BEFORE THE UTAH WATER QUALITY BOARD

IN THE MATTER OF)
)
PR SPRING TAR SANDS PROJECT, GROUND)
WATER DISCHARGE PERMIT-BY-RULE)
)
No. WQ PR-11-001)
)

Bozeman, Montana
April 27, 2012

VIDEOTAPED DEPOSITION UPON ORAL EXAMINATION
EDWARD L. HANDL, P.E.

PREPARED FOR:

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May 2, 2012

Mr. Edward L. Handle, PE
JBR Environmental Consultants
121002 Browns Gulch Road
Butte, MT 59701

RE: No. WQ PR-11-001, In the Matter of PR Spring Tar Sands Project, et al.

Dear Mr. Handl:

Enclosed please find a copy of your deposition taken on April 27, 2012 along with a Deponent's Certificate and a correction sheet.

Please read the copy of your deposition and fill out the correction sheet as needed. Sign the Deponent's Certificate *and* the correction sheet before a Notary Public, and then return both documents to us within thirty (30) days of the date hereon.

The copy of the transcript is yours to keep. If you have any questions or concerns please feel free to call our office at any time.

Truly yours,

Charles Fisher Court Reporting
CFCR:lf
Enclosures

cc:
Christopher R. Hogle
Joro Walker
Rob Dubuc

In the Matter of PR Spring Tar Sands Project, et al.

Edward L. Handl, P.E.
April 27, 2012

Charles Fisher Court Reporting
503 East Mendenhall
Bozeman, MT 59715
(406) 587-9016
maindesk@fishercourtreporting.com

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BEFORE THE UTAH WATER QUALITY BOARD

In the Matter of
PR Spring Tar Sands Project,
Ground Water Discharge
Permit-by-Rule

No. WQ PR-11-001

VIDEOTAPED DEPOSITION UPON ORAL EXAMINATION OF
EDWARD L. HANDL~~E~~, P.E.
VIDEO CONFERENCE

BE IT REMEMBERED, that the videotaped deposition upon oral examination of EDWARD L. HANDLE, P.E., appearing at the instance of U.S. Oil Sands, was taken at the offices of Charles Fisher Court Reporting, 503 E. Mendenhall, Bozeman, Montana, on Friday, April 27, 2012, beginning at the hour of 9:54 a.m., pursuant to the Utah Water Quality Board Rules of Procedure, before Jan M. Baldensperger, Court Reporter and Notary Public.

APPEARANCES

ATTORNEYS APPEARING ON BEHALF OF U.S. OIL SANDS:
Mr. Christopher R. Hogle, Esq.
Mr. M. Benjamin Machlis, Esq.
Holland & Hart
222 S. Main Street, Suite 2200
Salt Lake City, Utah 84111
(Mr. Machlis present in Salt Lake)
(Mr. Hogle present in Bozeman)

ATTORNEYS APPEARING ON BEHALF OF LIVING RIVERS:
Ms. Joro Walker, Esq.
Mr. Charles R. Dubuc, Jr., Esq.
Western Resource Advocates
150 South 600 East, Suite 2A
Salt Lake City, Utah 84102
(Present in Salt Lake)

Appearances (Continued)

ATTORNEY APPEARING ON BEHALF OF THE EXECUTIVE **SECRETARY:**
Mr. Paul McConkie, Esq.
Assistant Attorney General
160 East 300 South
Salt Lake City, Utah 84114-4870

VIDEOGRAPHER: Laura Fisher
ALSO PRESENT: Barclay Cuthbert
Dr. William Johnson

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MS. C. FISHER: This is the video and video conference deposition of Ed Handl taken before the Utah Water Quality Board, Cause No. WQ PR-11-001, in the matter of PR Spring Tar Sands Project Groundwater Discharge Permit-By-Rule.

Today is April 27, 2012. The time is 9:54 a.m. We are present at the offices of Fisher at 503 East Mendenhall in Bozeman, Montana. The court reporter is Jan Baldensperger, and the video operator is Laura Fisher of Fisher Court Reporting. The deposition is being taken pursuant to notice.

I would now ask the attorneys to identify themselves and who they represent, as well as where they are attending from.

MR. HOGLE: This is Chris Hogle. I am an attorney for U.S. Oil Sands.

MS. WALKER: Joro Walker, attorney for Living Rivers.

MR. DUBUC: Rob Dubuc, attorney for Living Rivers.

MR. McCONKIE: Paul McConkie, attorney for Executive Secretary.

MS. C. FISHER: The court reporter will now swear the witness in.

(Whereupon, the witness was sworn.)

WHEREUPON, the following proceedings were had and testimony taken, to-wit:

****

EDWARD L. HANDL, P.E.,

called as a witness herein, having been first duly sworn, was examined and testified as follows:

EXAMINATION

BY MR. HOGLE:

Q. Please state your name.

A. My name is Ed Handl.

Q. Where do you live?

A. I live at 42 Ballard Lane in Whitehall, Montana.

Q. How are you employed?

A. Employed by JBR Environmental Consultants, based in Sandy, Utah, but my offices are in Butte, Montana.

(Whereupon, Exhibit No. 6 was marked for purposes of identification.)

BY MR. HOGLE:

Q. Mr. Handl, you're here today in this matter because you've done some -- some work for U.S. Oil Sands in this matter. Right now I want to

ask you a little bit about your -- your background, your education, and your employment, but before I do that, I've marked as Exhibit 6 a copy of your resumé. I hand it to you, and I ask you if you recognize that as your resumé.

A. I do, yes. This is my resumé.

MR. HOGLE: And then I offer Exhibit 6 as an admission -- I'd move to admit Exhibit 6 as an exhibit in this case.

BY MR. HOGLE:

Q. Now, tell us a little bit about your educational background.

A. My education is a B.S. in chemical engineering from Montana State University and a master's of science in chemical engineering from Montana State University.

Q. When did you get your master's?

A. I received my master's in 1972.

Q. And your B.S.?

A. 1970.

Q. All right. Now, give us your employment background.

A. Well, I started -- my first professional employment was with 3M Company. It was a summer job. Then I worked for a number of different firms.

I -- I started with -- after -- after I worked for -- that summer job, then I started my full-time professional employment with Dow Chemical, worked for them for a few years.

Then I went to work for the Montana Power Company. Then Montana Power -- in several positions with Montana Power -- then I left Montana Power to work for a subsidiary of that company called Special Resource Management, which was an environmental-related firm, working in waste management and environmental consulting.

Then we spun off from Special Resource Management and formed a company that -- that I was the majority owner in, and that was called Atlatl Incorporated. And then Atlatl Incorporated was merged into JBR Environmental Consultants in 2008, and I've worked for that company since.

Q. Okay. When did you start for Special Resource Management, approximately?

A. Approximately, that would have been about nineteen -- I think around 1988, in that area.

Q. Okay. And since 1988, could you describe the focus of your work?

A. The focus of my work has been primarily environmental related. I've worked in such items as

permitting. I've worked in pollution control. I have done contamination assessments, designed and constructed and started up remedial operations to remediate contaminated sites.

I've been in business management and -- and managed firms. Also, I've done some safety and health work and training of people for OSHA HAZWOPER compliance, hazardous waste operations compliance.

Q. Okay. And are you a registered professional engineer?

A. I am a registered professional engineer. I was originally registered in California, and I believe my registration began in about 1977, and I've been registered -- then obtained reciprocity in Montana. So I'm registered in Montana and California.

Q. All right. Now, you were asked by U.S. Oil Sands to perform some work for this case; correct?

A. Yes, that's correct.

Q. Now, the -- the work you were asked to do, is that the kind of work you do -- that you have done since approximately 1988?

A. Yes, it's akin to that work. It -- it fits in with the type of consulting and deals with

the types of problems that -- that I have dealt with previously.

Q. All right. And in your work since 1988, you've dealt with real mine projects; correct?

A. Yes, I have. I constructed -- designed, constructed, and consulted on a number of systems that have resulted in actual field work.

Basically, a lot of my work has been boots on the ground type of work, very pragmatic type of work, where we've actually installed or operated systems or dealt with actual client problems that -- that exist from environmental transport -- or environmental contamination or permitting procedures and in, occasionally, litigation procedures.

Q. And your work for projects -- if I understood what you said -- sometimes it begins with the design phase?

A. That's correct.

Q. Okay. And you perform calculations and projections in that design phase?

A. I do.

Q. Okay. And have -- are your calculations and your projections validated with actual experience on the ground when the projects get up

Page 13

and running?

A. Oh, most definitely. That's one of the things I enjoy about this work is that I can get a chance to design those projects and then -- and then see how they conform to the design when they're operating, and that's -- that's part of the closure that -- that we do on our projects.

It's a full cycle type of a project when we can design it, operate it, close down a site, and complete the report. So we see the full cycle many times.

Q. And that's been your experience since approximately 1988?

A. Yeah, starting in 1988. Actually, about -- I guess it was 1986 when I started with Special Resource Management. But that's -- that's a typical cycle.

Q. What were you asked to do for this case?

A. I was asked to review Dr. Johnson's testimony and review his calculations and opinions and offer comments and critique of -- of -- of those works that he's provided.

Q. And what approach did you take in this case?

A. Well, initially I reviewed Dr. Johnson's work and formed some opinions regarding that work and then felt that it was necessary to provide an independent approach to contrast the results that -- that he came up with to what I felt was appropriate from a -- from a different -- completely different perspective.

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Q. And what was the -- I mean, describe for us the independent approach that you took.

A. The approach I took was a traditional chemical engineering approach that starts with utilization of a ternary phase diagram to model the three-component liquid system that U.S. Oil Sands is using to extract bitumen from the -- from the oil sands, the three components being water; d-limonene, which is a terpene chemical; and bitumen, which is the material that they're attempting to extract from the oil sands and produce as a valuable product.

Q. Okay. You mentioned -- just for purposes of defining terms, you mentioned a ternary phase diagram. What is that and why is it useful?

A. Well, ternary phase diagram is a diagram that graphically shows the relationships between the three components in -- in the liquid system. It -- it shows the equilibrium relationships between the three chemicals.

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In -- in our particular case, we have what is called a ~~Phase~~ TYPE 2 ternary diagram in which there are two immiscible or partially miscible phases, one phase being an oil-rich terpene phase which contains the bulk of the d-limonene and the bitumen, and the other phase is an aqueous phase which contains very minute concentrations of d-limonene and bitumen.

Q. Okay. And did you prepare a figure for this case that shows a ternary diagram?

A. Yes, I -- I did. I prepared a diagram that depicts a generalized ternary diagram, first of all, that will describe a ~~Phase~~ TYPE 2 system and --

Q. Before you get there --

A. Oh, excuse me.

Q. -- let me go ahead and mark it.

(Whereupon, Exhibit No. 7 was marked for purposes of identification.)

BY MR. HOGLE:

Q. Okay. I'm handing you what's been marked as Exhibit 7, and do you recognize that --

A. Yes. This --

Q. -- tell us what that is.

A. -- I do. This is the diagram that I prepared, a hand -- hand sketch.

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Q. Okay. Could you put that in the -- in the document camera so --

A. Yes.

Q. -- we can see that. All right. And this is a ternary diagram?

A. Yes, this is a -- this is a ternary diagram -- a generalized ternary diagram for a system similar to water, d-limonene and bitumen. It is not the exact ternary diagram, but it represents the -- the principles that -- that I would intend to talk about.

The diagram has three apexes -- it's a triangular plot -- and each apex represents a pure component. For example, the lower left-hand apex of the diagram represents pure water. The lower right-hand apex represents pure d-limonene, and the upper apex represents pure bitumen.

As we move away from any one of those apexes, the concentration decreases for that particular compound. So as I trace downward in this direction, the bitumen concentration would -- would decrease. And the same for the other apices.

So the relationship, then, is defined -- the relationships that we -- we want to talk about are the equilibrium relationships which are formed by these two lines in this Type II ternary diagram. There are two phases here: an oil-rich phase, which is represented by the line in the upper right-hand of the diagram, and then a raffinate phase, which is -- the nomenclature describes a water-rich phase. That -- that is the raffinate phase.

And the raffinate phase contains very dilute concentrations of the bitumen and the limonene; whereas, the extract or oil-rich phase contains very concentrated concentrations of -- of those two materials. So all possible combinations of this system in terms of any of the three components can be plotted on this diagram.

If we start out with a system that is -- or a concentration where I'm pointing here, that actual distribution of -- of compounds will distribute between the oil-rich line and the water-rich line and be -- be able to be plotted on those two lines. So any -- anywhere that -- in this diagram -- that a -- a possible combination of those chemicals exists, they will distribute to those two lines. So that -- that forms the equilibrium relationship.

Q. Okay. Now, there's a reference on this Exhibit 7 to a Perry 5th Edition.

A. Yes.

Q. Does Perry -- is -- is that an authoritative treatise?

A. Yes. Perry's Chemical Engineering Handbook is the -- the bible of chemical engineering. It's been used for -- for years and years. I was produced -- presented with my first copy of Perry's Chemical Engineering Handbook when I was a -- a junior in chemical engineering at Montana State University, and I still keep that as a keepsake. But all chemical engineers that -- that I have ever met own their own copy of Chemical Engineering -- Perry's Chemical Engineering Handbook and utilize it frequently.

(Whereupon, Exhibit No. 8 was marked for purposes of identification.)

BY MR. HOGLE:

Q. Okay. And I'm handing you what's been marked as Exhibit 8, and that is -- is that Reference No. 2 to the expert report that you prepared for this case?

A. It is.

Q. Okay. And are those -- is -- are those -- excuse me -- is Exhibit 8 excerpts from the Perry handbook?

A. It is, from the 1973 edition.

Q. Okay.

MR. HOGLE: I move for the admission of Exhibit 8.

BY MR. HOGLE:

Q. Now, on -- back to Exhibit 7, you've got this Phase -- this Type II ternary diagram, and explain to us where -- what type of mixture or what materials we're concerned with in this case in terms of post-process.

A. In post-process, we're primarily interested in the raffinate phase, which is the water-rich phase, contrasting that to the oil-rich phase which is -- which is separated out for further processing and separation of the -- of the bitumen, which -- which is the product.

The raffinate phase is what we're concerned with in terms of the residual sands that have been washed by the process and are -- are then produced as a -- a byproduct of -- out of the process.

The raffinate phase will be used to describe water that could potentially come into contact with those processed sands and come in -- then form an equilibrium relationship with the

remaining bitumen that is in those sands. That water, then, will be described by the -- the ternary diagram equilibrium line for the raffinate phase --

Q. Okay.

A. -- so that forms the basis of -- of making the projections.

Q. And is this Figure 1 in Exhibit 7 -- is this to scale, or is this just meant for demonstration purposes?

A. This is just a demonstration purpose. In actuality, the -- the components that we are dealing with in this particular case for the two phases have certain characteristics that make it difficult to actually show a -- a discernible line on the diagram.

For example, the oil phase is so rich in oil that it's very close to the -- the axis of the diagram. Additionally, the raffinate phase is so dilute that it is in the very, very corner of the diagram as well.

So this -- this Figure 1 is merely a -- a depiction of the relationships and not a -- an actual picture of what the ternary phase diagram for the system in -- in question looks like. I do have that in my report, however.

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Q. Okay. Now, did you describe -- did you complete your description of the approach that you took in this case?

A. No. The -- the approach started out with the ternary diagram and then proceeded to add additional calculations and extract -- or not extract -- but develop from the ternary drawing -- diagram an equilibrium relationship between the bitumen and the water in -- in the raffinate phase.

And then, from that, I was able to do calculations, based on other information, regarding concentrations of specific chemicals in the raffinate to project what real expected concentrations would be in the raffinate system with regard to some of the polyaromatic hydrocarbons that are in question. That was then used to compare what may have been an equivalent concentration from the virgin sands prior to processing.

So I think that -- that really forms the basis of -- of what I was attempting to do in my contrasting analysis to what Dr. Johnson provided, in that I was trying to compare the virgin sands' water contact relationship with the processed sands' water contact relationship.

Q. Okay. To the end of determining what impact on the concentration in bitumen would be the outcome of the U.S. Oil Sands process; right?

Page 22

A. Yes.

Q. Okay. Now, you mentioned that after -- you started with the Type II ternary diagram, and then you performed additional calculations.

Where did you -- what was the source for your -- the equations that you used for those calculations?

A. I -- I used the relationships from the Perry's Chemical Engineering Handbook, first of all, to plot out the actual ternary diagram. Now, could I -- could we see that?

Q. Sure.

A. It might be easier to --

Q. Sure.

(Whereupon, Exhibit No. 9 was marked for purposes of identification.)

BY MR. HOGLE:

Q. Okay. I'm handing you what's been marked as Exhibit 9. Do you -- can you identify that for us?

A. Yes. This is the actual ternary phase diagram that -- that I prepared for the water, d-limonene, bitumen system in this -- this matter.

Page 23

Q. Okay. Put that in the document camera so...

A. Will I have to turn it this -- this way to make it fit or --

Q. You can turn it any which way you like, and we can --

A. Okay.

Q. -- you know, we can pan back a little bit.

A. All right. It -- it -- it's actually easiest -- can you see the whole thing that way?

Q. Yes.

A. Okay. Great.

Q. Okay. Before you -- before you just -- you go further, I would move for the admission of Exhibit 9.

Now, I just want to make sure I -- I understand. I wanted -- I wanted to back up and -- and sort of follow up on some of the things you said.

You talked about performing additional calculations to extract from the Type II ternary diagram an equilibrium relationship between the bitumen and the water in the raffinate phase.

A. Yes.

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Q. What is an equilibrium relationship, and why is that a good thing to -- to -- to develop?

A. Well, the equilibrium relationship will show the amount of bitumen compounds that are in the -- in the raffinate phase as related to the relative amounts of bitumen and d-limonene concentrations that are in the oil phase.

This is important because there is residual d-limonene and bitumen in the -- in the residual oil sands, and thus, we are able to relate what a projected concentration would be in water in equilibrium contact with those processed sands.

Q. Okay.

A. So --

Q. And then, from there, you said you performed additional calculations with information regarding the specific properties of -- of materials?

A. Yes.

Q. Okay. And the equations that you used for those calculations, what's the source for those?

A. Those are -- those calculations were based on solubility relationships using Raoult's Law, ideal solution type of approaches for very dilute solutions.

Q. Okay. And is that appropriate for this case?

A. Yes, it is.

Q. Why?

A. It's appropriate because these are very minute solutions -- very -- very dilute solutions, and the interactions between those dissolved chemicals are -- are not great.

And the other exhibits -- or the other references that I have in my report indicate that these are valid type of approaches to use for looking at individual concentrations. And I believe I have an EPA reference in my report that backs that up.

Q. Okay. Is -- would that be Reference 8 to your report?

A. I believe it is. Let me just double-check here, through my materials.

(Witness reviewed document.) Well, it's actually Reference No. 1.

Q. Okay. Okay.

A. We're looking at the effective solubility --

Q. Okay.

A. -- for a -- a mixture of compounds.

Q. And just for the record, what is Reference No. 1?

A. That is an EPA online tool for site assessment calculations, and the -- it shows a -- an equation for effective solubility as a function of mole fraction and individual component solubility.

Q. Okay. And do you have a copy of that right there --

A. Yes, I do.

Q. -- is that what you're looking at?

A. Yes.

Q. Do you mind if we -- if we mark that?

(Whereupon, Exhibit No. 10 was marked for purposes of identification.)

BY MR. HOGLE:

Q. Okay. I've marked this Exhibit 10, and I'm handing it to you. And again, is that the EPA resource that you just described.

A. Yes.

MR. HOGLE: Okay. I would move for the admission of Exhibit 10.

BY MR. HOGLE:

Q. Now, have you described the approaches that you took to your -- to your work in this case?

A. In general terms, I have described the

approaches, yes.

Q. Now, is the approach you took the accepted approach -- accepted approach in your industry and in your profession?

A. It is. It -- the approach is actually summarized in Perry's Chemical Engineering Handbook, and I followed that template for -- for the approach.

Q. Okay. Is that the same type of pragmatic, real world-based approach that you take in your day-to-day work?

A. It is.

Q. All right. Now, how did -- explain to us in simple terms, please, for my benefit, how your -- you applied your approach and the outcome of your approach.

A. Well, the approach starts out with the actual construction of the ternary diagram. And in order to construct the ternary diagram, we need information regarding solubilities in the -- the various materials, so let's start out with the -- the top apex of the ternary diagram.

There we obtained -- as described in my report and referenced in my report -- a concentration for dissolved bitumen in water of

6,000 milligrams per kilogram. That is one point plotted on the upper -- at the upper apex on the left-hand axis.

Then, on the other right-hand axis, we have plotted the fixed point for the water solubility of d-limonene. This -- this is water dissolved in d-limonene. That point, then, is plotted on the lower axis -- the bottom axis of the diagram in the right-hand corner.

Those two points, then, are connected to form the -- to construct the equilibrium line which describes the oil-rich extract phase. This is a very dilute solution in terms of -- or excuse me -- a very concentrated solution in terms of content of d-limonene and bitumen, so it is very, very close to the axis of the diagram. So it makes it almost indiscernible in this case because it is so close to that axis.

Then to construct the raffinate phase line, which is in the -- the -- the lower left-hand corner of the diagram, we used two points that are -- that are also labeled on the diagram here. On the left-hand axis of the diagram, we have plotted a bitumen solubility in water that, again, was taken from a range of values as described in my report, and this is a very small or very low concentration, which is five times ten to the minus third milligrams per kilogram. That's on the left-hand axis.

Then, on the lower axis, in the left-hand corner, we have plotted a solubility point for d-limonene dissolved in water, and that is taken from the literature as 13.8 milligrams per liter. And again, it doesn't even show on the diagram. It's -- it's so small, that -- it is in this left-hand corner.

It's not -- it's important to understand that those lines exist, but it's not -- not really important for my analysis to show -- to -- to be able to show the -- the lines perfectly on this diagram because the important thing is the data that then comes from this diagram to produce the equilibrium diagram.

Q. Okay. Before you move on -- well, are you finished with this diagram?

A. I believe so.

Q. Okay. Before you move on to the next part of the application of your approach, you indicated that you used source information for the plot -- the -- the different apexes --

A. Yes.

Q. -- what I want to make sure we understand fully the source material that you used --

A. Okay.

Q. -- so what was the source material for the -- what was the upper apex again, and what was the source material you used for that?

A. The -- the upper apex was a 6,000 milligram per kilogram figure -- or value based on moisture content from an analysis, and I have that documented in my -- in my report.

Q. What reference number is that?

A. Hang on for a second here. Bear with me while I find this --

Q. No problem. Take your time.

A. -- okay. Here we go. In my report, it's on page 2, the -- the second -- or the third bullet, first sub-bullet, and it is Reference 3.

Q. Okay. All right. And Reference 3 is the February 28, 2008, JBR Permit-By-Rule Demonstration?

A. It is, yes.

Q. Okay. All right. And that's the source, then, for the value on the top apex of Exhibit 9; right?

A. That's correct.

Q. Okay. And then what about the lower right apex of Exhibit 9? What is that, and what was the source material for that?

A. That is the water solubility in d-limonene, and that is the -- depicted in -- or described in my report on page 3, at the -- near the top of the page. It's the first -- or the second full sub-bullet --

Q. Um-hum.

A. -- water solubility in d-limonene. And I -- there were several -- or a couple of different literature values that I reviewed with regard to what was reported in Reference 4 and 10, and those values ranged from 500 to 1,000 parts per million. And I felt that a -- a value for the water solubility of 1,000 parts per million was appropriate, so I used that to plot that.

Q. Okay. Reference No. 4 is a communication you had with Barclay Cuthbert; correct?

A. That's correct.

Q. And Reference No. 10 is some information from KIC Chemicals, Inc.?

A. Yes.

(Whereupon, Exhibit No. 11 was marked for purposes of identification.)

BY MR. HOGLE:

Q. I'm handing you what's been marked as Exhibit 11. Can you identify that?

A. Yes. This is the information that I received -- or obtained from the Internet website from KIC Chemicals which indicates the -- the moisture value that -- or the water content value that I was utilizing as one of the figures to make my projections.

Q. Okay. All right. And the reference materials -- the materials you referenced in your report and that you reference today, are all of those appropriate to rely on in this case for --

A. Yes. This is actually a commercial -- commercial value. This is -- this is a product sheet that shows the -- the range of water content.

Q. Okay.

MR. HOGLE: I would move for the admission of Exhibit 10.

BY MR. HOGLE:

Q. All right. Now, finally, in the lower left-hand apex of Exhibit 9, what is that, and what was the source of material for that?

A. Okay. On the -- the -- the lower axis of the right-hand apex, that is the d-limonene

solubility in -- in water, and that was -- that was taken from References 8 and 9, which both agreed on a solubility of 13.8 milligrams per kilogram -- or milligrams per liter. Excuse me.
Q. Okay. Now, identify for us what Reference 8 is.
A. Reference 8 -- Reference 8 is a -- a -- a physical property reference that I obtained from the Internet, from www.inchem.org, and it -- it lists the water solubility of d-limonene. Excuse me. Did you say 8?
Q. I said 8.
A. I'm sorry. I -- I --
Q. You were talking about 9.
A. -- I talked about -- I've got 9 here. I'm sorry.
Reference No. 8 is an EPA reference from -- from their -- one of the EPA website sources, and it is www.epa.gov, and then there are some other extensions to that website.
Q. Okay. Do you have Dr. Johnson's January 20, 2012, testimony, which has been marked as Exhibit 1 in this case?
A. I do have that.
Q. And could you turn to page 34, the last

page? And is your Reference 8 the same as his Reference 1?
A. I can't -- I can't relate these two by the information that -- that I have.
Q. Let me -- let me hand you -- and I'm not going to mark this. I'll just hand you what -- what is Reference 8 to your report.
Based on that, does it appear to be the same as the EPA publication on which Dr. Johnson relied?
A. (Witness reviewed document.) Well, Reference 8 in Dr. Johnson's --
Q. No, Reference 1.
A. Reference 1. I'm sorry. Yes, that -- that appears to be the same --
Q. Okay.
A. -- document that is in Dr. Johnson's report.
(Whereupon, Exhibit No. 12 was marked for purposes of identification.)
BY MR. HOGLE:
Q. Okay. And then -- and then, a second ago, you described Reference 9. I've marked as Exhibit 12 this document, and do you recognize that as Reference 9 that you just described?

A. Yes, this is the exhibit that I was previously speaking of.
Q. Okay.
MR. HOGLE: And I would move for the admission of Exhibit 12.
BY MR. HOGLE:
Q. Now, is there -- on the upper part of the lower access -- apex -- excuse me -- the upper part of the lower-left apex in Exhibit 9, there's some -- there's another reference -- or there's some -- another value; correct?
A. Yes. That is the -- the bitumen solubility in water. And again, that was -- the value was an interpolation of values from the literature, and that should be described in my report as well.
Q. Give us the reference.
A. Bitumen solubility in water, that would be on -- the last bullet on page 2 of my report references 5, 6, and 7 in my reference list.
Q. Okay.
(Whereupon, Exhibit No. 13 was marked for purposes of identification.)
BY MR. HOGLE:
Q. All right. I'm handing you what's been

marked as Exhibit 13. Can you identify that?
A. Yes. This is the Reference 5 that -- that I have used in -- in my work.
Q. And what is that again?
A. This -- this is a -- again, from -- from the website -- the www.inchem.org website. It is a listing of physical properties of -- of various materials. And from -- from this listing, I was able to obtain one of the values that I used to plot as the -- or that I used in reference to come up with the point on that diagram --
Q. Okay.
A. -- but one of -- one of the three -- three different sources.
MR. HOGLE: And I would move for the admission of Exhibit 13. And you can set that aside.
(Whereupon, Exhibit No. 14 was marked for purposes of identification.)
BY MR. HOGLE:
Q. I'm handing you another document. This one's been marked as Exhibit 14. Can you identify that?
A. Yes. This is -- this is Reference 6 that I've used in my calculation, and this is from an Internet source also -- www.sciencemag.org -- and it

is one of the -- one of the values -- wait a second here -- one of the reference that I've -- references that I've cited.

Wasn't there a second page to that? Okay, yeah --

Q. Well --

A. -- this is -- this is it, yeah. I'm sorry. There was -- there was just a single page.

But, yes, this is -- this is the -- this, again, makes up one of the points of information that I used to evaluate the chosen bitumen solubility in water for -- for plotting purposes.

Q. All right.

MR. HOGLE: I'd move for the admission of Exhibit 14.

(Whereupon, Exhibit No. 15 was marked for purposes of identification.)

BY MR. HOGLE:

Q. And then you mentioned one other reference. I'm handing you what's been marked as Exhibit 15, and please identify what that is.

A. This is a compilation of liquid equilibrium data from the Journal of Physical Chemistry, and it -- it was also utilized in the -- my -- in -- in the range of values that I considered for plotting that -- that point on -- on the diagram, which would be the bitumen solubility in water.

Q. Okay.

MR. HOGLE: I would move for the admission of Exhibit 15.

BY MR. HOGLE:

Q. Now, have we identified all the source material for the values on your diagram that's marked as Exhibit 9?

A. Yes.

Q. Okay. Now -- all right. So that's part of the -- the application of your approach. I interrupted you to introduce and offer the source material that you used. So please continue on with how you applied your approach and to what end.

A. Okay. Well, once -- once these -- once these values are plotted on the diagram and -- and documented on the diagram, then the approach is to construct an equilibrium relationship that relates the oil-rich and raffinate phases. And I wonder if I could refer back to the Perry reference to show that very quickly.

Q. Sure. I think that's 7. No, it's probably --

A. Reference 2 in -- oh, excuse me. Exhibit 8 --

Q. Yeah.

A. -- but Reference 2 in my -- and -- can I move this?

Q. Yes.

A. Okay. I'm going to show page 15-5 out of the Perry's reference, which is Exhibit 8, and does that show -- should I blow that up a little bit?

Q. Yeah.

A. I want to specifically look at the relationship for the -- for the Type II system here, and this -- this schematically shows the Type II system which relates the ternary phase diagram, which I'm pointing to here, to the equilibrium diagram, which I'm pointing to here.

And what it -- what it takes to construct this diagram are transferring points from the equilibrium -- or from the ternary phase diagram across and plotting them on the axis of the equilibrium relationship.

And it's -- it's important to note here that for -- for the Type II system, a relatively straight line is generalized for the Type II ternary phase diagram. And additionally, for very dilute solutions, these lines will become -- very dilute or very concentrated solutions -- these lines will be -- become straight, in many cases, on the ternary diagram, and that will yield a relatively straight equilibrium relationship here, where we relate the -- the equilibrium of a -- of the bitumen compound in our case to the oil and water phases or the oil-rich and water-rich phases, which the water-rich phase I, again, refer to as the raffinate phase.

So that -- that is the -- the diagram that -- that I will show then to be constructed from the ternary diagram that -- that I started out with.

And the equilibrium relationship is also attached to my report --

(Whereupon, Exhibit No. 16 was marked for purposes of identification.)

BY MR. HOGLE:

Q. I'm -- I'm handing you right now what's been marked as Exhibit 16. Could you identify that?

A. Yes. This is the equilibrium relationship that then is extracted from the -- or constructed from the data on the ternary phase diagram, and it shows the percent bitumen in the extract, which is the oil-rich phase, and relates that to the concentration of bitumen in the raffinate, which is the water-rich phase.

Q. Okay. I would -- and this is a document you prepared; correct?

A. I prepared this, yes.

Q. Okay.

MR. HOGLE: And I would move for the admission of Exhibit 16.

BY MR. HOGLE:

Q. Now, walk us through this figure.

A. Okay. The -- this is constructed in the same manner as the -- as was shown in Perry's Chemical Engineering Handbook.

So in order to construct this, I -- I -- the construction is described, again, in -- in my -- in my report. The -- directly from the equilibrium relationship -- or -- or the ternary phase relationship, we take the -- the point of the five -- excuse me. Let me just check here -- real quick here. (Witness reviewed document.)

From the water -- water-rich phase, we take the five times ten to the minus third milligrams per liter -- which is equivalent to milligrams per kilogram because we're talking about water, which is a density of 1,000 milligrams -- or

1,000 grams per liter -- so that -- that point is -- is plotted here.

And then the -- the corresponding point would be the 100 percent bitumen in the extract -- or in the -- in the extract, which would be the upper -- hang on for just a second here. It's been a while since I looked at this. I -- could we take a break for a second?

Q. Yeah, let's take a break.

VIDEOGRAPHER: We're going off the record. The time now is 10:49.

(Off the record)

VIDEOGRAPHER: We're back on the record at 11:06.

BY MR. HOGLE:

Q. All right. Mr. Handl, we're -- we're still talking about the application of your approach in this case, and walk us through the rest of your approach after you plotted the values on Exhibit 9. And I think you were explaining how you took that into an equilibrium relationship as depicted on Exhibit 10. Right?

A. Right. And what I was starting to explain before we took the break: The relationship between the -- the two phase lines on the ternary

diagram are -- the relationship is described as what -- what are called tie lines. And the -- the -- the most simple tie line is to tie the equilibrium phase diagram in the ternary system for the raffinate phase with that of the oil-rich phase with regard to the concentration of their -- of their relative amounts of bitumen.

So from -- directly from the diagram -- from the equilibrium -- or from the ternary diagram at 100 percent bitumen -- basically, this is -- point is plotted and ties back to the -- the line at five times ten to the minus third milligrams per kilogram for the bitumen solubility in the water.

And, of course, at -- at zero concentration of bitumen in the extract, where we would be looking only at pure limonene, there would be no concentration in the water, so we have the -- this -- the two points of the curve defined.

And then, from the relationships as I previously mentioned for the dilute systems as described in Perry's, the equilibrium becomes a relatively straight line.

So then this relates the concentration of bitumen in the extract to the concentration of bitumen in the water-rich or raffinate phase, and

that is the equilibrium diagram that I -- that I used for the -- for the basis of the -- the remainder of -- of the projections I made in my report.

Then to -- what I wanted to do was compare the -- the concentration of one of the polyaromatic hydrocarbons -- benzo(a)pyrene -- what the concentration of that would be, estimating it for the water in contact with virgin oil sands or unprocessed oil sands. And in order to do that, I first obtained some relative concentrations of PAHs in crude petroleum in shale oil from -- or shale sources from Reference 11, and -- and there were ranges for those -- for the B(a)P concentrations, depending on what the particular source of material was. But they ranged from 3 to 192 milligrams per kilogram for -- for B(a)P concentration.

(Whereupon, Exhibit No. 17 was marked for purposes of identification.)

BY MR. HOGLE:

Q. Let me go ahead and hand you a document. That's Reference 11 to your report; correct?

A. Yes.

Q. Okay. And that's the document you just described?

A. Yes.

Q. Okay. I would move for the admission of Exhibit 17 which I've handed you. Go ahead and proceed.

A. So -- obviously, there's a range reported in the literature, so I felt it somewhat conservative to weight that range toward the high end, the range being -- that -- that -- that I found -- from 3 to 192 milligrams per kilogram or parts per million of -- of B(a)P in the -- these petroleum sources.

So I -- I chose a value of 150 milligrams per kilogram to be conservative. And then using the relationship of solubility of that compound to its -- to its mole fraction, I converted the -- the mole fraction and the solubility and came up with a projected concentration for B(a)P in -- in the crude oil sands, for -- for water that would be in contact with the crude oil sands.

Again, this is only a projection, but it -- it comes up to 5.7 times ten to the minus fourth micrograms per liter. And that's -- that calculation is outlined in my -- in my report.

Then I wanted to compare that number -- which is the -- basically the number one would

expect from rain or precipitation in contact with the virgin oil sands -- I wanted to compare that number to the equivalent number where rain or other precipitation would be in contact with the processed oil sands, and in order to do that, I needed to find a percent bitumen concentration in the processed oil sands, and I obtained that from a -- Reference No. 3, which...

Q. That's the JBR demonstration; right?

A. Right. Which is the -- that was the reported range of moisture content.

And then also, using some of the d-limonene concentration as reported by Dr. Johnson as 1.8 percent in the fines, along with the .84 percent bitumen remaining in the combined spent solids -- and -- and that is from my Reference 3, is -- which is that same report -- I calculated a weight fraction of about 69 percent of d-limonene in the bitumen. And therefore, the corresponding weight fraction of -- of bitumen in that mixture would be 31 percent.

So then -- going back to the equilibrium curve -- at 31 percent bitumen in the extract phase, which would be somewhere in this range, I -- I can come across and relate that, through the equilibrium

curve, to an approximate bitumen concentration in the raffinate phase of about 1.5 times ten to the minus third milligrams per kilogram or parts per million.

Then using that basic concentration value for bitumen in the raffinate, I can again use the relative B(a)P concentration in the petroleum products which I derived before, and through a similar calculation, I come up -- I -- I -- I obtained a value of 2.3 times ten to the minus sixth micrograms per liter for -- for the B(a)P concentration -- projected B(a)P concentration in the raffinate phase of the processed oil sands, assuming that water was in contact with those -- with those sands and the water was in equilibrium.

So that -- that -- that made my -- made the comparison complete and, I think, rigorous in -- in respect to that I was comparing apples for apples, preprocessed conditions with post-processed conditions and talking about actual projected concentrations rather than orders of magnitude change or a percentage change in solubilities. I'm talking about actual concentrations in my analysis.

Q. So just to sum, what -- what did you compare and what was the value that you came up with

in terms of the preprocessed condition for the actual concentrations of B(a)Ps?

A. In the -- the -- the preprocessed condition, the B(a)P concentration, as I -- as I summed in my -- my report, I calculated 5.7 times ten to the minus fourth micrograms per liter, and that's from the -- in -- with water in contact with the raw bitumen and comparing that to the post-processed sand and fines, 2.3 times ten to the minus sixth micrograms per liter. And the reason for the big drop is that you've extracted much of the bitumen.

Q. Okay. So under your calculations, the concentration level actually goes down --

A. Yes.

Q. -- through the process; right?

A. Yes.

Q. And Dr. Johnson opines that the concentration levels go up by a factor of 1,500; right?

A. Yes.

Q. All right.

A. Well, let me -- let me just qualify that. Again, I think -- I think Dr. Johnson was analyzing solubilities rather than projecting actual concentrations. I think -- I think that's a fair statement.

Q. And why is it better to do what -- what you did and project the concentrations?

A. Well, again, from a pragmatic standpoint, what we're really interested in here is what is present in field -- in the field, what is present in the bitumen as it exists the way God put it in place versus that which exists after it's been processed by man.

Those are the two comparisons that we're trying to make, so I think it's -- it's extremely important to keep that in perspective and also to keep in perspective that what we should be looking at is as close to the bulk material data as possible and not particularly making a lot of projections based on, like, a proxy compound. So I think it's -- I think -- I think that what I did has a -- a high degree of validity.

Q. Okay. Now, you understand that in his March 16 testimony, Dr. Johnson takes issue with you --

A. Yes.

Q. -- and your approach?

A. Yes.

Q. How do you respond to that?

A. Well, if I could just return -- maybe look at -- at some of his responses to -- to what I'm saying.

First of all, I think that my approach starts with actual data from documented sources. There is a -- some discrepancy between the data, but I have managed to come up with interpolated values between actual published figures for most of the -- for most of the information that I was -- that I've used in my analysis --

Q. And --

A. -- those are actual numbers, actual concentrations.

Q. And you've been conservative, have you not?

A. I've been -- I've tried to be conservative in my analysis.

So I'm starting with -- my analysis starts with a bulk concentration, a -- a large-scale view of the system, and then I refine my calculations and try to project what a specific compound would be resultant from that analysis and -- so I think -- I think I'm looking at it starting with a -- a base of information that is

very general, and then I'm proceeding to the specifics.

And I -- I think that is in contrast to Dr. Johnson's approach, where he starts with a surrogate very specific -- or a proxy very specific compound and then tries to generalize the approach based on that -- that choice of -- of the proxy.

Q. Well, for example, he takes issue with your application of Raoult's Law, does he not?

A. Yes.

Q. And how do you respond to that?

A. Well, again, these -- these are very dilute -- dilute systems, and the application of -- of that approach is appropriate in -- in very dilute solutions. And in the -- especially in the -- the raffinate phase, we're -- we're talking about parts per million in -- in the raffinate. So it's very appropriate to use dilute solution assumptions or -- or models in -- in these -- in these cases of very low concentrations.

Q. And what -- is that what you mean by "dilute solutions"?

A. Yes. I -- I think a lot of the -- we'll -- we'll probably get into this in a -- in -- later on, but typically, the dilute solution

assumptions or simplifications that are used in the chemical engineering theory are, you know, less -- less than 1 percent concentration, and -- and here -- here we're way under 1 percent, so I believe these dilute solution simplifications are appropriate.

Q. Okay. Now, other than what you've already testified to in terms of how your approach uses -- how you -- you -- you view your approach as better, what other flaws -- what other significant flaws did you find in Dr. Johnson's January 20 testimony?

A. Okay. Turning, then, to -- I -- I had a -- I have a number of -- of items that -- that -- that I think I'd like to contrast his work with -- with my work, and the -- the first -- the first one is on -- on page 3, line -- starting on line 12 of his testimony, where he is comparing an increased concentration for what he calls a tar compound, an increased aqueous concentration of that, and he -- he's -- he's comparing the -- he's -- he's making the base of that comparison the pure component solubility of that material.

And again, thinking back to the real -- the real world, the bitumen is not 100 percent

B(a)P. It is a very, very minute concentration of B(a)P. So the basis of his starting comparison is -- I think sets up a -- an exaggerated comparison from the get-go, and I think it is somewhat misleading to do that.

There should be -- there will be insufficient B(a)P in the -- in the bitumen to anywhere nearly approach the pure component solubility, so I think -- I think his choice of -- of that starting point is -- is -- is somewhat exaggerated and sets up a -- a condition that should not be -- actually be compared.

Again, along the same line, on page -- page 7 of his testimony, in line -- in line No. 19, he indicates that the normal solubility of benzo(a)pyrene -- or B(a)P -- dissolving from solid tar in water at room temperature is 1.5 micrograms per liter, and that's not correct. That -- that is the pure component solubility. That is not the solubility that is dissolving from the tar.

And right above that, in the lines -- the middle of his page of testimony here, he shows a benzo(a)pyrene figure and some data for benzo(a)pyrene, and then in lines 16 and 17, he refers to perylene, which is a completely different

chemical, and so there's a bit of inconsistency in -- in what he's attempting to do here.

Additionally, on page -- page 8, I -- I don't see any citation for where he came -- comes up with the equation on line 11, and it appears to me that he -- he may be double-counting solubility terms there because the d-limonene, I think, is the organic solvent, and then he's attempting to justify additional solubility for that -- for that saturated material, for that solvent liquid, and this is -- his attempt to justify increased solubility is actually in -- in conflict with the guidance that -- that he uses from his own textbook on -- in the 1993 Schwarzenbach text, it -- on page 97 of that -- of that textbook, it clearly states that for -- for very dilute solutions of -- of hydrocarbons in water, one hydrocarbon does not enhance -- appear to enhance the solubility of -- of the other hydrocarbon. So he's attempting to -- to do something that his very reference says is not going to occur.

Then on page 8 of the same -- same page, I would just like to say that I don't believe that octanol is a particularly good proxy for d-limonene. If we're going to be looking at coefficients of --

phase coefficients, we should use as close to the actual extract -- extract solvent that we -- we can.

Octanol is an alcohol. D-limonene is a -- is a hydrocarbon. There are specific properties that are different between those two systems, solubility being -- being one of them, and -- so I think his choice of -- of that octanol, again, is a -- sets up a situation that adds to a compounding of errors in his analysis.

Those -- those are the main -- main points that -- that I have -- wanted to -- to bring out with -- with his analysis.

The -- the other thing is, starting -- just stepping back and looking at the big picture, the first thing I did was I -- I do sort of a logic test or you might call it a sniff test. Does it smell rotten or not?

We have two extremely sparingly soluble compounds, both hydrocarbons: the bitumen and the d-limonene. Now, the structure of the d-limonene is -- is, in -- in many cases -- or in many aspects, quite similar to the structural compounds that we see in the bitumen.

The d-limonene, which is used as a solvent in -- in this case, is a monocyclic

hydrocarbon with some -- with some appendages on it in terms of other carbon and hydrogen atoms, and it has some unsaturation. This is not unlike the chemicals that are in the bitumen.

So we have two very like systems that are very dilute, and we also have the -- the guidance from Schwarzenbach that the combination of dilute hydrocarbons does not enhance the solubility -- the mutual solubility of those hydrocarbons.

So from the get-go, it didn't smell right to me. I don't think that -- that what he's attempting to do here and what he's attempting to -- to show really adds up. It just doesn't make logical sense. So that's part of the reason I took my different approach and tried to contrast a different approach to -- to what he does.

So I think that's -- that pretty much sums up what I would have to say about his original testimony.

Q. Sure. And there may be some -- some other flaws that you saw in that, but you hit the significant ones?

A. I think those are the most significant things. I -- I did -- I did quibble over other items in there that --

Q. Okay. Now, before we move on to his March 16 testimony, I want to ask you if you have any specific experience with d-limonene.

A. I do, yes. My -- my thesis in -- when I was taking my master's courses at Montana State University, I worked on terpene chemistry, and the thrust of my research and my thesis was the separation of terpene chemicals, and I was separating a chemical called beta-phellandrene from a dipentene mixture. And dipentene actually is the racemic mixture of d- and l-limonene. "Racemic" means two different optical rotometers that are mixed together. Not -- I said -- I said "rotometers." I meant rotamers.

The -- so I -- I -- I had a -- a fair amount of experience working with those chemicals, and I'm familiar with -- with a number of the other terpenes that are associated with -- with that particular system. That system originated from a pulp product, turpentine. But I -- I am familiar with it, with the chemistry involved, yes.

Q. Okay. Based on your experience with d-limonene, in your view, would it be a -- good ingredient for U.S. Oil Sands to use for their operations?

A. Well, I -- I really think it's an excellent ingredient. It's a natural chemical. It is an extremely good solvent. It has a -- a pleasant odor. It's not any kind of an irritating odor at all. And it has a quite low, if -- if nonexistence, toxicity -- human toxicity. So I think it's an excellent solvent choice.

And it actually is -- d-limonene is becoming used more and more for a lot of industrial applications. And -- and, in fact, in -- in a lot of garage applications, you'll find d-limonene type soaps. Just last month I was using that when my hands were greasy. It has a very pleasant aroma and really cuts the grease, so it's an excellent solvent, excellent choice. And being a natural product as well, which is, you know, a very green type of approach.

Q. And what's your experience with its volatility?

A. In my separation of my chemicals, I -- I was able to volatilize the -- the -- the dipentene and the various chemicals by steam stripping with -- with a very small amount of -- of steam and then condensing that steam by steam distillation and then collecting the -- the terpenes from -- from the water -- the -- the condensed water-terpene mixture. So it -- it -- it is relatively volatile.

It is not as volatile as -- as gasoline, for example, but it has a significant vapor pressure. I believe it's 2 millimeters of vapor pressure at -- at ambient conditions, which is about 25 degrees centigrade and -- so it -- it -- it -- it could evaporate.

Q. Um-hum.

A. And, in fact, in -- in my laboratory, I -- I did need to keep my vessels tightly closed because I would lose material through evaporation otherwise.

Q. Okay. Let's move on to the March 16 testimony, which is Exhibit 2 in this case. His January 20 is Exhibit 1.

So the March 16 testimony, what did you find to be the -- the most significant flaws in that?

A. Well, starting on -- on page 3 of his testimony, I -- again, I think the -- the initial flaw is in -- is a flaw in approach. I explained how I went from the general to the specific.

Dr. Johnson's analysis assumes that benzo(a)pyrene -- or B(a)P -- can be a proxy for the bitumen, and at face value, that has some validity. However, you -- you -- we must consider that bitumen is comprised of hundreds -- I believe thousands -- of different individual compounds, so picking a specific proxy to represent that large suite of compounds in bitumen is a leap of faith.

I believe it's more appropriate to first look at the bulk characteristics and then move to the specific, rather than picking a specific proxy which may not encompass the entire range of chemicals --

Q. Um-hum.

A. -- and proceeding with that proxy analysis.

But he -- he does that, and he states that his -- his analysis is conservative, but I'd like to introduce that I think that it could be viewed as a -- a liberal estimate rather than a conservative analysis.

Page -- on page 4, Dr. Johnson begins to criticize my work, and he speaks to my report as speaking only to dilution, and as I've explained, that is not true. I'm speaking to the equilibrium between the different phases, and my report uses the published literature values for properties of the entire mixture, which are real -- real-world information, and I document my model results in that fashion; whereas, he is relying on a -- that single proxy compound.

Then on -- turning to page 7 of -- of Dr. Johnson's March 16 testimony, he raises the -- the issue of me not summing all of the concentration of bitumen compounds in water. However, in my analysis, that is not necessary because I'm looking at bulk concentrations. All bitumen components are implicit in that bulk concentration. So I don't understand his argument there.

And again, I was able to move from the specific -- or from the general to the specific, taking that general information that included all compounds and then moving toward a specific calculation of one of those compounds that might be contained which -- which has some toxicity, and that -- those are the sorts of things that we can -- we can look at.

I was not -- I did not look at all the possible B(a)P -- or -- or all the possible polyaromatic hydrocarbons that could be emanating from that solution, but I wanted to make the example of the one that he chose and -- and square that for

the record, that -- that I believe his analysis was flawed and that my analysis was a more appropriate approach.

Additionally, on page 7, down in line 22, he indicates that he used distribution coefficients of an actual -- or of a -- of an example bitumen compound between water and d-limonene, where, in fact, he didn't. He used the distribution coefficients based on octanol. So what he says is not precise in this case.

And as I pointed out before, octanol has specific properties, being an alcohol, that are nonexistent in a hydrocarbon.

Q. Like d-limonene?

A. Such as d-limonene --

Q. Right.

A. -- yes. There are -- there are a number of other misstatements in his -- in Dr. Johnson's work. Another one that I'd like to point out is at the bottom of page 10, line 23, where he asserts that I am contending a particular activity coefficient is nearly one billion.

I made no use of activity coefficient in my analysis, so his -- his statement is incorrect there. I made no such contention. And he's trying

to put -- evidently, he's trying to put words in my mouth.

Turning to page 18 of his testimony, Dr. Johnson, on -- on the entire -- through the entire page here, indicates that I was not accounting for some -- some of the bitumen existing in solid form.

That's not true because in the analysis method that I used, I'm looking at the -- the bulk concentrations and the -- the entire system in equilibrium, and I don't need to get into specific calculation details that -- that he attempts to employ.

Additionally, at this point, I -- I think it's important to also bring up that bitumen contains significant amounts of liquid hydrocarbons as well as the solid hydrocarbons or semi-solids that he -- that he purports.

And I know from -- from actual boots on the ground experience that those liquids do exist because I have personally been on two oil sand mine sites near Vernal, Utah, which I visited last year during the unconventional fuels symposium in Utah, and I saw with my own eyes oil seeps emanating from -- from those sands, so I know that a certain

portion of those oil sands do exist in liquid form, and I do believe there's other documentation that supports that.

Dr. Johnson has not accounted for -- when -- when he goes through his solid liquid calculations and vapor pressure adjustments, he has not -- he has not calculated the various fractions of solid and liquid in the bitumen, and that -- that is another flaw in his analysis.

On page 21 of his analysis, line -- line 12 and Equation 17, it's confusing in that particular equation. I -- I think the X sub W that he uses there may actually be referring to a -- a solid, but he hasn't got it labeled as a -- as a solid with any kind of a subscript or solid notation there.

I -- I just raise that question. I'm not -- because he doesn't show the detail of his work, it's hard to follow exactly what he's trying to get at there, but I think there's a question that that -- that could be actually a solid designation for that. And that then --

Q. And why would that be significant?

A. Well, it's significant because it can lead to, as he progresses through his derivation here -- first of all, it's -- it's significant to try to follow -- in order to follow his derivation. And secondly, if he has -- has made a -- a mistake or a -- he has -- he has left an important parameter out or misidentified a parameter, then -- then it becomes confusing and -- and possibly sets up another compounding error in his -- his analysis.

So I -- I -- I -- I think that that -- I'll just leave it there. I -- I just raise the question that -- that that is -- that's not labeled as to whether it's a solid or a liquid, and I think it's important that it should have been done.

On page 24 of -- of his analysis, he's getting down, now, to where he's calculating some factors that -- that he will later purport to increase the solubility of -- of the -- the -- of the bitumen compounds, but in his -- in his calculations on -- on lines -- first of all, on -- on -- on line 19 and 20, the -- the value that he uses does not appear to correspond to the table in the Schwarzenbach text that -- that he -- that he refers to.

And the -- on line 19 specifically, the delta S melt T sub M divided by R, it says it's approximately 6.8 for bitumen compounds, and the -- the value in the table reports a value for -- for similar PAH compounds of 45 for the corresponding number that is input into that -- into that calculation. And let me -- can I just check for a second here?

Q. Sure.

A. And I need to take another break too.

Q. Okay.

VIDEOGRAPHER: We're going off the record. The time now is 11:51.

(Off the record)

VIDEOGRAPHER: We're back on the record at 11:58.

BY MR. HOGLE:

Q. Okay. Mr. Handl, you were explaining an error that you saw in Dr. Johnson's March 16 testimony. It's Exhibit 2, on page 24, towards the bottom of the page; right?

A. Yes. I was getting into the -- the value that -- that he selected for the term in the X -- for the X exponent there on the natural -- or the -- the E, and it was -- he's got the -- a value of 6.8 for the bitumen compounds and -- which includes the -- the term, the delta S melt, the T sub M divided by R.

And when I looked up the compounds in the -- the reference that he uses on Table 4.5 on page 124 and did -- did that calculation, I came up with a different value for that, starting out with a value of 45 for the delta S melt T sub M. And that's representative of three of the compounds that are also PAHs on that -- that table. So there's one -- one discrepancy there.

Then the second discrepancy with that calculation is that his -- his temperature term -- he indicates that he's using around 230 degrees centigrade for the melting point, where the actual proxy that he used is the B(a)P material. And as he stated in his original testimony, the melting point for -- for the -- that material is 177 degrees centigrade.

So when you correct the -- the temp -- the correct temperatures -- include the correct temperatures in there, it ~~rained~~ RAISED -- it raises -- or lowers his T sub M divided by T minus 1 value to -- from .78 down to .52, and those two changes make a dramatic change in the factor that -- that he purports on the top of page 25, where he's reporting a -- a 200 factor there. And if you correct that calculation, it drops that down to 16.7, which is greater than an order of magnitude decrease in that number, which has a significant bearing on his later analysis which, on page 17 -- or 27, at the top of that page, he shows that 200 factor at the very top of the page, where I think that -- that factor has been exaggerated by the errors he's made in that calculation.

I think that's all I would like to comment on with regard to his March 16 testimony.

Q. Okay. Let -- let me ask you one more thing, though. What -- about his March 16 testimony -- you noticed his graphs in his testimony. What's your reaction to those?

A. First of all, the -- the -- the -- the graph that he shows here is, again, a -- a depiction that is not scaled properly --

Q. Which one are you referring to now?

A. I'm referring to the graph on the bottom of page 16.

Q. Okay. Why don't you use the document camera.

A. Okay.

Q. Why don't you --

A. This has -- this has some of my other notes that don't -- don't apply to what I'm going to say but --

Q. Okay. Here's a clean one.

A. Okay.

Q. There you go. Do you want zoom in on that?

A. You want to zoom in on this? There.

First of all, the -- the scale of the -- of the two axes is not -- the two axes are not properly scaled. And then he -- he really offers no calculation to support -- well, first of all, there's no scale, so the -- the line is a -- is merely an arbitrarily drawn curve that -- that we -- apparently an arbitrarily drawn curve because he doesn't show any particular calculation to -- to back up the shape of that curve.

The -- the two points that he shows on -- on the graph here are, in my opinion, not -- not what the point -- not -- the shape of the -- this curve is not what the actual shape would be if -- if the axes were properly scaled in the ternary diagram. This -- this line would be much -- much flatter. And I don't -- I don't see any backing for the amount of curvature or the -- the height of -- of the curve that he has there.

I understand the argument that he's

making, but again, it is -- it is -- it is merely a -- a depiction, and it's arbitrarily drawn as to how far that curve would deviate from -- from the straight line that he shows, neither of which are actual -- actually scaled to the -- the correct values.

Q. Okay.

A. The -- the end points may, in fact, be correct as he cited, but the depiction is out of -- out of scale.

Q. All right. Did you have a chance to review a transcript of Dr. Johnson's April 20 testimony?

A. Yes, I did.

Q. Do you take issue with anything that he said in that testimony?

A. I have several -- several points that -- that I'd like to make.

Q. Okay. What are the most significant?

A. On page 21 of the -- of the transcript -- it would be on lines 10 through 16 -- I'd, again, like to point out that -- that -- as I've already stated -- that he -- he made no correction for the fraction of bitumen that is already in liquid form.

Q. Just for clarity, when you're talking

about page numbers, are you referring to the page numbers at the bottom of the page?

A. Yes, I am.

Q. Okay.

A. Is -- should I be referring to another --

Q. No, no, no, no. That's fine. I just noted that there are page numbers embedded in the --

A. Okay.

Q. -- in this rough transcript, so --

A. Yeah, I didn't see that or I didn't notice that before, but I now -- I do now.

Q. Yeah.

A. Okay. Yes, this -- this is the -- the page number at the bottom of the page that -- that I've been supplied with.

And on page 42, in the lines around 19 through 25 -- or 19 through 24 -- I -- I'd just like to point out that in his response, I believe that he's putting his own spin on the Schwarzenbach statements in the text that -- I believe Schwarzenbach is very clear in that he states that slightly soluble compounds -- or SLIGHTLY ~~absolutely~~ soluble hydrocarbons do not appear to enhance dissolution of other hydrocarbons. That's very clear in the statement, and -- and he's kind of generalizing or

dancing around that -- that statement in -- in the Schwarzenbach text.

Q. Well, just for clarity, what's he talking about in the testimony you've just described, in sum -- in summary?

A. He's -- he's attempting to minimize the -- the effect of -- or minimize that -- that -- that statement within the Schwarzenbach text, I think, that -- as a generalization, and he's indicating that -- that it is not appropriate for the way he's looking at it, and so I -- I think it's -- it's an opinion that is unsubstantiated because it is very clearly stated in the -- in the text.

Q. Okay. And --

A. And --

Q. -- you're referring to the text regarding the cosolvent -- cosolvent discussion and the cosolute discussion?

A. Yes. The one that relates back to the 1993 Schwarzenbach statement. I think it was on page 40 --

Q. Ninety-seven.

A. Forty-seven? Was that it?

Q. Ninety-seven.

A. Yeah, page 97, where -- quote -- "Similarly, slightly soluble hydrocarbons present in a solution do not appear to enhance the dissolution of other hydrocarbons." That's directly from the 1993 Schwarzenbach text.

And then on -- I -- this is a -- a small matter, but I think it -- it -- it -- it goes to show intent -- or not -- not intent but maybe the -- the care at -- at which he approaches this -- but he -- he -- at -- on page 67, line 6 through 9, he erroneously states that the vapor pressure of d-limonene is 2 meters, which is really erroneous. It's 2 millimeters. So it's a 1,000 -- a factor of 1,000 different. And then misses the chance to make that correction in the response to the question at the bottom of page 71, line 17, continuing on to his response on page 72, line 6. That's -- that's all the comments I have on --

Q. Okay. Now, in response to his February 16 testimony and Dr. Johnson's April 20 testimony, did you conduct any additional calculations?

A. Yes, I -- I did. I attempted to take a -- take a look at a -- a different perspective from my own by -- by -- by utilizing some of the

information that Dr. Johnson utilized in performing an independent calculation of -- of the potential solubility increase as -- as he would report it for a proxy compound. Not that I'm endorsing the use of that proxy. I just wanted to compare -- make a comparison calculation to what his results were.

(Whereupon, Exhibit No. 18 was marked for purposes of identification.)

BY MR. HOGLE:

Q. Okay. I'm handing you what I've marked as Exhibit 18. Can you identify that for us?

A. Yes. This is the calculation that I just spoke of, and it's the -- my hand calculation of the -- a -- a slightly different approach to Dr. Johnson's results utilizing the same Schwarzenbach text that -- that he does.

Q. All right.

MR. HOGLE: I move for the admission of Exhibit 18.

BY MR. HOGLE:

Q. And why don't you put it on the document camera there and sort of walk us through that.

A. Sure. This is the first page --

Q. Now, you've got it zoomed in.

A. Oh, I'm sorry.

Q. Yeah.

A. Let's go the other way here. There you go.

So I'm starting out with -- in -- in this calculation -- with the equivalent information that Dr. Johnson used in his original testimony of March -- or, I guess, that was February, wasn't it?

Q. January.

A. January. His original January testimony, January 20. So I'm -- the first two numbers that I'm reciting come directly from his testimony and -- where he -- we're choosing, again, the benzo(a)pyrene as a surrogate or a proxy for the -- for the bitumen. And again, I'm not endorsing this approach. I am just using -- using this calculation to show a contrasting method to what he presents.

So starting with -- with that, on the third bullet then, assuming that the B(a)P is a proxy for all bitumen compounds, if I utilize the same values that I previously referred to in my -- in my report work, the spent sands would contain about 1.8 parts by weight of d-limonene to .84 parts by weight of bitumen. And again, we're using B(a)P as a proxy for bitumen.

Then assuming that all that dissolves

together, the bitumen -- or the B(a)P or bitumen dissolves into the d-limonene, I'm calculating a mole fraction just by incorporating the two molecular weights of those compounds, and I come up with a mole fraction of .201. This would be the fraction of bitumen in that solution of d-limonene and bitumen.

MR. HOGLE: We're going to take a break.

VIDEOGRAPHER: We're off at 12:15.

(Off the record)

VIDEOGRAPHER: We're back on the record at 12:22.

BY MR. HOGLE:

Q. All right, Mr. Handl. Just kind of picking up where you left off with the -- you know, assuming all the B(a)P dissolves into the d-limonene.

A. Yes. This -- we're at the bottom of the first page of my demonstration calculation here. So then, turning to the next page, starting with that .201 mole fraction of bitumen in solution with the d-limonene -- turning, then, to the second page of the calculation, we can then calculate the bitumen concentration in water, in equilibrium with the d-limonene, from the relationship on Equation ~~721~~ 7-21 from the Schwarzenbach text. I misspelled Schwarzenbach there. But that is shown -- the formula is shown here, and the activity coefficient is shown, and the -- that activity coefficient can be approximated as 1 with regard to the statements made on page 237 of Schwarzenbach.

And again, that deals with the ideality of the hydrocarbons mixing together, which should be a coefficient very close to 1.

So then combining the activity -- or combining the two items that are -- we obtain from -- from the first page -- the .201 mole fraction times the -- the liquid saturated solubility -- we come up with a calculated solubility of 9.89 micrograms per liter for -- for the approach -- a -- a similar approach to what Dr. Johnson uses. But this, again, is out of the Schwarzenbach text.

And then the solubility increase factor like -- like he is utilizing in -- in -- in his analysis would be comparing that increased solubility to the -- to the pure component solubility.

Dividing those two, the ratio then becomes 6.51, which is the increase factor that

could be attributed to this method, and that's vastly different than the 1,500 that -- that he obtained. So I think it does point back to the possibility of those -- some of those accumulative errors that -- that he made in his analysis.

Q. Okay. And one last area I want to go over with you...

(Whereupon, Exhibit No. 19 was marked for purposes of identification.)

BY MR. HOGLE:

Q. I'm handing you what's been marked as Exhibit 19. Do you -- can you identify that for us?

A. Yes. This is the -- the flowchart for the U.S. Oil Sands process that -- that I reviewed in the initial part of my work. That was supplied to me. I have seen this before.

MR. HOGLE: And I would move for the admission of Exhibit 19.

BY MR. HOGLE:

Q. Why don't -- yeah, use the document camera to show that. And -- and just summarily -- I mean, this will be done before your testimony is -- is -- is displayed, but I want to focus you in on the -- the lower right-hand portion, with respect to the de-watering unit --

A. Yes.

Q. -- so if you want to zoom in there so it shows up a little better. Okay.

Now, you have a -- you're -- you've become familiar, in this case, with the de-watering mechanisms that U.S. Oil Sands plans to use in its operation?

A. Yes. I'm -- I'm -- I'm not familiar, but I'm aware of them, and I understand the processes that are involved.

Q. Okay. And are you -- are you familiar with the mechanisms that they -- do you have any experience with the mechanisms that they plan to use?

A. Yes, I am familiar and experienced with different types of filtration and have actually used that on -- on sites. The two units that are shown here are a -- a vacuum disk filter and a horizontal belt filter.

Q. Okay. And how effective at de-watering are those mechanisms?

A. Those are very effective. Typically, they operate with a vacuum assist. So the slurry enters on top of the filtration element, and the liquid is pulled through the filtration element,

leaving the -- the solid material on top of the element. And then the solid material is either -- either -- well, it is then mechanically discharged.

But in the process of filtration, the filter is normally operated so that as the filter cake moves through the unit, the final -- the final filtration step or the final filtration portion of -- of the route through the unit involves actually sucking air through the cake by -- by that vacuum.

So you want -- you want the -- the vacuum filter to remove the liquid and then get it to the point where it's dry enough so that it's actually transferring air through that filter cake. And that -- that is both the case for the horizontal belt filter and the -- the disk filter, as -- as well as many other filtration elements.

Q. And when the cake or the solids come off the line, how would you characterize the -- its dampness or its saturation?

A. Well, the -- the whole object of filtration is to -- to obtain a cake that is handleable, so you want to remove as much of the water as possible. And I'd characterize the filter -- the filter cake at that point as being no longer free draining. It would be -- it would still have some moisture in it in terms of being a damp material, but it would be well below saturation.

MR. HOGLE: No further questions at this time.

MR. DUBUC: Are you ready to go off -- let's take a short break, please.

MR. HOGLE: All right.

VIDEOGRAPHER: We're going off the record at 12:30.

(Off the record)

VIDEOGRAPHER: We're back on the record at 12:42.

EXAMINATION

BY MS. WALKER:

Q. Thank you, Mr. Handl. Did you participate in the drafting of the Permit-By-Rule document?

A. I did not.

Q. Did you participate in the drafting of the Notice of Intent?

A. I did not.

Q. Did you give anything to the agency -- and by "the agency," I mean the Division of Water Quality -- before it made its decision in February

2011?

A. No.

Q. When did you first have a role in this project?

A. It was after Dr. Johnson's original testimony, and I don't know the exact date, but I think it would have been early February.

Q. February of what year, please?

A. This year, 2012.

Q. Does your analysis appear in that NOI, the Notice of Intent?

A. I don't know.

Q. Did you review the NOI?

A. No.

Q. Does your analysis appear in the Permit-By-Rule document?

A. I don't know. I don't think it does.

Q. Did you review that document?

A. I don't believe so. I -- that -- is -- is that the -- is that the document that Bob Bayer would have...

MR. HOGLE: He's not clear on what document you're referring to.

MS. WALKER: It's an exhibit to his testimony. It could also be called the demonstration letter.

Does that ring a bell?

THE WITNESS: Was this -- is that -- let -- let me just check. If it's referring to the February 21, 2008, attachment to Bob Bayer's letter to Mark Novak, titled "Request for Permit-By-Rule Determination," then the answer is yes. Otherwise, the answer is no.

BY MS. WALKER:

Q. Okay. So let's call that the -- for -- for the time being -- the Permit-By-Rule. Okay? Does that work for you?

A. Yes.

Q. Okay. So you did review that document?

A. Yes.

Q. So is your analysis in that document?

A. No.

Q. As far as you're aware, is your analysis in any documents that were before the agency when it made its decision in February 2011?

A. No.

Q. Does your testimony answer or attempt to answer the question of whether, in your opinion, d-limonene affects the solubility of the tar compounds in water?

A. Yes.

Q. Does the Permit-By-Rule answer the question of whether d-limonene affects the solubility of tar compounds in water?

A. I don't recall.

Q. Does your testimony ask the question of whether d-limonene affects the solubility of the tar compounds in water?

A. Yes.

Q. Is that question relevant to understanding whether the processed sands are a potential source of contamination?

A. Yes.

Q. So -- but you're unaware of whether the Permit-By-Rule answers that question?

A. I was not asked to look at that, so I'm not really aware of that.

Q. Okay. Well, would you turn to page 7 of the Permit-By-Rule, please? That is an exhibit to your testimony. Oh, Reference No. 3 you call it. This is already an exhibit because it's part of your testimony. So if you would turn to page 7, please.

Okay. So I'm reading from the -- it's not the full paragraph but the last paragraph on that page, and I'm going to read a statement, and that is from this document, it says "The processed

tar sands would" -- "that would be disposed back into the open pit represent the material with the characteristics most likely to contaminate the water that contacts the material." Do you agree with that statement?
A. Yes.
Q. And would that statement also apply to processed sands disposed of in the waste piles?
A. Yes.
Q. Okay. So the next sentence says "Petroleum compounds associated with bitumen ridual" -- "residual" -- I'm sorry -- "entrained process water, or remaining process chemical represent, in theory, potential sources of contamination." Do you agree with that sentence?
A. Yes.
Q. And does that apply to processed sands disposed of in the waste piles as well?
A. Yes.
Q. Okay. So the next sentence, which goes on to page 8, says "To further investigate this potential, lab analyses -- using Toxicity Characteristic Leaching Procedure (TCLP Method 1311) and Synthetic Precipitate Leaching Procedure (SPLP Method 8270C/3510C and GC/MS 8260B), as well as

leaching procedures using other solvents (EPA Method 8015B/3545), were run on unprocessed tar sands, processed sands, and processed fines."
Do you agree that that's the proper way to answer the question of whether the petroleum compounds associated with the bitumen are a potential source of contamination?
A. Yes, I believe those would be appropriate methods.
Q. Okay. So I'd like to go through those tests one at a time, starting with the assessment of petroleum analysis and other hydrocarbons, which appears in a table on page 8 and 9, but the text discussing it is on page 10 and 11, with another table, so if you could turn to Table 4.
Is it your understanding that this table summarizes the results of those tests?
MR. HOGLE: Objection, foundation.
THE WITNESS: Do I need to answer or --
MR. HOGLE: Yes.
MS. WALKER: Oh, I -- I -- so you need more foundation for a document that was attached to your witness's testimony?
MR. HOGLE: Your question, Joro, is whether he knows whether all the tests are -- test results are

summarized in that table?
MS. WALKER: I think you're -- I'm sorry if I -- let me restate.
BY MS. WALKER:
Q. Do these tables purport to summarize those tests?
A. I -- I don't know what the intent was.
Q. Okay. So what does this table tell us about the potential of -- what does this table tell us about the potential of the petroleum compounds associated with the bitumen residual to be a source of potential contamination? What does it tell us about that?
A. It appears to give some concentration values; however, there's no speciation.
Q. I'm sorry. Can you say what -- can tell me what "speciation" is?
A. I -- I -- I -- I meant the organic speciation with regard to the other hydrocarbons.
Q. Okay. I'm sorry. I still don't understand what "speciation" is.
A. Individual chemical makeup.
Q. So are you saying that it doesn't tell us --
A. Yes.

Q. -- whether a petroleum compound --
A. Yes.
Q. Okay. I'm going to have to -- I'm going to have to say the whole question. Sorry.
So are you telling me it doesn't tell us whether the petroleum compounds associated with the bitumen residue, entrained process water, or remaining processed chemicals represent a potential source of contamination?
A. No.
Q. No, it doesn't tell us?
A. That's correct.
Q. Okay. Thank you. So I'd like to move on to the next test. This is on page 10, under the heading of Volatile and Semi-Volatile Organics, and it's referring to -- well, it's referring to the charts on those previous pages.
So I'm wondering if this test tells us anything about whether the petroleum compounds associated with bitumen residue -- residual -- I'm sorry -- entrained process water, or remaining process chemicals represent a potential source of contamination?
A. I think it speaks to that, yes.
Q. In what way, please?

A. That there is a de minimis or -- or minimal effect.

Q. Does this test talk about petroleum compounds?

A. Yes.

Q. What does it say about petroleum compounds?

A. You want me to read it back to you?

Q. Sure.

A. "Tar sands are comprised of bitumen, which is the non-volatile end member of the petroleum maturation process. By definition, then, bitumen contains little or no volatile or semi-volatile constituents. Therefore, it is believed that the results still indicate a de minimis effect on groundwater from volatile or semi-volatile components, particularly given the hydrogeologic settings as described below."

Q. So you're saying this test tells me that tar sands are comprised of bitumen, which is a nonvolatile -- I'm sorry -- which is the nonvolatile end member of the petroleum maturation process? This test shows me that?

A. I'm telling you that's what that said. That's what you --

Q. Does the --

A. -- asked me to do.

Q. -- test that -- okay. I'm sorry. I'm not being clear. Does the test that they ran show that tar sands are comprised of bitumen, which is the nonvolatile end member of the petroleum maturation process?

MR. HOGLE: Objection, compound. You can go ahead.

THE WITNESS: I -- I don't --

MS. WALKER: Does that tell us --

THE WITNESS: -- see a --

BY MS. WALKER:

Q. Go ahead --

A. Do you want --

Q. -- go ahead. Sorry.

A. I don't see a test for bitumen here. I do see a test for hydrocarbons, including oil and grease, and total recoverable petroleum hydrocarbons.

Q. But those results were the ones you just said were not helpful in determining whether the petroleum compounds are a potential source of contamination.

MR. HOGLE: Objection. It misstates the testimony, argumentative.

BY MS. WALKER:

Q. Was it your --

A. I --

Q. -- was it your testimony --

A. Do you want me to answer or --

Q. I'm sorry. Was it --

A. -- rephrase your question again. I -- you're --

Q. Yeah, yeah, I'll rephrase. So was it your testimony a few minutes ago that the test that resulted in the figures for oil and grease and total -- oh, PH -- total petroleum hydrocarbons -- Table 4 -- okay. Let me try -- try again. Sorry. Okay.

Was it your testimony earlier that the figures presented in Table 4 were not helpful to determining whether petrochemicals were a source of -- a potential source of contamination?

A. I believe that's what I said.

Q. Okay. So then, when I was asking you about the volatile and semi-volatile organics and the tests that were supposed to reveal those, I was asking if that test shows that tar sands are comprised of bitumen, which is the nonvolatile end member of the petroleum maturation process.

So my question is: Do those tests show that? And if I understand your -- your answer, you referred back to those same oil and grease and TRPH numbers. Is that right?

MR. HOGLE: Objection --

THE WITNESS: Your --

MR. HOGLE: -- compound.

THE WITNESS: Your -- your -- your question is -- is -- is confusing, but what -- what I'd like to summarize is that those tests do not fully characterize the bitumen.

BY MS. WALKER:

Q. Okay. So what does a volatile and semi-volatile organic test show us?

A. A volatile organic test shows the -- depending on the analysis -- the specific compounds that are -- that can be readily evaporated or are volatile that are tested for in the particular test procedure applied to that material.

A semi-volatile test does the same except for it quantifies the various materials that have a lower volatility that -- that, again, are part of the -- this -- the test suite. Not -- not all semi-volatile compounds nor all volatile compounds are usually included in any one test.

Q. So is this the proper test to run to determine if the petroleum compounds are a potential source of contamination?

A. It would -- it would show the potential for the materials that are analyzed here, yes, but -- but -- let me just stop there.

Q. Does it rule out the petroleum compounds being a potential source of contamination?

A. No.

Q. Okay. Then I'd like to go to this -- the TCLP test. It's on page -- which the narrative explaining that is on page 11. So I'd like to ask you if this test is helpful in determining whether the petroleum compounds are a potential source of contamination.

A. Yes.

Q. It is helpful?

A. Yes.

Q. Does it rule out -- so do the results of this test mean that the petroleum compounds are not a potential source of contamination?

A. The -- the TCLP test does -- does not speak to petroleum contamination, as described --

Q. Okay.

A. -- on page 11.

Q. So is it fair to say that these tests then, in the Permit-By-Rule, don't rule out petroleum compounds as a potential source of contamination?

A. Yes, I think that's fair.

Q. So what tests would rule that out?

A. I haven't been asked to look at that.

Q. Do you have any opinion on it?

MR. HOGLE: Objection, lacks foundation.

THE WITNESS: I -- I really don't have an opinion on that.

BY MS. WALKER:

Q. Okay. So is there any test that would test your analysis in your testimony?

A. Yes.

Q. What would that be?

A. It would be chemical tests to confirm the bitumen content and other chemical content in the two phases and relate those together.

Q. So you could actually run a test that would determine the effect of d-limonene on the solubility of the tar compounds in water?

A. Could I do that? Is that your question? Or are you questioning --

Q. Could one --

A. -- whether a test --

Q. -- could one --

A. -- be performed?

Q. The second: Could a test be performed? Yes.

A. Yes.

Q. And does the -- do the results of any such tests exist in the record as far as you know?

A. I can't answer that. I don't know.

Q. Have you seen any results of any such tests on the processed fines from the PR Springs site?

A. I have not.

Q. So is there any empirical data that you've seen anywhere that supports your contention that the presence of d-limonene will suppress the transfer of PAH compounds into solution as compared to the case of those same materials dissolving into water from the original virgin oil sands?

A. Would -- would you repeat that, please?

Q. Okay. Just to be clear, that's a quote from your testimony at page 5. So what I'm asking is: Is there any empirical data that you have seen anywhere that supports your contention -- and here's

where the quote from your testimony starts -- "The presence of d-limonene will suppress the transfer of PAH compounds into solution as compared to the case of those same materials dissolving into water from the original virgin oil sands"?

A. I have -- I have no -- not seen any empirical data.

Q. Is there any empirical data that you've seen anywhere that contradicts Dr. Johnson's testimony that the presence of d-limonene will cause more tar -- tar -- sorry -- will cause more tar to dissolve in water than what occurs in its absence?

A. Yes.

Q. Empirical data?

A. What do you consider to be data?

Q. What do you consider to be data?

A. Is it -- does a textbook qualify?

Q. I took "data" in this question to mean actual tests on actual compounds and actual processed fines.

A. Yes, I've seen summaries of the data, but I have not actually viewed the data.

Q. And where is that data?

A. The one report that I reviewed that -- that speaks to that is an EPA document:

EPA/600/M-91/009, March 1991.

Q. And that document was created as a result of -- of actual lab tests or in-the-field tests?

A. That's my understanding.

Q. And did it deal with tar and d-limonene?

A. No.

Q. Okay. Any other data you want to refer me to, please?

A. No.

Q. Is it fair to say that you're assuming, for the basis of your analysis in your testimony -- or -- I'm sorry. I should call it your expert report -- that ideal conditions exist?

A. Yes.

Q. So your analysis is based on an ideal solution?

A. Portions of the calculations are, but the analysis itself is not.

Q. Can you tell me which portions are based on ideal solution --

A. Yes. When I --

Q. -- or -- an ideal solution or...

A. Okay. Yes, I -- I can -- when I made my final calculations of B(a)P from the -- from the bitumen dissolved in the raffinate phase, those are

ideal calculations.

Q. I'm sorry. So is that the -- the exhibit -- is it 19? Is that what you're referring to? Or are you referring to your testimony?

A. I'm referring to my report.

Q. Your report. So is there anything in your report that does not assume ideal solution?

A. Yes.

Q. Please point that out.

A. All of the data that I input are actual data as reported in the literature. They may or may not have come from ideal solution information, but they're actual data. That's one example.

The theory of the ternary diagram is another example. The -- the approach that is outlined in Perry's handbook is another example.

Q. So are you saying, when you did your ternary analysis, that you weren't relying on an ideal solution?

A. I was relying on the data that was presented in the literature and interpreting --

Q. So --

A. -- interpreting that in accordance with standard practice in Perry's hand -- handbook.

Q. So is standard practice to assume ideal

conditions?

A. For dilute solutions, yes.

Q. Are there any dilute -- I'm sorry. Are there any dilute systems -- oh, I'm sorry. Let me try again.

Are dilite -- are dilute systems always ideal?

A. I can't answer that.

Q. Is that because you don't know?

A. No. Because I don't -- I don't -- I'm not aware of all ideal -- of all dilute solutions. That was your question.

Q. So there could be some dilute solutions of which you're not aware that are nonideal?

A. I don't know.

Q. Do you know of any kinds of dilute solutions that are not ideal?

A. I -- I don't have the -- the knowledge to answer that question.

Q. So when you assumed that -- well, let's bring up your -- your -- your ternary diagram, please. Is that the right term?

MR. DUBUC: Do you -- do you want it up on the screen?

Exhibit 7. Can we get Exhibit 7 on the

screen? Can we get Exhibit -- Exhibit 7, could we get that on the screen, please?

BY MS. WALKER:

Q. Can you push it up a little, please, or -- that's good --

A. Yeah --

Q. -- thank you.

A. -- just hold your horses.

Q. Okay. So on that diagram, you have an arrow pointing to a point which says "Bitumen solubility in water." Do you see that?

A. Yes.

Q. And you also have a point that says "d-limonene solubility in water." Do you see that?

A. Yes.

Q. And so you drew a straight line between those two points; is that correct?

A. Yes.

Q. And is it your understanding of Dr. Johnson's testimony that he drew a curve between those two points?

A. Yes.

Q. What's the basis for drawing a straight line?

A. Perry's handbook.

Q. So what in Perry's handbook gives you the basis for drawing a straight line?
A. Dilute solution assumption.
Q. So you're assuming that dilute solutions produce straight lines?
A. Yes. In this case.
Q. All right. Are there -- in this case --
A. Yes.
Q. -- are you saying that -- and that's based on what?
A. My education, training, and background and experience.
Q. Is it based on testing -- data that tests the points on the line?
A. No tests were conducted under my work.
Q. Okay. So when you say it's based on your education and experience, are there any references you can point to?
A. By "references," do you mean -- you mean written references? Is that what you're saying? I --
Q. Yes.
A. I didn't bring any with me, no.
Q. So does a straight line assume ideal conditions?

A. Yes, I believe it does.
MR. DUBUC: Are you going to hand him this?
MS. WALKER: I don't know. Leave it.
MR. DUBUC: All right.
BY MS. WALKER:
Q. So I would like you to look at, I think, what you've been calling Perry's handbook. Bible? Perry's Bible?
MR. MACHLIS: Is that Exhibit 8?
BY MS. WALKER:
Q. Oh, Exhibit 8. If I might turn your attention to -- I guess it's page 15-3, under the heading Phase Equilibriums.
MR. DUBUC: Can we put that up on the screen, please? Exhibit 8, the second page.
BY MS. WALKER:
Q. So you see that part at the bottom that says "Phase Equilibriums"?
MR. DUBUC: Could we enhance that, please? Could we zoom in on that? The bottom of that. Back --
MS. WALKER: Right.
BY MS. WALKER:
Q. So the first paragraph under Phase Equilibriums --

MR. DUBUC: Thank you.
BY MS. WALKER:
Q. Okay. Under -- I'm going to read that first -- those first couple of sentences to you. "Accurate knowledge of phase-equilibrium relationships is vital for quantitative considerations of extraction processes. The required quantities of solvent (and reflux, if used) are set by these data. Also, the driving forces determining rates of mass transfer are governed by these thermodynamic considerations. Since formulation of two stable liquid phases in contact with each other is an essential requirement, at least one phase is almost certain to be one in which solute components behave thermodynamically in a strongly non-ideal way."
So I'm wondering: Do we have a situation in -- with our d-limonene and tar where there are two stable liquid phases in contact with each other?
A. Is that a question?
Q. Yes. Do you want me to say it again?
A. Well, you're wondering. I don't -- I don't know how to respond to your wonderment.
Q. Okay. In your opinion, do we have a situation with our d-limonene and bitumen where we have two stable liquid phases in contact with each other?

A. Yes, we do.
Q. So in -- according to Perry's Bible, then, we have a situation where at least one phase is almost certain to be one in which solute components have behaved thermodynamically in a strongly nonideal way?
A. We -- we have -- we have that condition, but you need to read to the bottom of that paragraph.
Q. Well, right now let's talk about this sentence. Does it mean something?
A. I'm sure that it does.
Q. Okay. So if we have -- in our situation, we have two stable liquid phases in contact with each other. Are you saying they're both ideal?
A. In -- in this -- in this case of the particular limonene, bitumen, and water, I believe those phases are close to ideal, if not ideal.
Q. So does that conflict with this statement here?
A. It -- it -- it can be resolved with that statement in the context of the entire paragraph.
Q. Okay. I'd like to turn your attention,

then, to the bottom paragraph of that same column, and it says "In what follows, only the simplest and most commonly occurring systems are described."
Do you agree with that statement?
A. Yes.
Q. So is our d-limonene and tar situation a simple and commonly occurring system?
A. I believe it to be a simple system. I don't believe it to be a commonly occurring system because I think this is a fairly unique system.
Q. So is d-limonene completely immiscible in water?
A. No.
Q. So how would you describe its immiscibility?
A. You -- you cut -- your last word cut out. I wasn't sure what you said.
Q. How would you describe its immiscibility?
A. It has a very minute solubility but tends to be immiscible in water.
Q. And how would you describe -- I'm sorry -- and how would you describe the immiscibility of bitumen --
A. It has a --
Q. -- in water?

A. -- it has a very low solubility in water but some measurable concentration.
Q. Can you explain that in terms of immiscibility, please?
A. The -- the liquid -- the liquid itself forms a -- a layer or a separate phase with water; therefore, it is -- it's considered, from a lay standpoint, to be immiscible. But the immiscibility does not always speak to the slight solubility in the raffinate phase or the -- the water phase. But they --
Q. So --
A. -- they --
Q. -- is it fair to --
MR. HOGLE: Hold on. He's not done yet.
THE WITNESS: They -- they are considered to be immiscible when -- when speaking strictly of miscibility.
BY MS. WALKER:
Q. Okay. Did you -- would you describe d-limonene as being partially miscible in water?
A. I -- I would call it an immiscible fluid in water.
Q. Immiscible? Is that what you said?
A. Immiscible, yes.

Q. Okay. And would you describe bitumen as immiscible in water?
A. Yes.
Q. So it's not more accurate to call it partially immiscible?
A. It's -- it's a degree of -- of expression, but I would consider both of those to be immiscible with water.
Q. So by immiscible -- when you're saying they're immiscible in water, are you saying they're completely immiscible in water?
A. Define "completely immiscible," and I'll tell you the answer.
Q. I'm asking you if, by "immiscible," you mean completely immiscible.
A. Yes, I would say they're completely immiscible. As I described before, there is some solubility in the water phase, but the fluids themselves are immiscible. They form a -- an oil-rich -- or a layer that does not completely dissolve in water, and the dissolution in the water is very, very minute. I would consider them to be immiscible.
Q. Okay. So in your report, on page 2, you stated "In a Type II system" -- and by "Type II

system," you're talking about the ternary phase diagram -- "the two liquids used to effect the extraction of the solute are only partially immiscible." I'm sorry. I said that wrong. Let me start over.
"In a Type II system, the two liquids used to effect the extraction of the solute are only partially miscible and the solution dissolves between both phases." (As read)
So are you saying that -- that -- now that the Type II system doesn't apply?
A. No.
Q. Okay. So it says -- if I understand your testimony correctly, are you saying that a Type II system is appropriate only where the compounds are partially miscible?
A. No.
Q. So why did you use a Type II diagram?
A. Because it applies to this system.
Q. So why did you say in your testimony "In a Type II system, the two liquids used to effect the extraction of the solute are only partially miscible and the solute dissolves between both phases"?
A. Because that's what happens. The -- the term "miscibility" is not an exact term, and what I

meant in that paragraph was -- was I was accounting for the dissolution of materials that I spoke to before.

They are immiscible, but when you look -- when you talk about that immiscibility in relation to the dissolution in the water phase, I was allowing for the fact that there is some dissolution in the water phase, but the compounds are considered to be immiscible with water. It's more of a semantics question.

Q. Okay. So in Perry's bible, on page 5-14, which is the next page there -- can you have it up on the document screen, please. Flip --

A. 5-14? I don't have a page 5-14. You'll have to tell me what you're talking about. I don't see 5-14.

Q. Well, the pages -- the next page -- so if you turn the page on this Perry's Bible -- there we go. That's 5-14. I don't know why it's numbered that way. And then --

A. Where? I have no idea what she's talking about.

Q. On the left-hand side of the page -- so the first column -- in that -- just above that -- okay. So the first column -- can you zoom in on the first column, kind of in the bottom, the bottom of the first paragraph?

A. (Witness complied.) I'm going to have to take another break.

Q. Okay. So I'm looking --

MR. HOGLE: Joro --

MS. WALKER: -- at the last sentence in that circle --

MR. HOGLE: -- Joro, can we take a break real quick? The witness needs a break.

MS. WALKER: Okay.

VIDEOGRAPHER: We're going off the record at 1:34.

(Off the record)

VIDEOGRAPHER: We're back on the record at 1:46.

MR. DUBUC: Are you ready? Back on the record. Sorry.

MS. WALKER: I'm sorry. I'm trying to eat. I -- I apologize. We haven't had a lunch break.

BY MS. WALKER:

Q. Okay. I'm going to read the last sentence in that first paragraph in the left column.

MR. MACHLIS: I think it's on page 15-3.

MS. WALKER: 15-4.

MR. MACHLIS: 15-4? Sorry.

BY MS. WALKER:

Q. "In Type II systems (Figure 15-2b) S is partially miscible with both A and B, and a feed of any proportions of A and B may be processed."

Oh, it's not the last sentence. Second to last sentence.

"Raffinates lie on Curve UC, extracts on WZ."

So what does that state -- how does that statement reflect on your contention that d-limonene and bitumen are immiscible?

A. That -- the immiscibility is what causes the phases to occur. The more immiscible they are, the closer they -- the closer the water -- the raffinate phase will be to the apex and the more highly soluble the oil phase is the closer it will be to the -- to the axis on the right hand of the equilibrium -- or of the ternary diagram. So it is a degree of -- it is -- it is a question of degree.

Miscibility in this context is a somewhat variable term. The system that we are looking at is a lot more immiscible than the one that is diagrammed in the Perry's example with regard to the water phase.

Q. So the system we're talking about is more -- if I understand you correctly -- is more immiscible than the diagram on page 15-3?

A. Yes.

Q. Can you flip that page over again? Sorry.

So does it matter how you define immiscibility for your analysis?

A. No.

Q. It's irrelevant?

A. No.

Q. How is it relevant?

A. It's relevant with regard to the amount of dissolution you get of the bitumen and bitumen compounds into the water phase and, as well, the limonene into the water phase, so it is not irrelevant.

Q. So are you defining miscibility, then, to fit your argument, sometimes calling it partially miscible and sometimes calling it immiscible?

A. I am not defining miscibility.

Q. Are you then referring to it sometimes as partially miscible and partially -- I -- I'm sorry -- are you referring to miscibility sometimes as partially miscible and sometimes immiscible?

A. No, I think I've already answered that question. I'm saying that miscibility is a variable term that it's hard to say when a -- when a system -- if we were to have a series of miscibility, it would be hard to define when one considers the immiscible threshold to be crossed into partially miscible. It's a degree of -- it's a spectrum type of an -- an approach, so it's -- it's -- it almost defies explanation. But it's a degree of -- a -- a degree of separation.

Q. So how are we supposed to know what you're talking about?

A. Listen, I guess.

Q. But how do we know if you're talking about -- where on that spectrum you're referring to?

A. I'm referring to a highly immiscible system, as I stated before.

Q. So when you say you're referring to a partially miscible system, that's inaccurate?

A. No.

Q. So you're referring to both?

A. In my report, I -- I refer to the partial immiscibility -- immiscibility with -- as it -- as it relates to the dissolution of materials into the respective phases. But in this system, it is very -- it is a very immiscible-type system. That's why the large, large separation between the two phase plots on the ternary diagram. That's about as best as I can explain it.

Q. So at what degree of immiscibility is the system ideal?

A. It is -- it is ideal with respect to the dilute solutions that we have in this system. I think there would be great debate as to when that threshold is -- is crossed.

Q. So it's hard to say when a system is ideal?

A. Again, it's a -- it's a degree of -- it's -- it's a degree. The -- the transition from nonideal to ideal can be a gradient or a -- a -- a degree.

Q. And yet you assume that the system was ideal.

A. Yes. The -- for this system, I'm assuming that it is ideal because of the very, very dilute solutions in the water phase and the very, very concentrated solutions in the oil-rich phase.

Q. So are you saying that in a dilute system, then -- I'm sorry. Yes -- in a dilute system, the -- the compounds can't affect one another?

A. No, I don't say that.

Q. Okay. Are you saying, in the system we have here with d-limonene and bitumen, that the d-limonene and the bitumen can't affect each other?

A. No.

Q. So are you saying that the presence of d-limonene in the water will affect the -- the dissolving of bitumen in the water?

A. In -- in the entire system, it will, yes.

Q. In the raffinate?

A. The raffinate is part of that system, yes.

Q. So you're saying the presence of d-limonene in the raffinate will influence the dissolving of bitumen in the water -- in the raffinate?

A. Actually, the driving force will be the other way around. The amount of limonene in the oil-rich phase will -- will drive concentrations in the raffinate phase.

Q. Okay. So I'd like to turn to Exhibit -- the -- the part from the textbook. What's his name?

DR. JOHNSON: Schwarzenbach.

MS. WALKER: Schwarzenbach? Which is Exhibit -- didn't we get to it? Maybe it's an exhibit from -- from last week. Okay.

Okay. It's Exhibit 3 from last week. Do you have those?

MR. HOGLE: Yes. He's just going to use my copy. Okay, Joro?

MS. WALKER: Sure. Page 97. We've talked a lot about this.

MR. HOGLE: That's it, right there (indicated).

THE WITNESS: Ten?

MR. HOGLE: Yeah. It's -- it's right in there. It's open to it.

THE WITNESS: Oh.

MR. DUBUC: Can you put that on the screen, please? Thank you.

BY MS. WALKER:

Q. Can you zero in a little, please, at that lower paragraph?

A. (Witness complied.)

Q. Thank you. So I'm just going to read a -- a statement sort of halfway down that paragraph, starting with "Finally," where the little mark is.

"Finally, if the organic chemicals are present at a" -- "low enough levels (less than 10 to

the minus 3 volume fraction) then there is a low probability of even their hydration shells overlapping, we can expect no effect on the aqueous activity coefficient or (liquid) solubilities." (As read)

So is this a rule of thumb?

A. I -- I don't know. He's speaking of a probability here, and the --

Q. Okay. So is it a --

MR. HOGLE: Were you finished with your answer?

THE WITNESS: He's speaking of a probability and overlapping of hydration shells, which are a theoretical consideration beyond what I have -- am familiar with.

BY MS. WALKER:

Q. So does this statement apply to our situation with d-limonene and bitumen?

A. The very low volume fraction portion of that statement would apply.

Q. So does it -- are there any situations where you would still see an effect on the aqueous activity or on solubility?

A. Certainly.

Q. Could the situation with d-limonene and bitumen be one of those?

A. No.

Q. So you're saying that this statement rules out the possibility that d-limonene could have an effect on the dissolving of bitumen in water?

A. No.

Q. So it doesn't rule it out?

A. No.

Q. So there are -- there could be -- so based on this statement, d-limonene could have an effect on the dissolving of bitumen in the water?

A. Yes.

Q. And that effect could be to increase the concentration of bitumen in the water?

A. I don't think so.

Q. Why don't you think so?

A. Because it is a dilute solution, and reading to the final sentence there, "Slightly soluble hydrocarbons present in a solution do not appear to enhance the dissolution of other hydrocarbons." That doesn't rule out any effect as you described it.

Q. So what's the solubility of d-limonene?

A. In what material?

Q. Water. I'm sorry. In water.

A. 13.8 milligrams per liter at room temperature.

Q. And so, based on this statement or your experience, you wouldn't expect to see an effect or an increase in the dissolving of bitumen in the water where the solubility of d-limonene is 13.8 milligrams per liter?

A. That's correct.

Q. And you're basing that statement on the solubility of d-limonene in water?

A. Partially.

Q. What else?

A. On the solubility of d-limonene in water; on the extremely low solubility of bitumen in water; on the ideal solution -- dilute solution assumption; and additionally, on the guidance given in Schwarzenbach.

Q. What did you say about "ideal solution situation"?

A. Dilute -- very dilute solutions.

Q. All right. And you're assuming them to be ideal?

A. In this case, yes.

Q. Okay. So I have an exhibit. I don't know what number -- should we just continue with our numbers, or do you want letters?

MR. MACHLIS: No --

MR. DUBUC: No. This --

MR. MACHLIS: -- you can put --

MR. DUBUC: -- should be an exhibit for him.

MS. WALKER: Okay. This exhibit is called "Enhanced Concentrations of PAHs in Groundwater at a Coal Tar Site."

(Whereupon, Exhibit No. 20 was marked for purposes of identification.)

THE WITNESS: For things like this that I have not reviewed --

VIDEOGRAPHER: Should we go off the camera?

MR. HOGLE: Yeah.

VIDEOGRAPHER: We're off -- we'll go off the record at 2:06.

(Off the record)

VIDEOGRAPHER: We're back on the record at 2:08.

MS. WALKER: I'd like to move for this to be admitted as Exhibit -- I've forgotten the number already.

MR. DUBUC: Twenty.

MS. WALKER: Twenty.

MR. HOGLE: I'd object to that. Has this been provided before?

MS. WALKER: No.

MR. HOGLE: Okay. That's the basis for my objection at this time.

MS. WALKER: Well, you presented exhibits when Dr. Johnson was testifying that you hadn't provided to us.

MR. HOGLE: The deadline for exchanging exhibits was after Dr. Johnson's deposition.

MS. WALKER: Have you given us a list of exhibits?

MR. HOGLE: Yes.

MS. WALKER: When did you give it to us?

MR. HOGLE: I think the 23rd is when we did that.

MS. WALKER: Well, objection noted.

BY MS. WALKER:

Q. This article comes from a reputable journal; is that correct?

A. I don't know.

Q. You've never heard of the Environmental Science Technology -- Environmental Science & Technology journal?

A. I believe I've heard of it. I'm not familiar with it.

Q. Isn't this the top journal in your field?

A. No.

Q. What is the top journal in your field?

A. My field is more chemical engineering, so I look at Chemical Engineering Progress, Chemical Engineering. I look at a variety of those type of magazines and some periodicals. I -- I don't review the scientific technology journals.

Q. So are you saying that the enhanced concentrations of PAHs in groundwater at a coal tar site is not your expertise?

A. Yes.

Q. Okay. I'm wondering if you've heard of the Massachusetts Institute of Technology.

A. Is there a question there? I have heard of it, yes.

Q. I'm sorry. And I'm wondering if you could read the authors on this paper?

A. Allison MacKay and Phillip Gschwend.

Q. So I'm wondering -- I'm sorry. Is Phillip Gschwend also a co-author on a textbook? Organic Chemistry? Environmental Organic Chemistry?

MR. HOGLE: Objection, foundation.

THE WITNESS: The -- the names appear the same, yes.

///

BY MS. WALKER:

Q. Do they -- are they the same or do they appear the same?

A. They are the same.

Q. So before we took the break, did you say that the solubility of d-limonene is 13.8 milligrams per liter?

A. Yes.

Q. And that that concentration was a factor in your analysis?

A. Yes.

Q. Okay. So I'm asking -- and that -- I'm sorry. And that that was a factor -- did you say that that was a factor in your analysis determining that d-limonene would actually suppress the solubility of bitumen in water?

A. Did -- are you -- you're asking did I say that? Or what --

Q. Yes.

A. I think -- I think --

Q. Or --

A. -- it was in my report. I don't remember saying that today.

Q. Okay. So do you agree with that statement then?

A. What -- what -- read --

Q. Do you want me to repeat the --

A. -- read that statement back to me again, please. I -- I want to be careful how I answer this.

Q. Okay. So --

A. That question, rather.

Q. -- is it your opinion that the solubility of d-limonene at 13.8 milligrams per liter is a factor in your conclusion that d-limonene would actually suppress the solubility of tar in water?

A. Yes.

Q. Okay. Is bitumen a high -- a hydrophobic organic -- a hydrophobic organic compound?

A. Yes.

Q. So -- and are petroleum compounds hydrophobic organic compounds?

A. Yes.

Q. And are PAHs hydrophobic organic compounds?

A. Yes.

Q. Can you tell me what PAHs are --

A. Polyaromatic --

Q. -- please?

A. -- hydrocarbons.

Q. So does this paper represent actual field data?

A. I don't know.

Q. Would you take the time to review it so that you can answer the question?

MR. HOGLE: I'm going to object and instruct the witness not to answer. This is a lengthy document -- eight pages, single spaced, both columns -- it's never been provided before, and we don't have -- time is limited.

MS. WALKER: So when you provided documents to our witness -- exhibits, we had never seen them before. We didn't prevent him from answering your questions.

MR. HOGLE: I don't -- I don't think I had your witness review a document like this that he had never seen before.

MS. WALKER: Well, you gave us a -- you gave us an EPA document that was --

MR. MACHLIS: That was your witness's testimony. The EPA document that we -- that was given in Johnson's document was -- was a document that was referenced in his testimony, wasn't it?

MS. WALKER: That's not true --

MR. MACHLIS: There was --

MS. WALKER: -- this document --

MR. MACHLIS: -- never mind.

MR. HOGLE: Okay, guys. All right. Let -- Let's -- let's continue with the examination, and we can have the debate offline.

MS. WALKER: But -- so are you going to instruct him not to answer that?

MR. HOGLE: That's what I am doing, yes.

MS. WALKER: Then we have to have the debate.

MR. HOGLE: I'm not going to change my instruction.

BY MS. WALKER:

Q. All right. Well, I'll read you a paragraph, the introductory paragraph to this paper. "Concentrations of polycyclic aromatic hydrocompounds (PAHs)" -- "hydrocarbons." Sorry -- "in groundwater at a coal tar site were elevated by factors ranging from 3 (pyrene) to 50" -- I'm not going to say that -- "over purely dissolved concentrations."

Do you think that analysis is relevant to determining whether the presence of d-limonene would influence the solubility of tar in water?

THE WITNESS: Am I supposed to answer?

MR. HOGLE: Objection, lacks foundation. Go

ahead and answer it to the best you can.

THE WITNESS: No, I -- I -- I don't think it refers or relates specifically to the limonene-bitumen water system.

BY MS. WALKER:

Q. Why is that?

A. Because the sentence that you read just says that there -- there was these increases. That's all -- that's all the information I have.

Q. Okay. I'm going to read another sentence. "This suggested" -- this is just a few sentences down -- "This suggested pyrene association with humic acids. Given the decrease in groundwater total organic carbon of 4 milligrams per liter upon acidification and ultrafiltration" -- okay. Scratch that. Sorry. Hang on just a second.

Okay. I'm going to try to be more helpful here and read a sentence from 1326 --

MR. HOGLE: Page 1326.

BY MS. WALKER:

Q. -- which states that the degree -- the decrease in total organic carbon concentration of 4 milligrams per liter was assumed to indicate the concentration of sorbent colloids. Does that indicate a cosolute?

A. I don't believe a colloid is a solute.

Q. Is humic acid a solute?

A. I don't know.

Q. What -- okay. So is this paper saying that there is a very low concentration of humic acid in the groundwater?

MR. HOGLE: Objection, lacks foundation.

THE WITNESS: I don't know what the paper says.

BY MS. WALKER:

Q. Okay. Can you -- can you read that paragraph, please, starting with the organic colloid -- you don't have to read it out loud.

A. What -- which paragraph are you talking about?

Q. Okay. It starts -- so it's the -- on page 1326, the second column. It starts with "An organic colloid."

A. (Witness reviewed document.) I've scanned the paragraph.

MR. DUBUC: Let's take a brief break, please.

VIDEOGRAPHER: We're going off the record at 2:24.

(Off the record)

VIDEOGRAPHER: We're back on the record at 2:41.

MR. DUBUC: You can remove that document screen, please. And can we have full screen on Mr. Handl? Thank you.

BY MS. WALKER:

Q. Okay. So let's talk about a different topic. I'm sure you're disappointed.

You estimated the solubility of bitumen in water, did you not?

A. Yes. Oh, the --

Q. And in --

MR. HOGLE: Repeat it. Did you?

THE WITNESS: "Did you?"

MS. WALKER: I'm sorry.

THE WITNESS: "Did you not?" What does that mean? Did you -- I did not -- I did estimate, yes.

BY MS. WALKER:

Q. And in doing so, did you state that the actual makeup of bitumen will consist of hundreds to thousands of different hydrocarbon molecules?

A. I have stated that.

Q. And did you choose five of those as being representative of those compounds?

A. Yes.

Q. So for each of those compounds, did you determine the proportion of the total of the bitumen that -- I'm sorry. Let me restate that.

And did you determine for each of those compounds -- each of the five -- the proportion of the total 1,000 -- 100 to 1,000 compounds they make up?

A. No.

Q. So you looked at five compounds out of the 100 to 1,000 without knowing the proportions of those compounds in the bitumen?

A. Correct.

Q. So how did you come up with the 5 milligrams per liter solubility --

DR. JOHNSON: Micrograms.

BY MS. WALKER:

Q. -- micrograms per liter solubility?

A. That's explained in my report. I looked at that range of compounds, and I wanted to include some at the light end of the range and some at the heavier end of the range, and I looked at the entire range and picked some in between and weighted it conservatively.

Q. And do we know the compounds that make up the bitumen?

A. No.

Q. So that's nowhere in the record?

MR. HOGLE: Objection, foundation.

THE WITNESS: I -- I don't know the answer to that.

BY MS. WALKER:

Q. Okay. Have you reviewed any documents that tell you the compounds that make up the bitumen?

A. I have seen references to some compounds that are in bitumen, but in no way do I purport to have seen an indication of all the compounds that are in bitumen.

Q. So is there a test that would tell you the makeup of the compounds in the bitumen?

A. I believe tests, plural, would be appropriate.

Q. So did you use a proxy, then, for the 100 -- for the solubility of the 100 to 1,000 compounds?

A. No. I used a range of compound and then made a judgment on a -- a representative figure for that range. I did not use a single proxy.

Q. So you necessarily estimated the solubility of the compounds?

A. Yes. I -- I -- I estimated -- I --

Q. And what was that --

A. -- let me rephrase that. I estimated a bulk solubility for bitumen. I -- I -- I did not estimate the solubility for the individual compounds I used. I used actual solubility figures.

Q. Okay. So is it fair to say that the pragmatic, real world approach to determining the makeup of the compounds in bitumen would be by testing?

A. That -- that would be the preferred approach.

Q. So this -- am I correct in saying the solubility you came up with was 5 micrograms per liter?

A. Yes.

Q. And do you know what figure Dr. Johnson used for -- for that same solubility?

A. Not offhand, but I -- I think he used a -- I think he -- I don't believe he estimated a -- a bitumen solubility. I believe he used a solubility of B(a)P.

Q. Okay. So --

A. I -- I --

Q. -- do you know what solubility --

A. I -- I --

Q. Sorry.

A. -- think his solubility figure was already mentioned, but I -- let me just check here. I think it's in my report. It was 1.5, wasn't it?

(Witness reviewed document.) I believe Dr. Johnson started with a B(a)P solubility of 1.5 micrograms per liter, so my starting solubility is more conservative than his in that it shows a higher solubility.

Q. Is that value reasonably comparable to yours?

A. Which value are you speaking of?

Q. Is 1.5 micrograms per liter close to 5 micrograms per liter?

A. It differs by 3.5.

Q. So would you expect a lower concentration based on Dr. Johnson's solubility figure or your solubility figure?

A. Dr. Johnson uses a lower solubility figure. I'm not sure I'm answering your question, though.

Q. So is the concentration calculated in water higher for a solubility of 5 micrograms per liter or 1.5 micrograms per liter?

A. It's -- it's higher for the 5.

Q. So Dr. Johnson's estimate is actually more conservative than yours.

A. Not with regard to the calculation that I'm performing because my calculation starts out with a higher concentration. The -- the fact of being conservative means that I am starting with a higher concentration; therefore, forecasting -- the basis of my calculation will be higher, and that higher calculation basis would, in theory, support a higher dissolved basis, which is what we're contending is the problem here. So I disagree with -- with that. I believe that the 5 micrograms per liter is more conservative.

Q. Well, compared to your analysis, is, then, Dr. Johnson underestimating the solubility of his representative compound?

A. I believe that Dr. Johnson starts with a handbook solubility, which should be accurate.

Q. Okay. I'm sorry. Compared to your estimate of the solubility of the bitumen, isn't Dr. Johnson underestimating the solubility of the bitumen by using a lower solubility?

A. It's a -- it's a different approach. His -- his -- his figure is lower than mine, granted; but he's picking a single proxy compound, where I am trying to pick a figure that is

representative of the entire mix.

Q. Didn't you both use B(a)P as your representative compound?

A. Absolutely not.

Q. So on page 4 of your expert report, are you estimating the concentration of B(a)P --

A. I do estimate the --

Q. -- or were you --

A. Is she talking again? I am estimating the concentration of B(a)P, yes.

Q. And was that for a single compound?

A. It was for B(a)P, yes.

Q. So did this calculation include all the hundreds to a thousand other compounds in bitumen?

A. I accounted for their presence, yes.

Q. How did you account for their presence?

A. By starting with the range of solubility data that we spoke of just previously.

Q. So you did use B(a)P as a representative compound?

A. Let me check back. (Witness reviewed document.)

The compounds that I used are listed on page 2 and 3 of my report, and benzo(a)pyrene was one of the several compounds that I did list but not

the only one.

Q. Okay. So on page 4, though -- there, were you calculating the -- were you estimating the concentration of B(a)P in equilibrium contact with the raw bitumen?

A. I was estimating the concentration of B(a)P in water that was in contact with the raw bitumen.

Q. Okay. And so does this estimate account for all the 100 to 1,000 other compounds in the water?

A. Yes, it -- it estimates the presence of those compounds because of the calculation of mole fraction that I performed.

Q. Are you saying that no other compound would go into the water?

A. No.

Q. So how does this account for other compounds going into the water?

A. It doesn't. I'm calculating it for that specific compound. But in the calculation of that, I incorporated the presence of the other compounds. That's the specificity of my approach.

Q. Would other compounds dissolve in the water?

A. Certainly.

Q. How many?

A. I have absolutely no idea. Hundreds to thousands.

Q. So doesn't your testimony at page 1 to 2 -- by that I mean this bulleted paragraph that's indented, that goes from page 1 to 2 -- doesn't that conflict with the notion that d-limonene will evaporate quickly from the processed fines?

A. No, I don't see that relationship.

Q. So does this paragraph assume that half of what's in solution will be d-limonene?

A. For -- for purposes of the demonstration that I'm -- I'm making in that first bullet, I made an assumption. I'm -- I'm not talking about a real world case. I'm only demonstrating the mathematics of -- of the -- how the mole fractions would -- would distribute. I'm not indicating that that is a real world example. Or real world in -- as related to the specific system with -- with regard to U.S. Oil Sands.

Q. Okay. But is it correct to say that your conclusion in that paragraph is that you have to have a fair amount of d-limonene in order to

suppress the entry of B(a)P into the aqueous phase?

A. What -- what I'm saying is that the -- the mole fraction of d-limonene -- whatever it is -- will displace proportionate amounts of the compounds present in bitumen in that solution.

Q. So you have to have half the d-limonene present to suppress the entry of B(a)P into the aqueous phase by a factor of two?

A. It would -- it would decrease -- it would decrease it by a factor of .5.

Q. Okay. So you said that you agree -- are you -- am I correct in saying that you agree that d-limonene will evaporate quickly from the processed fines?

A. I -- I agree that d-limonene will tend to evaporate from the processed fines. The -- the quickness of that evaporation is dependent on a lot of other parameters.

Q. So when you were doing your steam test -- steam-stripping test, what did you conclude from that?

A. I did no such test for this work.

Q. Didn't you testify about a stream test -- I'm sorry -- a steam-stripping test?

A. I -- I said that I had used that in my

college thesis work, yes.

Q. Does that tell you anything relevant to whether d-limonene will evaporate from the processed fines?

A. Yes.

Q. What does it tell you?

A. It speaks to the volatility of the d-limonene.

Q. So will it tell you how quickly that will happen?

A. No.

Q. Does vapor pressure tell you how quickly d-limonene will evaporate from the processed fines?

A. It is one of the parameters that will tell you that.

Q. So why does vapor pressure always include a temperature?

A. Because they vary with each other.

Q. In what way?

A. Increased temperature increases the vapor pressure.

Q. So is it fair to say that a decrease in temperature will suppress evaporation?

A. It has that tendency, but the evaporation is dependent on other factors as well.

Q. So would you expect d-limonene to evaporate less readily from the processed fines if the temperatures were cold?

A. The -- yes, the rate of evaporation should decrease with colder temperatures if the -- if the temperature of the -- the fine -- or the -- the spent material is decreased as well.

Q. Okay. Do you know the relationship between temperature and the evaporation for d-limonene?

A. No. That's dependent on a lot of other parameters.

Q. So, then, you don't know the effect that temperature will have on the evaporation of d-limonene other than to say it will decrease, generally, with temperature?

A. As I've stated, temperature -- either an increase or a decrease -- will have an effect on the evaporation rate, but it is not the only parameter in the evaporation.

Q. So is it important to know temperatures when you're trying to determine whether d-limonene will evaporate from the processed fines?

A. Oh, absolutely.

Q. Okay. Do you know the temperatures at

the mine?

A. No. I imagine today it's a little cool, though.

Q. Do you know any -- of any data in the record that relates the temperature of -- the temperature at the mine with the -- with the evaporation of the d-limonene?

A. If it's there, I have not read it.

Q. Do you know the vapor pressure of d-limonene?

A. The d-limonene vapor pressure is purported to be 2 millimeters at atmospheric pressure and at 25 degrees --

Q. Do you know --

A. -- centigrade.

Q. -- do you know that compares to water?

A. It is roughly ten times lower than water, I believe.

Q. So what does that mean in comparison to the vapor pressure of water -- in terms of evaporation?

A. It -- it will tend to evaporate relatively slower than water given all other conditions being equal.

Q. And does the handling of materials affect the degree of evaporation from the processed fines?

A. Absolutely.

Q. So does it matter if the fines are stacked in a pile or spread out?

A. Does it matter with regard to what?

Q. The rate of evaporation of d-limonene.

A. Yes, I believe it would have an effect.

Q. You're not sure?

A. If you give me the parameters of the two piles you're speaking of, I could probably tell you; but generally, it should have an effect.

Q. And so would d-limonene evaporate more slowly from a pile?

A. As compared to what?

Q. Sand spread out flat.

A. The -- the spreading should enhance the evaporation.

Q. Does vapor density affect the evaporation of d-limonene from the processed fines?

A. It may or may not, depending on the velocity of air above it.

Q. Does that mean wind?

A. It could be wind or other movement of air.

Q. Do you know the vapor density of d-limonene?

A. Not right off the head -- no, I don't.

Q. So generally, the higher -- what does a higher vapor density mean?

A. Higher vapor density is -- vapor densities are usually reported in terms of their -- their bulk density with air as a basis. So if -- if a higher gas density is reported, it is usually -- it -- it is always a -- heavier than air and tends to -- tends to settle if there are no mechanical -- additional mechanical movements of the air in a completely still environment.

Q. So what does that mean -- if it tends to settle -- in terms of evaporation?

A. It doesn't really mean anything in terms of evaporation because if it's in the gas phase, it has already evaporated.

Q. But how about evaporation from the pile?

A. You're going to have to ask a better question so I can answer it.

Q. Okay. So let's assume some of it has already evaporated but there's still some d-limonene that hasn't evaporated. So how would the vapor density of the d-limonene that has evaporated affect the evaporation of the d-limonene that hasn't evaporated?

A. Evaporation is a concentration-driven process. In the absence of mechanical transport of the air -- i.e., wind or a fan or any kind of air movement -- the evaporation will be driven by the vapor pressure and concentration gradients.

If the concentration gradients are not enhanced by mechanical means, like wind or other movement, the evaporation will be slower.

Temperature will increase evaporation. Surface area will increase evaporation.

Q. Okay. Does the fact that d-limonene is mixed with tar affect the rate of evaporation into air?

A. Yes.

Q. In what way?

A. The -- the mixture -- the mixture will exhibit a -- a lower vapor pressure than the pure component.

Q. So are you saying the mixture will evaporate more quickly?

A. No.

Q. So it will evaporate less quickly?

A. Yes.

Q. Does the salinity in water influence the

effect of d-limonene on dissolving of tar in water?

A. Did you say "salinity"?

Q. I did.

A. Yes.

Q. In what way?

A. Typically, ionic materials or saline materials will tend to decrease the solubility. It has a salting-out effect.

Q. So you said it would decrease the solubility?

A. Yes.

Q. So you're saying that the presence of salinity in water would decrease the solubility of d-limonene in water?

A. Yes.

Q. And it would also decrease the solubility of bitumen in water?

A. Yes.

Q. Okay. So when Mr. Hogle asked you why you assume that we had ideal solutions, is it accurate to say -- can you hear me?

A. Yes, I can --

Q. I'm sorry. There's a lot of noise.

A. -- hear you.

Q. Okay. So when Mr. Hogle asked you why you assume that we had ideal conditions, is it accurate to say that you said it was because we have dilute solutions?

A. Yes. Extremely dilute solutions.

Q. Okay. And then are you also saying that, as a result, the interactions are not great?

A. (No audible response.)

Q. Let me ask that better.

A. Yes.

Q. Are you saying that the inter -- the interactions between d-limonene and the bitumen are not great?

A. At these very low concentrations, yes.

Q. And is that the basis for assuming that the -- the line on your -- what's it called? Ternary -- is it "ternary diagram"? I'm not saying that right, am I? Oh, yeah. Ternary phase diagram -- why the line is straight?

A. It is one of the bases, yes.

Q. So isn't the basis for your conclusion what you are trying to prove?

A. "Basis for my conclusion." No, the basis is what I'm founding the starting point of my conclusion on.

Q. Can you explain that, please?

A. The basis of my calculation lays the foundation for the final calculations that I make.

The basis of the foundation is the ternary diagram and the relationships in it. Then I further that to the equilibrium relationship. Then I further that to specific calculation of compounds in water from the bitumen.

Q. Aren't you trying to prove that the interactions between the d-limonene and the bitumen are not very great?

A. No, I -- that's not the intent of what I was doing.

Q. What was the intent of what you were trying to do?

A. The intent was to project a comparison of a specific compound -- B(a)P -- that may be washed, in -- by water contact with the virgin oil sands and compare that to the same mechanism of washing in the processed oil sands.

Q. Well, didn't you assume that the conditions were ideal because the interactions between d-limonene and tar were not great?

A. No.

Q. Okay. I will just review my notes for a second here, and I think I'm done, but I just want to check, so give me a minute, please.

VIDEOGRAPHER: We're going off the record at 3:17.

(Off the record)

VIDEOGRAPHER: We're back on the record at 3:23.

BY MS. WALKER:

Q. Okay. So in the very beginning of your testimony, you talked about your actual field work; is that correct?

A. Yes.

Q. Do you place a high value on data that's taken from the field?

A. Oh, yes.

Q. And do you wait until projects are underway to do -- to test your design theory?

A. In some cases.

Q. Do you consider that a better approach?

A. Better than what?

Q. Do you -- do you think the best approach is to wait until projects are underway to test your design theory?

A. It depends on the project. In some cases, it can't be tested until the project commences or is constructed or moved along. In other cases, things can be well designed ahead of time.

Q. So in our situation here with the PR Spring mine, were there tests that could have been done to determine the -- the effect of d-limonene on the dissolving of bitumen?

A. Yes.

Q. And were there tests that could have been done to determine the compounds that make up the bitumen?

A. Yes.

MS. WALKER: Okay. Thank you.

EXAMINATION

BY MR. McCONKIE:

Q. Mr. Handl, thank you for hanging in there with us today.

A. Certainly.

Q. I know it's been a long day, but I just -- I just have a few questions.

For purposes of evaluating a potential threat to groundwater quality, what would be the purpose of evaluating chemical characteristics of the processed fines?

A. The -- the value of that would speak to -- or -- or allow you to project with greater precision and detail estimates of what may occur when those materials became contacted with -- with water or may -- may actually lead additional information toward the evaporation.

Q. Okay. In evaluating a potential threat to groundwater, what would be considered the receptor?

A. Well, a receptor is -- in our terminology that -- that we use -- is usually a -- a -- some -- some sort of a downstream water -- down-gradient water user that utilizes that aquifer.

Q. Would -- would groundwater itself be considered a receptor?

A. Not typically in the context that -- that -- that I use in my work.

Q. What would be the purpose of determining solubility of the compound residual -- of the residual compound?

A. I'm having trouble understanding your question. The solubility of residual compounds would be a laboratory -- a theoretical laboratory number, so the purpose of that would be whatever the person had in mind that ordered that test. Maybe you could rephrase the question.

Q. Well, let me just -- let -- let me just move on.

You know, we -- we spent a lot of time today talking about the chemical characteristics of -- of processed tar sands, the residual compounds, things like that. What if there were no groundwater to be impacted? How might that affect the -- the relevancy or the importance of what we've been talking about today?

A. I believe it would have great -- great bearing on that because with -- with no groundwater, there would be no off-site transport in the subsurface to be carried to what I would call receptors.

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

MR. HOGLE: I just have a few follow-ups.

EXAMINATION

BY MR. HOGLE:

Q. Mr. Handl, could you distinguish miscibility from solubility?

A. Yes. Solubility is a -- a fixed parameter that -- for a particular solute that depends on the characteristics of the -- of the solvent and the solute and is also a function of temperature, but it is a -- a fixed parameter that can be well defined.

Miscibility is the tendency of two fluids to become dissolved within each other, and -- as opposed to immiscibility, which is a tendency to form two layers. And in between miscibility and immiscibility is a continuum of different states or -- I guess states would be the way to put it -- that -- or different degrees of miscibility and immiscibility so that it is not a -- one specific parameter like -- like solubility is.

Q. Okay. When you developed your ternary diagram, what did you use as your basis?

A. The basis of my ternary diagram was actual data that is reported in the literature for the various materials that I found. And where I could not find specific parameters, such as for bitumen, I made estimates based on a range of values that are representative of the compounds within that mixture.

Q. Okay. I want to direct your attention to the Permit-By-Rule Demonstration -- what's been referred to as the Permit-By-Rule -- on page 10, part of Table 3.

And my question is: Is it significant to you -- is it -- is it significant to you that the other hydrocarbons -- oil and grease, TRPH -- that the concentration of those are substantially less in the processed materials?

A. Yes, I think that is a very significant factor. The availability of those materials is -- is lessened by the amount that has been removed for -- during processing; and therefore, the available material for transport by hydrologic mechanisms or by precipitation is lessened because of that lesser availability.

Q. And one final question: When presented with the -- the operations -- the -- the planned operations of the PR Spring mine, would one in your field expect that d-limonene would increase water solubility or concentration of PAH compounds in the spent materials?

A. Well, the -- if -- if the -- if there were no d-limonene in the spent materials, I would say -- as -- as compared to the presence of d-limonene in the spent materials -- I would say the presence of d-limonene would tend to decrease the release of -- of any materials from the -- from those spent sands.

Q. Okay. Would you -- would one in your position think that that should be something that needs to be further tested?

A. For purposes of this -- of obtaining this permit, I do not think so.

MR. HOGLE: Okay. No further questions.

MR. DUBUC: Just one second.

MS. WALKER: We're just moving the microphone. Sorry. Okay, just a few.

EXAMINATION

BY MS. WALKER:

Q. So back to Table -- on page 11 of the PR -- PBR, of the Permit-By-Rule. It's not page -- I'm sorry. It's on page 10, the one I want you to look at.

THE WITNESS: I'm going to have to leave shortly here.

BY MS. WALKER:

Q. Okay. So are you saying that this table is instructive in determining whether petroleum compounds are a potential source of contamination?

A. It -- it's instructive in determining the -- the amount available that could be transported.

Q. So are you saying that for oil and grease in the processed fines, 30,000 milligrams per kilogram are available for transport?

A. That's what the table indicates, yes.

Q. And so for TRPH, there's 9,500 milligrams per kilogram available for transport?

A. That looks correct.

MS. WALKER: Okay. Thank you. I'm done. And I -- I should have said before that I really appreciate how much work you've put into today. I'm sorry I didn't say that before --

MR. HOGLE: We'll --

MS. WALKER: -- because I really do appreciate it.

MR. HOGLE: We'll read and sign.

VIDEOGRAPHER: We're going to go off the record now. The time is 3:36.

\- - -

(Thereupon, the deposition was concluded at 3:36 p.m., on Friday, April 27, 2012.)

\- - -

SIGNATURE REQUIRED

DEPONENT'S CERTIFICATE

I, EDWARD L. HANDL, P.E., the deponent in the foregoing deposition, DO HEREBY CERTIFY, that I have read the foregoing - 155 - pages of typewritten material and that the same is, with any changes thereon made in ink on the correction sheet and signed by me, a full, true and correct transcript of my oral deposition given at the time and place hereinbefore mentioned.

EDWARD L. HANDL, P.E.

SUBSCRIBED AND SWORN TO before me this ____ day of ____________________, 2012.

Notary Public State of Montana
Print Name
Residing in:
My Commission expires:

JB-PR Spring Tar Sands Project

CERTIFICATE

STATE OF MONTANA)
: ss
COUNTY OF GALLATIN)

I, Jan M. Baldensperger, RPR, freelance court reporter and notary public for the State of Montana, do hereby certify:

That the witness in the foregoing deposition was by me first duly sworn to testify to the truth, the whole truth, and nothing but the truth in the foregoing cause; that the deposition was then taken before me at the time and place herein named; that the deposition was reported by me in shorthand and later transcribed into typewriting under my direction, and the foregoing pages contain a true record of the testimony of the witness, all done to the best of my skill and ability.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my notarial seal on this the _____ day of _____________, 2012.

Jan M. Baldensperger
Notary Public State of Montana
Residing in Bozeman, MT
My Commission expires: 1/8/2013

Correction Sheet

Please make all changes or corrections on this sheet showing page, line and correction for Court Reporter's insertion into the Original Deposition. Sign this sheet and sign the Deponent's Certificate Page before a Notary, then return to the Court Reporter for filing. If there are no corrections, please write "No Corrections" across this sheet and sign at the bottom of the page.

Page	Line	Now Reads	Should Read	Reason
1	4	HANDLE	HANDL	CORRECT SPELLING
15	2	PHASE 2	TYPE 2	CORRECT NOMENCLATURE
15	13	PHASE 2	TYPE 2	CORRECT NOMENCLATURE
67	19	RAINED	RAISED	CORRECT SPELLING
71	22	ABSOLUTELY	SLIGHTLY	CORRECT STATEMENT
76	25	721	7-21	CORRECT REFERENCE

State of Montana

County of Silver Bow

This instrument was signed and sworn to before me on 5/4/2012

by Edward L. Handl

Print name of signer(s) EDWARD L. HANDL

David C. Lambrecht

Notary Signature

Affix seal/stamp as close to signature as possible.

[Montana notaries must complete the following, if not part of stamp.]

David C. Lambrecht

Printed Name

Notary Public for the state of Montana

Residing at Butte

My Commission expires: 10/9, 2012

WORD INDEX