel pretty good about that.

I feel real good about it, that that will not be influenced by seasonal fluctuations.

With respect to the McCoy Well and with respect to the Paine Well, I believe that those would be influenced by fluctuations.

Q Okay. With respect to the study plan in your Exhibit One, given 1200 oil and/or gas wells in the area, do you have any idea as to the number of sites that would have to be examined in order to obtain a 95 percent level competence?

A I haven't done that statistical analysis.

Q You mentioned hydrogeologic studies were done on at least 75 oil and gas wells. Does this include chemical analysis of groundwater at the sites?

A Well site evaluations, hydrologic well site evaluations, perhaps, is what was done in about -- was actually done at -- the forms were completed on approximately 50 to 55 wells.

Then we did the three -- three detailed sites, so again about 58 in there.

Then there's a list that shows other wells that I visited in the same area and did a mental evaluation of them, if you will.

So in terms of sampling the pits or groundwater, no, that has only been done on three sites, three wells that we -- well, let me take that back.

Pits, of course, and separators were sampled by OCD and I believe as well as ourselves, and I believe the data base shown here in Table 1, and with respect to groundwater monitoring, we're doing with these three sites.

Q Given the subject matter of the hearing, isn't a chemical analysis of groundwater at more sites necessary to come up with a valid --

A You know, I think that if we really had some high levels of benzene, I mean I'm talking strictly about benzene here, if we talked -- if we had some significant differences and some significant variations with respect to the benzene concentrations, or if indeed we were close to standards after you moved 20 feet away from the well, indeed I would be the first to recommend more sites to be studied, but the consistency of the data that we have here shows that in a mere -- in a wide range of hydrogeologic conditions we come up with the same result with respect to benzene and therefore I am comfortable, I would be comfortable doing more sites and I would be comfortable not doing any more.

Q But essentially from what I get, you only tested three sites and the rest were paper analysis or there was not testing done at the other 60 or 75 sites.

A Well, I think that in terms of -- there was testing done at other sites as reflected by Table 1 with respect to the degradation that occurred between the separators and the pits.

Indeed, that data, those data are consistent and they also agree with what we see in groundwater. It's just interesting that we've got this degradation occurring consistently in the pits and also in the groundwater and I feel -- I feel comfortable with respect to benzene at the present time based on these three sites, and again let me say that I would be comfortable putting some more -- doing some more sites; perhaps even doing a statistical analysis with respect to -- I wouldn't be comfortable doing it, perhaps OCD would be comfortable doing it -- with respect to looking at the representative numbers so that they can be assured of corroborating even these data, because I think it will.

Q Thank you.

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

MR. STAMETS: Other questions?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Hicks, I want to go back to the volume of waters reported produced from the well.

You said that of the 50 wells that you surveyed or visited some had reported zero water production, however, there was water in the pits.

Where did you get those volumes?

A They were provided to me by the companies.

Q It seems like the volume of water may be significant in the calculations, especially if we're looking at dilution and biodegradation.

If the volume of water produced instead of being four barrels a day would, say, be one-fourth of a barrel a day, how much difference would that make in your calculations of dilution to see whether or not biodegradation was or was not taking place, or if there were other factors?

A We based our calibrations on the data

that was presented in terms of our dilution versus biodegradation that I talked about earlier.

If you reduce the volume of water that was entered into the pits that again could potentially enter groundwater, dilution might be, might be more of a factor and it might not be. It would depend upon -- it would depend upon the actual data.

If we look at the sites, if we assume that the sites that we visited were -- did not vary significantly, i.e., we report 4 barrels, if we assume that it's not 40 and it's not .4, it might be 3-1/2, it might be 3, it might be 6, we've got a test case where we have a relatively high volume of water that shows no degradation of groundwater beyond 20 feet away from the pit.

Then we have another case of McCoy where we've got a low volume entered into the pit and again we have no degradation, so I can't say that the volume produced is really going to have a significant effect, whether it's dilution or whether it's biodegradation. I think we seem to be coming up with the same, same numbers despite the volume produced. That's just -- that's my feeling based on the data.

Q Assuming that -- you're assuming that the produced volume is exactly as was reported to you, is that correct?

A That's what I used in my mixing calculation.

Q But you still didn't answer the question. What significance would there be had the volume been 1/4th of a barrel, say, instead of 4?

A Let's use the Eaton site. I think that's what you -- in terms of 4 was reported, what would happen if it was 1, or 1/4? We would perform the mixing calculations and perhaps we would not have to -- have to call on as much biodegradation. Dilution would be a mechanism that we could call on to account for the values that we saw in groundwater.

It certainly is the first mechanism that I tried to use to determine how we got from 3.5 milligrams per liter in the pit to .11. I'm -- let me -- from 3500 PPB in the pit to 11 PPB in the closest well to lower limit of detection in the well at 20 feet away. Dilution wouldn't account for that. In this case at 4 I didn't run through the calculation for 1/4 but, you know, it may show that dilution would account for more of it, but I seriously doubt whether it would account for all of it, because what we're dealing with here is a large -- we're still dealing with a large source term relative to the standards. We're dealing with 3500 PPB in the source term and 10 PPB for the standard, or 11 PPB in our actual result.

I don't think that the underflow at this site would permit a quart a barrel. I can't say that for a fact but I could trot through the calculations, or Mr. Boyer could trot through the calculations to determine -- determine the answer to your question with respect to how much dilution would be occurring at a quarter barrel and how much we would get -- how low we could get standards calling only on dilution if it's a quarter barrel, an eighth of a barrel.

Did I answer your question?

Q No, but thanks a lot.

Is one of the criteria used for picking these wells that they were representative by produced water volume?

A The wells that we studied for the monitor wells?

Q Yes.

A I don't think that they were representative or necessarily representative with respect to produced water.

For the Eaton site we wanted to choose one where we knew we had a high volume and so we skewed it, if you will, to the worst case.

In the -- in the Paine site we again tried to pick a relatively high producer. It's -- our report showed that it was one barrel per day, and indeed the pit was, was not only a large pit but it did indeed have significant volumes of water in it.

And so again it was -- we tried to skew it to a worst case scenario.

In the McCoy case it was perhaps more representative and so we did not use produced water as a criteria for representativeness. We used the geologic and hydrologic criteria for representativeness and then tried to take what we believed was going to be the worst case for these kinds of populations.

Q In your exhibit you showed the McCoy Well uses one quarter of a barrel a day but it's a 20-year old well.

The other two wells produced more water per day but they are newer wells.

Did you try to make a determination over the life of the well whether or not they were similar in regard to the amount of produced water that was put in the pits?

A No, we did not.

Q In your work with the EID are you familiar with other cases of benzene in groundwater such as had occurred in Prewitt, New Mexico?

A I'm vaguely familiar with the Prewitt case.

Q In that case are you aware whether there is or is not benzene in the groundwater?

A I believe it is benzene in the groundwater.

Q Do you recall how long that benzene had been there?

MR. KELLAHIN: I'm going to object to this line of questioning. He's talking about the

Prewitt case, which I believe has nothing to do with an unlined surface pit disposal and is not the subject matter in this hearing.

MR. STAMETS: I'm sorry, I was conferring with our lawyer.

Mr. Chavez, what did you ask him?

MR. CHAVEZ: My question concerned the benzene in the groundwater at Prewitt, New Mexico, his familiarity with it.

I was trying to make the point of the dilution and degradation of benzene that has been there in that groundwater; trying to draw some analogies. It is within District III.

MR. KELLAHIN: Is that contamination from produced water being put into an unlined surface pit?

MR. CHAVEZ: We don't know. There is a produced water pit there.

MR. STAMETS: I hate to --

MR. KELLAHIN: Is this in the vulnerable area?

MR. STAMETS: I hate to muddy this record any further and so I believe that we should leave the refinery out the testimony.

Q Mr. Stamets earlier mentioned that our concern should also include spills and upsets as well as produced water.

What sort of protection do the unlined pits provide in the event of these occurrences?

A They'll contain a spill of the magnitude that the -- the volume of the pit and permit that kind of containment until you can get a vacuum truck or a pumper there to clean it up. That would be my answer.

Q Should some contingency planning be required since spills and upsets may be equal or of greater import than a small volume of produced water?

A I think there's an economic incentive to do so by the producers. Keep in mind that the pumpers are going to the wells on a daily or almost every other day basis. If there's condensate going into the pit people are losing money and there's an economic incentive to get a truck out there, A, first to fix the problem; B, to get a truck out there to recover what you've got.

Q Mr. Hicks, based on your study have you come up with any idea or thought of what an upper limit might be for allowing the discharges into unlined pits in the vulnerable area?

A Based on our study of benzene, benzene being what we believed to most the critical parameter, it appears as though 5 barrels of day being consistent with the other orders of the -- that I'm aware of, would be an upper limit.

MR. CHAVEZ: No further questions.

RECROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Hicks, earlier I believe you indicated that there was to your knowledge no contamination of drinking water in the San Juan Basin from produced water, is that correct?

A That's correct.

Q And that was not necessarily counting the Flora Vista site, which -- it's not counting Flora Vista --

A I --

Q -- and I'm not asking you to say that Flora Vista's produced water, but if we dismissed that one from consideration, there is no site?

A None that I -- none that I am aware of.

MR. STAMETS: Mr. Chavez, even though you're not under oath, from your experience as director and supervisor of that District Office, does that square with your recollection of the situation there?

MR. CHAVEZ: Yes, sir.

Q Mr. Hicks, how much could rainfall affect the figures that you show on these -- on Exhibit Three, as far as dilution is concerned?

A Rainfall falling in the pit, for example?

Q Yes, right.

A We've got a volume of fluid in many of these pits -- well, I guess it would depend on how much volume is in the pit to begin with. If we got an inch rain and there's only a half inch of fluids standing in the pit, the rainfall would be a significant factor in sampling the pits.

If in fact there is 4 feet of standing water in the pits and we get a half inch of rainfall the impact would be much less significant.

Q Would it be possible to make a calculation, not today, but sometime before a decision is rendered in this case, relative to one of these facilities based on only a quarter of a barrel instead of 4 barrels and what the effect would be of rainfall?

A A theoretical --

Q Yes.

A --mixing model --

Q Yes.

A -- that would consider a quarter barrel a day and the input of rainfall into the pit. Do we then consider evaporation as well?

Q Yes.

A Do we give any consideration to volatilization of benzene?

I don't -- we've got some -- I hate to simplify this thing to two or three things when we do have some -- some complex mechanisms acting.

Q Whatever you'ld like to throw in.

A It can be done.

Q Are your clients willing to pay for it?
A Don't ask me that.
MR. BUYS: Yes.
MR. STAMETS: Very good. We'd be appreciative if you could supply us with that information at an early date.
Q Mr. Hicks, I'm trying to figure out how we could handle some of these things.
I'm wondering if this would be a reasonable, practical was to do it, to require, say, a pit registration in the vulnerable area, where the owner would put his name down, put the location of the pit down, give us some specifics as to pit size and depth, the volume of water that goes to that pit, and then the water analysis, which would perhaps include TDS and Water Quality Control Commission standards. I'm not sure which standards ought to be used, surface water standards or groundwater standards, and require a ban, automatic ban if volume is over 5 barrels a day, or if any of these standards are exceeded.
A In the -- in the pit itself?
Q In the water going to the pit.
A Oh, I don't -- I don't think that would be representative. I think that would be -- I don't think it would work that way because we -- we're talking about several mechanisms in the pit itself that reduce certain constituents; additionally there's only certain constituents that would be of concern, and I think the representa-

tive, perhaps a more representative sampling with respect to some of the concerns that the EID has brought forth with respect to heavy metals or bringing that data to light.

We've recognized that the water going to the pit is considerably higher in benzene, for example, than the water that's in the pit itself.

We've also shown that benzene may not be, or according to the field studies is not a concern with respect ot groundwater degradation.

Perhaps --

Q I'm thinking more in terms of arsenic and chlorides, those type constituents.

A I think that --

Q If we have a produced water which exceeds the level of arsenic by 2, should that be allowed to be disposed of in an unlined pit?

A I think that what can be done is that, too, can be calibrated similar to what we've done to benzene.

As we found that benzene is not a problem with respect to groundwater, perhaps the same is true for arsenic. There may be some parameters that are of concern. There may be some parameters that need to be further investigated.

One of the things that I could -- I could foresee would be a pit registration similar to what you're talking about where the volume of water is produced and then the specific conductants of that -- the specific conductants, of course, can be related to TDS. The specific conductants of that fluid in the pit itself would then also be submitted to the OCD so that a calculation with respect to TDS may be permitted and you would be able to draw your order from that. With respect to the heavy metals, perhaps that needs some investigation for field corroboration or some theoretical aspects which I don't believe have been brought out in this -- in this hearing at all, with respect to the mobility and the potential effect of heavy metals.

Q Is such a registration also reasonable to contain a spill or upset contingency plan?

A I think that a standard plan for the entire Basin would apply. For the vulnerable area, rather.

MR. STAMETS: Any other questions of this witness?

You may be excused.

At the last go-round when we asked who all was going to testify, it seemed like half the audience stood up.

How many more witnesses do you have at this point?

MR. KELLAHIN: Mr. Chairman, we might be able to figure out what to do about the balance of our case in the evening hours. I can't guess for you on the number of witnesses just now.

We need to talk about Mr.

Hicks' testimony and determine if we are going to put on additional witnesses. We could have as many as four. We could have as few as one. We need to talk about that.

MR. STAMETS: We're certainly planning on going home right away.

I'm trying to figure out whether to tell my fellow commissioner here that maybe he needs to plan on staying late, but we can work on that tomorrow.

We do need to finish this thing up tomorrow. I don't want to restrict anybody's testimony but we have a record that some sort of order can be based on and not just go on and on and on arguing the same points over and over again.

MR. KELLAHIN: Well, from the point of view of the producers, I believe we could finish tomorrow but I do not know what additional witnesses the Division's calling or whether EID proposes to call a witness.

MR. STAMETS: Ms. Pruett, at this point do you have any idea of putting on additional testimony?

MS. PRUETT: We have one additional witness that we're holding in the wings and at this point we don't plan to have him testify but we don't know what will happen tomorrow.

MR. STAMETS: Mr. Taylor.

MR. TAYLOR: Mr. Chairman, we

have, I think, one rebuttal witness who will take just a few minutes time.

MR. STAMETS: We'll recess this hearing until 8:30 tomorrow morning.

(Thereupon the hearing was recessed until the following morning, being 23 April, 1985.)

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