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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	:	Videotaped Testimony of: **WILLIAM JOHNSON, Ph.D.**
No. WQ PR-11-001	:	

Place:	TEMPEST REPORTING, INC. 175 South Main Street, #710 Salt Lake City, Utah 84111
Date:	April 20, 2012 9:06 a.m.
Reporter:	Vickie Larsen, CSR/RPR

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I N D E X

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EXHIBITS

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I N D E X

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E X H I B I T S

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(09:04:42-09:05:45)

April 20, 2012 9:06 a.m.

P R O C E E D I N G S

THE VIDEOGRAPHER: We are going on the record, the time is 9:06.

This is the videotaped deposition of William Johnson, taken in the matter of PR Spring Tar Sands Project, Ground Water Discharge Permit-By-Rule, before the Utah Water Quality Board.

This deposition is being held at 175 South Main, Salt Lake City, Utah, on April 20th, 2012.

My name is Max Nelson from the firm of Tempest Reporting, with offices at 175 South Main, Salt Lake City, Utah. I am the video specialist. The reporter is Vickie Larsen from Tempest Reporting.

Counsel will now state their appearances for the record and the witness will be sworn.

MS. WALKER: Good morning. I'm Joro Walker for Living Rivers. And with me is Rob Dubuc.

MR. HOGLE: I'm Chris Hogle for U.S. Oil Sands, respondent. With me is Ben Machlis and representative of U.S. Oil Sands, Barclay Cuthbart.

MR. McCONKIE: I'm Paul McConkie appearing on behalf of the executive secretary, and with me is Rob Herbert of The Division of Water

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(09:06:02-09:06:39)
Quality.

WILLIAM JOHNSON, Ph.D.,
called as a witness, having been duly sworn,
was examined and testified as follows:

DIRECT EXAMINATION
BY MS. WALKER:
Q. Just to be clear, this isn't a deposition, it's actually testimony.
But that said, would you please state your name for the record?
A. Sure. William Paul Johnson.
Q. And your profession?
A. Professor.
Q. Where?
A. University of Utah.
Q. Okay. And in what area?
A. Geology and geophysics.
Q. Okay. And if you would briefly state your credentials.
A. My credential include a doctorate in civil and environmental engineering at the University of Colorado, Boulder. Post doctorate in -- at the University of Arizona, Department of Chemical and

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(09:06:52-09:07:43)
Environmental Engineering and Hydrology and Water Resources. And then professor at the University of Utah.
Q. So how long have you been a professor?
A. About 17 years.
Q. And is that a full professorship?
A. Well, it's been a full professorship for the past seven years.
Q. Okay. And did you prepare a report for submission in this case?
A. Yes.
Q. And is that report dated January 20th, 2012?
A. Yes.
Q. And in most general terms, what is that report about?
A. It is about developing the -- well, performing some calculations to show d-limonene, in addition to -- in the residual from the tar sand processing will enhance the dissolving of tar compounds into water.
Q. Okay. And does this report represent your expert opinion about that subject?
A. Yes.
Q. And does it still represent your expert

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(09:07:53-09:09:11)
opinion about that subject?
A. Yes.
MS. WALKER: Okay. I move to enter that report as an exhibit.
MR. HOGLE: No objection.
MR. McCONKIE: No objection.
(There was a discussion held off the record.)
(Exhibit 1 was marked for identification.)
MS. WALKER: Okay. That's marked as Exhibit 1.
Q. So you just explained generally what the report is about, but I think we need a little bit of background, because some of the terms and the references you were making are a little unclear.
So when you're talk about what you were doing, can you provide a little bit more context?
A. Sure. I was reviewing the NOI provided by U.S. Oil Sands, and some claims that are made in the NOI struck me as unsupported. And so I did some further research -- well, "research" probably too strong a word -- calculations to see if those claims could be substantiated. And so the report provides some information that, at least weakens, if not counters, those claims that were made in the NOI.
MR. HOGLE: I'm going to object and move

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(09:09:25-09:14:54)
to strike that last answer. He didn't reference the NOI in either set of his testimony, and under the scheduling order that we stipulated to he was required to identify the work he did and the conclusions he reached in his testimony.
THE REPORTER: Can I ask you to speak up a little louder?
THE WITNESS: Sure.
MS. WALKER: Okay. Let's go off the record for a second, please.
THE VIDEOGRAPHER: We're going off the record, the time is 9:11.
(There was a discussion held off the record.)
THE VIDEOGRAPHER: We're going back on the record, the time is 9:15.
MS. WALKER: Would you read back his last statement, please.
(The previous answer was read back.)
Q. BY MS. WALKER: So did you review other documents relevant to this proceeding?
A. Yes.
Q. And what would those be?
A. Well, documents that are referenced in here are those that I didn't think interested parties would be aware of, and so I focussed my referencing

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(09:15:05-09:16:02)

on -- on those documents, because I'm bringing new information into this.
Q. Okay. Let me rephrase the question a little bit.
A. Sure.
Q. So were there other documents that you reviewed that were provided by the applicant or U.S. Oil Sands?
A. Yes.
Q. And what would those be?
A. Well, I can't remember exactly the titles, but there was other information related to U.S. Oil Sands in different reports that were provided to me.
Q. Okay.
A. I can look that up if it helps.
Q. No, I think that's fine.
Okay. So I just want to make sure we're clear on terms. When you speak of the residual mixture, what do you mean by that?
A. The residual mixture is the organic mixture that's remaining in the process sands. That's a mixture of the bitumen that's extracted from the process sand and the d-limonene or the solvent they're using to extract the bitumen.

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(09:16:19-09:17:32)

Q. Okay. And when you talk about bitumen, do you call that something else often?
A. Yeah, we often call that tar, you know, so I use tar as the catch-all term for the compounds that comprise the bitumen.
Q. Okay. And can you just give us an idea of what those compounds are?
A. Sure. There's a range of compounds in that. Asphalting is a compo- -- predominant component. Polycyclic aromatic hydrocarbons are another component. These are all related organic compounds.
Q. Okay. So why are you in a position to address this issue?
A. Well, my doctoral research concerned the solubilization and transport of polycyclic aromatic hydrocarbons by agents that will increase their solubilizing into water. And the particular agent I was looking at was natural organic mater, which shares significant properties with d-limonene.
Q. And so as a result of your evaluation or calculations, what did you conclude?
A. I concluded that the d-limonene would enhance the solubility of the tar compounds in water that's in contact with the residual mixture. And I

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(09:17:51-09:18:52)

concluded that the transport of the organic -- the tar compounds would be facilitating, would be increased, the mobility would be increased by the presence of d-limonene.
Q. And why is that a concern?
A. It's a concern because if this material were to come into contact with water, and if that water had a potential receptor of these compounds, you know, a number of scenarios could be envisioned, but if there were a receptor, whether that's something in the ecosystem or whether that's a human ingesting the water for some reason, then that would be a toxic concern. Toxicological concern.
Q. And why do we care about an increase in concentration?
A. Because the toxicity's directly proportioned to the concentration. So the dose encountered by a receptor is increased with increased concentration.
Q. And is there anything about tar that makes it a matter of concern?
A. Sure, yeah. The polycyclic aromatic hydrocarbons, a significant number of those compounds are highly carcinogenic.
Q. But now I'd like to delve a little deeper

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(09:19:07-09:20:14)

into your testimony.
You said that you were testing an -- an assertion. Would you just repeat that assertion that -- made by oil sands?
A. The predominant one is that the d-limonene will vaporize readily from the residual -- from the process sands.
Q. And what are the consequences if the d-limonene doesn't evaporate readily?
A. So the addition of the d-limonene changes the tar. First the tar is in a solid form, or a semi-solid form. It's not mobile in its natural state. It's been there a long, long time because it doesn't dissolve readily into water, it doesn't flow on its own. But when you extract this tar compound with d-limonene, now you've turned it into a liquid mixture, and that changes its properties.
And the property that I focussed on is its -- its dissolution or dissolving into water, okay. And so the d-limonene enhances that dissolution into water.
And so now -- I'm not sure I answered your question, because I think maybe you were focussing on the vaporization.
Q. No, no. You answered my question.

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(09:20:32-09:21:48)

So in -- so is there an additional reason for why -- the effect that d-limonene would have if it didn't evaporate? You talked about the solidity of the tar.

A. Right. So it -- now you're dealing with a liquid mixture, okay, and that greatly -- the solubility of the tar compound in a liquid form is much, much greater than in a solid form. And so that increases the concentration of those compounds in water and the transport is, therefore, affected by that as well.

Q. Okay. And in your opinion was it reasonable for the company to assert that the d-limonene would evaporate quickly?

A. They -- no. And -- and they didn't support that assertion. There was a statement that was made that -- that had no backing and it -- it -- d-limonene's not a particularly volatile compound. It has a relatively high boiling temperature, it has a vapor pressure that's ten times lower than that of water. Which means that it would -- its propensity to vaporize is ten times lower than water, and therefore, it's not going to be rapidly removed from the residual -- residual mixture.

Q. And are there any physical reasons that

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(09:22:00-09:23:06)

you believe that the d-limonene won't evaporate readily?

A. Yeah. In addition to just considering vapor pressures, there's physical processes that you would expect to occur.

So if you have this liquid mixture of d-limonene and tar compound, the tar compounds will not vaporize and they will accumulate, and they will accumulate typically on the interface between the air and the liquid mixture. And so they'll form kind of a rind that will inhibit the vaporization of d-limonene, and we can expect that based on studies that have been done looking at organic mixtures dissolving into water. The same processes have been documented.

Q. And are there any issues with the handling of the waste that may affect the evaporation of d-limonene?

A. Yeah, possibly. I mean, I didn't focus on how the waste is disposed of, but if it's being piled you would expect that you'll inhibit the vapor transport from the interior of the pile.

And furthermore, the vapor density is fairly high, about -- almost five times higher than -- than air. And so it will tend to accumulate over the organic liquid, and that will further inhibit

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(09:23:17-09:24:27)

d-limonene vaporization.

Q. Okay. Is there any way to test whether d-limonene will evaporate quickly?

A. Oh, yeah, that's -- that's very simple. All they need to do is do this themselves or just have university or a consulting company do this, but they can simply have a chamber in which they put residual material and monitor the vaporization of the d-limonene.

Q. And in your review of the record did you see any such test?

A. No, there's no such test.

Q. So you gave two reasons as to why in the presence of d-limonene tar will dissolve to a greater extent in water. Do you recall the first of these? Just to repeat it so that we can provide context for the discussion we're going to have.

A. Sure. If -- so the two -- the two issues that fall out of d-limonene and tar compounds being mixed together are the -- now, I'm sorry, I've got to take a quick break. I got to look back at my notes.

MS. WALKER: Okay.

MR. HOGLE: Should we take a break?

MS. WALKER: Yeah.

THE VIDEOGRAPHER: We're going off the

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(09:25:08-09:26:00)

record, the time is 9:25.

(There was a discussion held off the record.)

THE VIDEOGRAPHER: We're going back on the record, the time is 9:26.

Q. BY MS. WALKER: Okay. I asked you to recall or restate the first reason that, in your expert opinion, you determined that the presence of d-limonene will dissolve tar into water -- or will cause the tar to dissolve into water at a greater extent?

A. Okay. So --

MR. HOGLE: Let me interpose an objection here.

The witness refreshed his recollection with something, I don't know if I've ever seen before. It didn't look like he was looking at his report. I'm entitled to see what he's refreshing his recollection with. I'm entitled to a copy. And furthermore, if it's not in his report, I'm not sure why he's looking at it anyway. This is supposed to be a summary of his testimony, and it seems like we're going well beyond that.

That's my objection.

MS. WALKER: Okay. Well, he won't refer to that any more.

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(09:26:16-09:27:04)

From now on, please refer to your report if you need to refresh your memory, okay?
THE WITNESS: Sure. Sure. It's just a matter of framing the response, it's not an important aspect.
MS. WALKER: Yeah, no, I don't think it's important.
THE WITNESS: So there's two reasons why the addition of d-limonene to the tar changes the behavior of the tar compounds.
As I said before, you were taking what was a solid or a semi-solid, and you're turning it into a liquid. It's going to behave as a liquid, and therefore, the solubility is greatly increased with water.
The second is that the d-limonene itself is much more soluble than the tar compounds in water. And so the d-limonene will be present in the water, and the d-limonene, I think we all agree, is a very good solvent for the tar compounds. So if it exists in the water, it will act as a carrier for the tar compounds to come into the water.
Q. BY MS. WALKER: Okay. So I just want to -- you to provide your basis for that first reason.
A. Well, the -- there's two ways to get at

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(09:27:26-09:28:15)

this. But in my initial testimony what I used were so-called partition coefficients that represent the distribution of tar compounds between this organic mixture and water. And those are available in the literature from any similar compounds, and so I used those partition coefficients.
Q. And with those coefficients, what were you able to do?
A. Well, you can combine those coefficients to predict what the concentration would ultimately be of the tar compounds in water. And I chose a representative tar compound, benzo(a)pyrene.
Q. And is this the typical way in your profession to do such calculations?
A. Sure.
MR. HOGLE: I'm going to interpose another objection. I think this is getting beyond a summary. I don't want to keep repeating it, Joro, so if you want to let me have a continuing objection that this goes beyond the scope of a proper summary, I won't bring it up any more.
MS. WALKER: Okay.
MR. HOGLE: I mean, I won't waive it, but I won't have to keep interposing the same objection.
MS. WALKER: Fine. It seems to me that

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(09:28:33-09:30:01)

it's a summary of his report.
MR. HOGLE: Well, he gave a summary of his report in the first pages of his testimony. That's a typical summary, and he's going well beyond that.
MS. WALKER: Well, that may be your understanding of a summary of a report, but my understanding of a summary of a report is to actually explain it, and given how technical it is, it's very difficult to explain. And I think the ALJ will appreciate his efforts to explain it.
Okay. So -- but I understand you're going to have an ongoing objection that he's talking too much.
So would you kindly read back his last response.
(The previous answer and pending question were read.)
Q. BY MS. WALKER: So do you want to answer that question, please.
A. Yes. This is a typical way to address that problem. This kind of approach is substantiated in a staple -- in a textbook that's a staple in environmental engineering curriculum.
Q. Okay. And did you actually calculate the increase in concentration of tar in water?

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(09:30:12-09:31:14)

A. Yes, I did, for a representative compound.
Q. And what was that?
A. It was three orders of magnitude. It came out to be about 1600 -- or 1400, something like that. Three orders of magnitude.
Q. So can you explain what an order of magnitude is?
A. Factor of ten. So this would be a factor of a thousand.
Q. And why, in your mind, is that significant?
A. Well, that's significant because if you increase the concentration that you'd expect in water by a factor of a thousand, then you increase the potential toxic dose by a factor of a thousand.
Q. And did you find further support for your conclusion?
A. Yes, I did. I was shown some data from U.S. Oil Sands that showed concentrations of polycyclic aromatic hydrocarbons in their process water. And the concentrations that were in that water were a factor of something like 20,000 higher than you'd expect, according to their normal water solubility. So that agrees with my calculation that

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(09:31:36-09:32:28)
you greatly enhance the dissolution -- the dissolving into water.
Q. Is there a way to verify whether the presence of d-limonene in the residual mixture will increase the concentration of --
THE REPORTER: I'm sorry. Is there a way to verify whether the presence of the...
Q. BY MS. WALKER: -- d-limonene in the residual mixture will increase the concentration of tar compounds in the water?
A. Certainly. All that's needed is a leech test to equilibrate to put in contact the residual with water and monitor the concentration of these kinds of compounds in the water over time.
Q. And did you see any such test in the record?
A. Not that test. There was a leech test, but it was done with hexane instead of water. And so they took the residual material and they equilibrated with hexane and measured the polycyclic aromatic hydrocarbon compound concentration in the hexane.
Now, what they found were extremely high concentrations of the polycyclic aromatic hydrocarbons, which is -- if that were water you'd be alarmed. But it was hexane, and you'd expect that

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(09:32:42-09:33:46)
from hexane, because hexane is acting like d-limonene. It's extracting the tar compounds.
And so the apparent conclusion that was drawn is that hexane was the inappropriate solvent to test to represent water, which is correct, but then there was no follow up.
Q. Okay. And did you submit further testimony in this case?
A. Yes. I submitted a supplemental testimony in response to comments by Mr. Handl.
Q. And is that testimony dated March 16th, 2012?
A. I believe it is. Can I look at your copy?
Q. Yeah.
A. Would there be an objection?
Yes.
Q. And in most general terms, what's this report about?
A. So this was -- I wrote this in response to Mr. Handl's criticisms of my testimony. What they -- what those criticisms boiled down to was that the d-limonene has no effect on tar compound dissolution into water. And so I wrote a response to demonstrate that that criticism was incorrect and that

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(09:34:00-09:34:52)
in fact d-limonene has a major effect on tar compound dissolving into water.
Q. And does this report represent your expert opinion on that subject?
A. Yes.
Q. And does it still represent your expert opinion on that subject?
A. Yes.
MS. WALKER: So I'd like to move to enter that as an exhibit, please.
MR. HOGLE: No objection.
MS. WALKER: And this would be Exhibit 2.
(Exhibit 2 was marked for identification.)
Q. BY MS. WALKER: So what materials did you review to address that second point? Mr. Handl's testimony.
A. Yeah, Mr. Handl's testimony.
Q. I didn't mean to answer the question for you. I meant -- okay.
And what I meant is what -- it's fine.
Okay. So can you briefly summarize Mr. Handl's analysis that you were responding to?
A. Yeah. His analysis is that the d-limonene simply dilutes the mixture, okay. The residual organic mixture is comprised of tar compounds

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(09:35:12-09:36:17)
and d-limonene, or in his terminology, bitumen compounds and d-limonene. And his assertion is that that is simply a dilution of the tar compounds, and therefore any tar compounds that would dissolve into water would be lower than their normal water solubility, according to Raul's, which is the equation that he used.
Q. Okay. And your response to this analysis was?
A. That it's incorrect because it's missing two very important terms when you do a more complete thermodynamic analysis.
Q. And can you explain that a little bit more --
A. Sure.
Q. -- fully?
A. If you -- if you -- if you go back to the basic thermodynamics and solve for the change in the, basically the ratio of the concentration of the tar compound in the water, pure water, versus water that has d-limonene as a result of being in contact with this residual, then you can calculate the ratio of those two concentrations, and a value that is -- I don't want to confuse things because I'm changing the -- let me put it this way:

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(09:36:31-09:37:41)

A ratio of the -- so if we have a high concentration of the tar compound in the water in the presence of d-limonene, versus a relatively low concentration in water in the absence of d-limonene, then that ratio will be very high, okay.

And so we can solve for that ratio. And what we find is that, going back to the basic thermodynamics, is that in addition to the typical Raul's law term in that expression that Handl had, there are two additional terms.

One is the ratio of the activity coefficients of the tar compounds in water without versus with d-limonene. And the other is the ratio of the vapor pressures of the tar compound in the solid versus the liquid form, which represents that change that occurs in response to turning that tar compound into a liquid, as opposed to its solid, natural state.

Q. And did you believe that these terms were significant?

A. Yeah, they're significant. Both of those terms are much greater than one, and so they contribute anywhere between the factor of 10 to 100, each of those terms, to increase the concentration of the d-limonene in the water.

Q. So what happens when you correctly

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(09:37:56-09:38:50)

account for those terms?

A. Then you show that the d-limonene increases the solubility of the tar compounds in water by about three orders of magnitude.

In this case I calculated a factor of 2,000, pretty close to the factor of six -- or 1400-ish that I calculated using a different method.

Q. So do you believe in the absence of those terms that Handl's analysis showed the effect of d-limonene on the dissolving of tar in water?

A. No, it absolutely does not.

Q. And is your analysis more accurate?

A. Yes.

MS. WALKER: Okay. That concludes my -- my questions. Thank you.

MR. HOGLE: Okay.

MS. WALKER: Want to take a break?

THE WITNESS: I'm good.

MR. HOGLE: Dr. Johnson, I'm Chris Hogle. I'm going to ask you some questions about your work in this case.

CROSS-EXAMINATION

BY MR. HOGLE:

Q. You indicated that generally your report

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(09:39:15-09:40:13)

is about performing some calculations to show that d-limonene in the residual from the tar processing, tar sand processing, will enhance the dissolution of the tar compounds in the water?

A. Right.

Q. And the concern there, I mean, the ultimate concern is that the -- the -- that process, the increasing the solubility of the tar compounds, might lead to groundwater, which somebody or some animal may get to, and the tar compounds contain a carcinogen, right? Is that a fair summary?

A. Not quite. Because I'm not speaking to the likelihood of this reaching groundwater.

Q. Okay.

A. I'm speaking to the possible -- what would happen if this comes into contact with water.

Q. Right. But -- but in order for your concern to materialize, it has to come into contact with groundwater?

A. No. It has to come into contact with water. And whether it's surface water or groundwater, I don't know specifically how they plan to manage all this at the site.

Q. But if it doesn't come into contact with groundwater, doesn't -- it's not going to be ingested

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(09:40:22-09:41:16)

by a human or animal?

A. It could be if it's coming into contact with surface water that's in contact --

Q. Okay.

A. -- that has a receptor.

Q. Do you know of any information that it's going to come into contact with surface water?

A. Again, I'm not speaking to the likelihood of contact with surface water or groundwater.

Q. So let's set aside surface water, all right? If it -- if it doesn't come into contact with groundwater, then your concern is a nonissue, true?

A. If it doesn't come into contact with water, my concern is a nonissue.

Q. Okay. And if it doesn't come into contact with usable amounts of water, water that somebody or some animal's going to use, your concern is a nonissue?

A. If it doesn't come into contact with a receptor downgrading, it's a nonissue.

Q. "Receptor" is usable amount of water?

A. Well, I wouldn't define it that way.

Q. How would you define it?

A. Some organism that would be dosed with the polycyclic aromatic hydrocarbons as a result of

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(09:41:27-09:42:12)
ingesting or coming into contact with the water.
Q. Okay. But the water has to be in a sufficient quantity for the organism to use, true?
A. Yes.
Q. And if in fact the -- the d-limonene does not increase the solubility of the tar compounds, then your concern is a nonissue?
A. If the d-limonene does not increase the solubility of the tar compounds?
Q. Right.
A. Well, it -- that's a tautology, because there's no "if" there.
Q. No.
A. The -- the d-limonene will increase the solubility of the tar compounds.
Q. You make assumptions in your -- in your work?
A. No, there's no assumption there.
Q. No. But you do make assumptions in your work, correct?
A. Generally?
Q. Yes.
A. Yes.
Q. Okay. So you're capable of making an assumption?

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(09:42:20-09:43:07)
A. Yes, I am capable of making an assumption.
Q. Can you assume for me that the d-limonene does not increase the solubility of the tar compounds in water?
A. It would be an incorrect assumption, but for the sake of argument, yes.
Q. I'm not trying to make a point here that it does or it doesn't.
A. I'm just trying to speak accurately.
Q. Thank you. But make that assumption for me, please, would you?
A. Okay. For the sake of argument, I will assume that.
Q. Now if it -- if it in fact does not increase, the assumption is correct, you have that assumption, then the concern about the inappropriate or excess risk of a -- of a receptor receiving a carcinogen -- carcinogen is a nonissue?
A. It's certainly much diminished.
Q. Yeah. I mean, your -- your concern relies on d-limonene increasing the solubility of tar compounds in water?
A. That's right.
Q. Okay. You have Exhibits 1 and 2 in front

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(09:43:35-09:44:38)
of you, right?
A. Uh-huh.
Q. Exhibit 1 on Page 3 to Page 4 has a summarization of your initial testimony, right?
A. Right.
Q. Is that a fair summary?
A. Should I review it now?
Q. Well it's your summary, so --
A. Please let me --
Q. -- if you need to.
A. -- review it.
Q. Sure.
A. Well, it's been a while since I looked at this.
Q. And just for clarity, my question is: Is this a fair summary of your initial testimony?
A. Okay. Yes.
Q. Did you review your -- both sets of your testimony in preparation for today?
A. I wrote them, so...
Q. So the last time you reviewed them was January 20th and March 16th?
A. That's right.
Q. Okay. Let me have you take a look at Exhibit 2. All right. And then on Page 30 to Page 31

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(09:45:08-09:46:19)
there's a summary of your supplemental testimony, right?
A. Uh-huh.
Q. Is that a fair summary of your supplemental testimony?
A. I'm just going to take a minute to review. Yes.
Q. Okay. Now, in the summary that you gave this morning you indicated that d-limonene will not readily vaporize or will not readily evaporate under air or transport the air, right?
A. That's right.
Q. Okay. And you gave that this morning in the summary of your testimony.
A. (Witness nods head.)
Q. You have to answer audibly yes or no for her benefit.
A. Sure.
Q. And that's an important part of your testimony, is it not?
A. It's an important part -- what's the important part is that d-limonene in the residual mixture will not -- well, their claim, U.S. Oil Sands' claim, that it will readily vaporize, is not supported. And I bring up in my testimony one reason

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(09:46:39-09:47:40)

to do that, and then I've added -- you know, I've, in addition to that, raised the issue that d-limonene itself is not -- does not have a high vapor pressure.
Q. Okay.
A. Does not readily vaporize.
Q. And that's -- that's an important part of your work in this case, right?
A. Well, I would say that if d-limonene vaporizes out of that mixture quickly, then the mixture reverts back to the original tar mixture, which is not, by itself, a concern.
Q. Okay. Could you go to Exhibit 1, please. And turn to Page 4.
All right. And you see you -- there's a question and an answer on Lines 8 through 11, right?
A. Uh-huh.
Q. And the question is: "Can you briefly describe d-limonene?" That's correct, right? I read the question correctly?
A. Yes.
Q. And your answer is:
"Based on the properties listed in Appendix B, d-limonene is a small molecule that is readily transported to air. Therefore d-limonene by

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(09:47:52-09:48:33)

itself will likely vaporize/volatilize readily to the atmosphere."
That was your testimony, was it not?
A. That was my testimony, but that statement comes out of the NOI. That's U.S. Oil Sands' statement.
Q. You don't reference NOI -- the NOI in that statement?
A. No, that's true. That's a mistake on my part, but that's where it comes from.
Q. But I -- I read the complete answer to the question on Line 8, Page 4, did I not?
A. Yes.
Q. And that was your testimony?
A. Yes. But --
Q. And your testimony was under oath, was it not?
A. Well, I don't know. Was it under oath?
MS. WALKER: Yes.
THE WITNESS: Okay. So, yes, it was.
Q. BY MR. HOGLE: You don't know. Okay.
A. But my point is that I -- I was not focussing on d-limonene in this testimony. I was focussing on the effect of d-limonene on tar

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(09:48:49-09:50:04)

compounds. And so to me I did not emphasize the properties of d-limonene itself. That was not the issue I was addressing.
Now on further, you know, understanding of the properties of d-limonene, I've realize that in fact d-limonene itself does not readily vaporize.
Q. You said in your answer on Page 4, Line 9, you said your answer is based on the properties listed in Appendix B, correct?
A. Yes, properties.
Q. You wrote that.
And Appendix B is on Page 31 of Exhibit 1, correct?
A. Yes.
Q. Okay. And these properties of d-limonene, there's no reference to the NOI, is there?
A. No. And so again --
Q. In fact your references are References 1, 2, and 3, which are listed on Page 34, correct?
A. Page 34. Yes.
Q. Okay. Reference Number 1 is to what?
A. Reference Number 1 is to a USEPA document.
Q. Okay. Reference Number 2?
A. Is to a Chemical Safety document.

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(09:50:15-09:51:23)

Q. Not the NOI?
A. Correct, not the NOI.
Q. And Reference Number 3?
A. Reference Number 3 is a National Toxicology Program document.
Q. Okay. Again, not the NOI?
A. Not the NOI. But I didn't reference the NOI because that document was obvious throughout all this. I was bringing new information, aside from the NOI, that's why I referenced those documents, not the NOI.
Q. But your answer on Page 4 says based on the properties listed in Appendix B, d-limonene is a small molecule that is readily transported to air, correct?
A. Right. But again, that is -- what my intent was with this statement is that I'm not going to focus on d-limonene, okay. What I'm interested in is the issue of dissolution of the tar compound in the water and how d-limonene affects that, okay.
I wasn't at that -- in this testimony focussing on the issue of d-limonene evaporation itself. And I did raise the point that you would form a rind of these polycyclic aromatic hydrocarbon compounds on that organic mixture. And that was the

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(09:51:40-09:52:58)

statement that I was making that substantiated my concern that d-limonene would not readily vaporize, okay.

So this -- this small, two sentence piece of this larger testimony wasn't the focus, okay. And so now as a result of more time passing and having, you know, examined the issue further, what I've learned is that d-limonene itself is not a particularly small molecule and it is -- or actually let's look at the structure of it in the appendix.

Its properties that actually are relevant here are not so much size, but the fact that it -- it's -- it's large enough that it isn't going to readily move into the vapor phase from its own organic mixture, okay. It has Van der walls forces holding those molecules together that they have to break free from in order to move into the vapor phase, okay. And it's a large enough molecule that that process is going to be slow, okay.

So regardless of whether we focus on the properties of d-limonene itself or the fact that you'll accumulate polycyclic aromatic hydrocarbons on the air/water interface of this residual mixture, there are good arguments for why we wouldn't expect d-limonene to leave that mixture as readily as the NOI

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(09:53:13-09:54:33)

seems to state.

MR. HOGLE: Move to strike as nonresponsive everything after the answer to the question, which was "right."

Q. Where in your testimony do you say that -- that d-limonene by itself is not likely to vaporize/volatilize readily to the atmosphere?

A. I'm sorry, could you repeat that.

Q. Sure. Where in your testimony did you say what you're now saying, that d-limonene is not a small molecule -- molecule that is readily transported to air?

A. I did not say that in my testimony.

Q. Okay. How about in your March testimony?

A. I did not address that in my March testimony.

Q. All right. So in your initial testimony and both your supplemental testimony, you relied on textbook Schwarzenbach RP? It's Reference Number 5 on Page 34.

A. That's right.

Q. And it's the, according to the reference here, a 1993 publication?

A. Yes, the edition I used was 1993.

Q. Okay. And you consider that to be

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(09:54:42-09:55:30)

authoritative in this area?

A. Uh-huh, yes.

Q. The title of it is Environmental Organic Chemistry?

A. That's right.

Q. And do you teach using that?

A. I do. Not that edition, but I teach.

Q. Which edition do you use when you teach?

A. There's a newer edition, I forget the year. But it's harder to get the older edition, so the students need to buy the newer one.

Q. Okay. Is it 2003?

A. Possibly. I don't remember off the top of my head.

Q. I'm handing you a book we checked out of the library, and can you -- can you identify that for us?

A. Sure. This is apparently the same textbook that I referenced.

Q. Okay. And how long is that?

A. How long?

Q. Yeah.

A. How long is the book?

Q. Yeah, easy question.

A. Well, I don't have it memorized so I'm

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(09:55:45-09:56:37)

going to look, and it's 680 pages.

Q. Okay. You don't identify a single page in any -- either of your testimony, do you, out of that book?

A. No, but I could easily do so.

Q. Okay. Maybe we'll get to that.

But you also don't attach to your testimony the pages from that book on which you rely. That's true, right?

A. That's true.

Q. Okay.

A. Quite true.

Q. So it's not clear, from your testimony anyway, which portions of the text you're relying on, right?

A. Sure.

Q. All right. And then if we go to Page 6 of Exhibit 1. The question on Page 6 -- the question on Page 6:

"How did you go about substantiating these concerns..." it goes on.

Do you see that question?

A. Sure.

Q. And then you have an answer that starts in the bottom of Page 6 and goes to close to the

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(09:56:51-09:58:07)

bottom of Page 7. You see that?
A. That's right.
Q. And there's no reference to any literature, correct?
A. Well, it references Appendix B.
Q. Appendix B isn't literature. Appendix B is the properties of d-limonene, right?
A. Well, that's -- let me check here, because I'm just looking at this quickly.
The statement -- okay. So first of all, several statements are made. So which statement are you concerned about not being referenced?
Q. I don't see any reference to a textbook or any published literature in your answer that starts at the bottom of Page 6 to Page 7, is there?
A. Okay. Well, yeah, there is. So benzo(a)pyrene is shown there and it says from Reference 5. Now, let me check that I didn't identify the wrong reference. I don't think I did.
Q. That's the Schwarzenbach, right?
A. Yes.
Q. Can you identify in the Schwarzenbach book where that is?
A. Sure. The appendix of this text has properties of all these different compounds, okay. So

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(09:58:35-10:00:03)

there's the appendix in benzo(a)pyrene.
Q. What page is that, please?
A. Sorry?
Q. What page is that, please?
A. Page 621.
Q. Okay. And that is -- has the properties of benzo(a)pyrene. It doesn't have any equations there, does it, on that page?
A. Not on the appendix, no.
Q. Now, Page 7 we just -- you just indicated of your initial testimony, Exhibit 1, has a reference to Exhibit B. So you rely on -- not Exhibit B, Appendix B.
You rely on Appendix B throughout your testimony, do you not?
A. In a minor way.
Q. Okay. But now you're saying that the properties of d-limonene as set forth in Appendix B you've come to -- come to question?
A. No. No. These are correct. But the statement that it readily vaporizes is a subjective statement that is not reflected in this appendix.
Q. All right. Now you mentioned that there's an updated edition of the Schwarzenbach publication, right?

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(10:00:13-10:02:02)

A. Yes.
Q. And that's the -- you use an updated edition for your classroom work?
A. Only because they can obtain that updated edition much more readily that this previous edition.
Q. Is there anything wrong about the updated edition, I mean --
A. Yeah, it's massive.
Q. Other than that?
A. It's about two times thicker than this one, and I thought you'd have an easier time getting through this one.
Q. I think it's sixes, from my perspective.
But -- but it's not -- would you -- it's bigger, so would it have a more extensive discussion?
A. Not in this subject. It goes into much greater detail on different organic compound reactions that aren't relevant here.
Q. Okay. All right. Could you -- hold on a second.
I'm handing you copies of excerpts from the Environmental Organic Chemistry textbook that you just identified. And could you verify that those are true and correct copies of Pages 90 through --
A. 98?

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(10:02:13-10:03:15)

Q. 93. Looks like I don't have them all.
A. It's 98, but yes.
Q. Okay.
MS. WALKER: Excuse me, do you want to check with the book?
I'm sorry, Chris, are you saying that these are pages from the book he has.
THE WITNESS: And they are. I recognize them.
MS. WALKER: You recognize them, okay. Thank you.
Q. BY MR. HOGLE: All right. So on Page 97, there's an excerpt here kind of in the middle of this bottom paragraph. It says:
"Finally, if the organic chemicals are present at low enough levels --"
Let me know if you're with me --
A. I'm with you.
Q. -- before I continue on. It says:
"Finally, if the organic chemicals are present at low enough levels (less than ten to the negative three volume fraction) that there is a low probability of even their hydration shells overlapping, we can expect no

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(10:03:26-10:04:36)
effect on the aqueous activity coefficients or (liquid) solubilities."
Do you see that?
A. Yes.
Q. All right. And then on the next page, 98, it says at the top:
"For the purposes of predicting organic chemical fates in the environment, we are primary interested in cases where cosolvents are present in relatively large proportions (more than 10% by volume)."
Do you see that?
A. Yes.
Q. Okay. Now, in the water, tar, d-limonene mixture, the d-limonene cosolvent is less than ten percent by volume, true?
A. Oh, I don't believe that's true.
Q. Okay. Could you go to your Appendix B in Exhibit 1. Okay. You see the top there, it says, "Properties of d-limonene," and then on Line 3, "solubility and water equals 13.8 milligrams per liter"?

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(10:04:43-10:06:02)
A. Yes.
Q. Okay. So doesn't that indicate that it's -- it would be less than ten percent by volume in the mixture?
A. You asked me what the volume fraction of d-limonene would be in the mixture. That's the organic mixture. And this is a solubility in water, which is the raffinate, which is not the organic mixture.
So the two don't -- there's no -- there's no relevance of this solubility to the volume fraction of the d-limonene in the organic mixture. So I'm confused by your question.
Q. Go to Page 9 of your initial testimony. So on Page 9 you're utilizing a calculation that relies on the 13.8 milligrams per liter of d-limonene in the solubility of water, right?
A. Oh, that's correct. Yeah, but that's not the question you asked me.
Q. What is the concentration of d-limonene in water?
A. 13 milligram -- 13.8 milligrams per liter is the value that I was able to find.
Q. And what did you conclude would be the concentration of d-limonene in the d-limonene water

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(10:06:19-10:07:12)
tar compound mixture?
A. Well, I didn't calculate the actual -- actually I did. I calculated 2.2 milligrams of benzo(a)pyrene is a representative compound. Sorry, ask the question again, I'm not sure if I heard it correctly.
Q. What -- what did you calculate the concentration of d-limonene to be in the tar compound, water, d-limonene mixture?
A. Oh, okay. I didn't calculate the concentration of d-limonene. I used the 13.8 milligrams per liter water that I was able to find.
Q. Okay. And that's less than ten percent by volume of the mixture?
A. In water you're saying?
Q. In the mixture.
A. Well, okay. We have to make sure what we're talking about.
When I refer to "mixture," I'm referring to the organic compound mixture. And when we're talking about the water, we're talking about what Handl -- Mr. Handl calls the raffinate. And so are you asking about the organic mixture or the raffinate?
Q. I'm talking about the d-limonene, tar compound, water mixture. And you refer to that as the

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(10:07:27-10:08:20)
organic mixture, right? So we're talking using the same terms?
A. We need to be more precise, because they don't mix. The water largely stays -- there is some minor amount of water in the organic mixture, but it largely stays separate. And likewise the amount of d-limonene and organic -- or tar compound in the organic mixture, largely it all stays there. Some d-limonene and some tar compound ends up in the water, okay, but the two phases are largely separate.
So the reason I'm -- I'm trying to understand your question is, I'm not sure which phase you're asking about the volume for -- which phase you're asking about; whether you're asking me about the d-limonene in the organic mixture, or the d-limonene in the water.
Q. I'm talking about the d-limonene in the -- in the -- in post process, the post tar sands extraction process --
A. Yeah.
Q. -- whatever that is.
A. Okay.
Q. All right. That's what we're concerned about, right?
A. Sure.

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(10:08:34-10:09:24)

Q. All right. So in that phase, whatever that phase is, what is the concentration of d-limonene in that mixture?
A. In the overall mixture of the d-limonene, tar compound and water that comes into contact with it, the d-limonene is by far the dominant component.
Q. What is -- what is the concentration?
A. I don't know. They haven't given that to us.
Q. What did you assume it to be for purposes of your calculation?
A. It's not involved in my calculation.
Q. Okay. You didn't consider that in your calculations?
A. It's -- it's not relevant. It's the -- what we're focussing on is what's the concentration of these things in the raffinate in the water.
Q. But you would agree, wouldn't you, that the d-limonene would have to be present in relatively large proportions in order for it to act as a solvent?
A. No. No, this statement in Schwarzenbach, Gschwend, and Imboden is a generalization, okay. When they say for the purposes of predicting organic chemical phase in the environment, they're primarily interested in cosolvents. Well, that's true when

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(10:09:49-10:10:38)

you're considering hazardous waste clean up, okay.
And the issue of clean up of organic solvents that are in the subsurface, their transport, when there is another cosolvent present, is affected not by the few orders of magnitude -- you know, three orders of magnitude that I calculated, but by much greater amounts, okay. That's what they're referring to here. They're talking about massive changes.
Q. So you're saying in this context the concentration of d-limonene can be less than ten percent by volume?
A. Well, I haven't actually calculated that. Have you calculated that?
Q. Of course not.
A. Okay. Well, you're doing a good job, so I -- I'm not sure.
Q. Well, I'm not asking you if you've calculated it. I'm asking you, in your opinion, what you're saying is is that the presence of d-limonene in the mixture can be less than ten percent by volume and still create the increased solubilities that you're talking about?
A. Yes. Absolutely.
Q. How much less?
A. How much less of what?

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(10:10:47-10:11:46)

Q. Ten percent. How much less than ten percent? What does it have to do --
A. Well, as stated in the text, there can be cosolute effects, far below the ten percent, okay.
Q. But my -- my --
A. And remember that these -- these ten percents, one percents, obviously those are round numbers because this is a generalization of a process, okay. The organic compound is referred to as being hydrophobic because it's not compatible with the structure of water.
And as stated in this text, you've done a good job identifying the relevant material. As stated in the text, the water has to form hydration cavities to accommodate these hydrophobic compounds. And so what is being discussed here is this generalization that you need something on the order of ten percent for a cosolvent effect to occur, where their hydration shells overlap and the water has an energetic advantage to pushing these molecules together, basically, a so-called cosolvent effect.
But these are very rough numbers.
Q. Is the cosolvent effect the same as aqueous solubility?
A. No.

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(10:11:58-10:49:31)

Q. How is it different?
A. Because when you're talking about a cosolvent, you're add -- you're talking about addition of a compound to the water in large amounts, okay, like an alcohol to the water, in order to -- which ends up solubilizing compounds that wouldn't normally dissolve in the water.
So physically it's the same process we're talking about, but at ten percent, you know, by volume you're talking about huge additions, okay. You're talking about the kinds of things you'd see in a hazardous waste site where multiple compounds had been dumped, okay.
Q. All right. Now you said -- we've been going for a while. Can we take a break?
THE VIDEOGRAPHER: We're going off the record, the time is 10:14.
(There was a break taken.)
THE VIDEOGRAPHER: We're going back on the record, the time is 10:50.
Q. BY MR. HOGLE: Okay. We took a break. Back on the record now. Dr. Johnson, to try to clean up this a little bit. The point of your calculations is to estimate the cosolvent effect of d-limonene to increase the solubility of the tar compounds, right?

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(10:49:43-10:50:54)
A. Cosolvent effect?
Q. Yes.
A. No.
Q. But you do opine in your testimony that the presence of d-limonene increases by a factor of over 1440 the concentration of BAP, right?
A. Yeah, I calculated a factor of 1440.
Q. Okay. And it's the d-limonene that causes that -- that increased concentration of BAP, right?
A. Yes.
Q. And you would agree with me, wouldn't you, that the most -- the maximum amount of d-limonene that can exist in water is 13.8 milligrams per liter?
A. That is the solubility that I found, I can't even remember the source, but it's in the testimony, but yes. But that -- I wouldn't call that the maximum amount, but that is the normal water solubility of d-limonene.
Q. Okay. At room temperature?
A. Yes, I believe it was room temperature.
Q. Okay. And you would agree with me, wouldn't you, that 13.8 milligrams per liter is less than ten percent by concentration, by volume?
A. By volume. I would agree with you that

Page 55
(10:51:11-10:52:23)
13.8 milligrams per liter is less than ten percent by volume.
But I need to clarify that the ten percent is irrelevant, because I'm not speaking to a cosolvent effect.
MR. HOGLE: Okay. Move to strike everything following the answer that I got.
Could we mark the excerpt of the Schwarzenbach textbook at Exhibit 3, please. And I move for the admission of Exhibit 3.
MR. McCONKIE: No objection.
MS. WALKER: No objection.
(Exhibit 3 was marked for identification.)
Q. BY MR. HOGLE: Dr. Johnson, I'm handing you a document that's entitled Environmental Research Brief Solubility, Sorption and Transport of Hydrophobic Organic Chemicals in Complex Mixtures. Do you see that?
A. Yes.
Q. Is this the type of publication that you rely on?
A. It's the type, but this concerns cosolvent effects, and that is not what I'm addressing in my testimony.
Q. Okay. But this is the type of -- of

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(10:52:37-10:53:42)
publication that you rely on in the course of your -- of your -- of your work, your profession?
A. This is one of a million.
Q. Okay. And you rely on publications like these in your -- in your regular work, right?
A. Sure. Yeah.
Q. Could you go to Page 11, please. All right, and I'm going to read from -- well, before I get there, I'd like to mark this as Exhibit 4 and move for its admission.
MS. WALKER: Do you have a copy?
MR. HOGLE: Oh, I'm sorry.
(Exhibit 4 was marked for identification.)
MS. WALKER: Thank you. Say the page again.
MR. HOGLE: 11. But I guess I would mark that Exhibit 4 and move for its admission, if there's any objection.
MR. McCONKIE: No objection.
MR. HOGLE: Unless there's an objection.
MR. DUBUC: No objection.
Q. BY MR. HOGLE: All right. If we go to Page 11, just under the graph there's a sentence. Tell me when you're there.
A. I'm there.

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(10:53:54-10:55:10)
Q. Okay. There's a sentence that says:
"Our data and model calculations suggest that solubility enhancement for most organic contaminants is likely to be small (less than 20% Increase) as long as cosolvent concentrations in pore water are less than 2% by volume (or about 20,000 milligrams per liter)."
Do you see that?
A. Yes, I do see that statement.
Q. Okay. And it's true, isn't it, that the d-limonene in a water solution would be less than two percent by volume?
A. Yes, that's true. But this document concerns very different compounds than the polycyclic aromatic hydrocarbons that I was examining. And so this generalization is for compounds that are much more soluble in water.
MR. HOGLE: Okay. Move to strike everything after "Yes, that's true."
Q. All right. Switching gears a little bit here. What you did -- if you look at Page 7 of Exhibit 1, your initial testimony.
A. Uh-huh.

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(10:55:33-10:56:33)

Q. -- is you purport to derive the hypothetical liquid solubility of BAP based on the solid solubility; is that right?
A. No. I have data for solid and liquid solubilities.
Q. Where's the --
A. Page 7.
Q. What's the data for the liquid solubility?
A. What's the value?
Q. The data. You said you had data for the solid and liquid, and I'm asking you about the data for the liquid.
Okay. Where did you get that from?
A. These are from Schwarzenbach.
Q. Okay. Could you point me to where the 49.19 figure is from Schwarzenbach?
A. And it could be that I -- I used the ratio of the vapor pressures to get these solubilities. If they had one of them then I could get the other one, and I don't recall off the top of my head, but one of them would be in here.
So liquid solubility of the liquid is given here.
Q. And what's the number given?

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(10:56:50-10:57:46)

A. It's a log value and so it's 6.71.
Q. 6.71 what? Micrograms per liter?
A. That is moles per liter.
Q. Can I see that, because I -- I only have one.
A. This?
Q. Yeah. So you're -- you looked at Page 6- -- which page did you look at? 621 or 620?
A. I can't even see it from here, sorry. 621.
Q. 621. Okay. All right. I see the benzo(a)pyrene, and under the -- what -- yeah, could you interpret for me what column that's under?
A. That's under one, two, three, four, five, six, seven, the eighth column from the left.
Q. And what is the label for that?
A. That is the negative log of the solubility of the pure compound in water.
Q. And how did you --
A. As a liquid.
Q. Okay. And that's expressed in moles per liter?
A. Yes.
Q. So how did you go about converting that to micrograms per liter?

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(10:58:00-10:59:29)

A. The molecular weight of the compound.
Q. Is that somewhere in the book?
A. Yes. It's in Column 2.
Q. And what's the label for that column?
A. The molecular weight.
Q. Okay. All right. Now, this -- maybe you can explain something for me, but the column heading for the 6.71 shows that -- in the parenthesis it says it's for solids and gases?
A. Yes. That -- that's for compounds that at the temperature that this is given for. Room temperature, basically, 25 degrees Celsius. For compounds that are normally solids or gases, they're providing the liquid solubility. The solubility of a liquid form of that compound.
Q. Okay. And what -- is there any assumption that goes into how the solid or the gas becomes the liquid?
A. I'm not sure what you're asking. There's no assumption. There's no assumption, it's just that a standard for understanding the behavior of compounds is to characterize them as a liquid.
So compounds that are solid at room temperature would be liquid at elevated temperature, and you can use data at elevated temperature to

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(10:59:43-11:00:40)

project down to room temperature to understand what the solubility would be at room temperature.
Q. Okay.
A. But that's -- that's well established thermodynamic --
Q. All right.
A. -- experimentally.
Q. So in order for a solid like the tar compounds, right, naturally they're in a solid state, as you've indicated. In order for those to be a liquid they'd have to be super heated, right?
A. They are liquid -- it would be a sub-cooled liquid at room temperature.
Q. It would be heated and then sub-cooled?
A. No. The term that's used to describe a compound acting as a liquid, okay, but at a temperature at which it would normally be a solid, is called a sub-cooled liquid.
Q. Sub-cooled to what?
A. Sub-cooled below its melting temperature.
Q. Okay. And does that -- does that exist in reality?
A. Yeah, the melting temperature exists in reality --
Q. Well, sure.

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(11:00:54-11:02:40)
A. -- and the compound exists. That's precisely what's happening when you add d-limonene to the tar. You're making the tar compounds transition from a solid to a sub-cooled liquid state.
Q. Okay. Through the -- okay.
And where in the text did you find the equation for the follow-up calculation that you did on Pages 7, 8, and the top part of 9?
A. The -- well, I can't recall off the top of my head whether this specific equation is in this text, but I've got my own publications that also have that and similar equations. So do you -- are you asking me to identify specifically in this text where this equation is?
Q. Yes.
A. If the exact equation's not there, certainly related equations would be in here. So it would be in Chapter 7, Organic Solvent Water Partitioning. Okay. So here's Equation 7-1 is a typical partition coefficient, which is what my analysis is based on.
Q. What page is that on, sir?
A. 125. And let's see if it gives a normal water solubility, just a minute. Yeah, it's not in here.

Page 63
(11:02:58-11:04:00)
But the equation that I provide is a simple algebraic combination of different partition coefficients in order to get the enhanced solubility of the compound in the water. And it's well substantiated in my own publication, publications by Keri Chiou who is referenced in the excerpt here, and other experts in organic compound solvent partitioning.
Q. Is it in the Schwarzenbach book?
A. Is what in it?
Q. Does the Schwarzenbach book support your algebraic equations?
A. It -- it does in the form of providing a partition coefficient, and then the rest is just simple algebra.
Q. Okay. That's on Page 125, Equation 7-1?
A. Yeah, that's a -- that's an example of partition coefficient.
Q. Okay. Let me ask you about this one. I'm handing you another textbook, and ask you if you can identify that?
A. Sure. This is the newer edition -- one of the newer editions of this textbook (indicating).
Q. Okay. And just --
A. 1993.

Page 64
(11:04:10-11:05:08)
Q. -- for the record could you give the author and title of that?
A. The same set of authors, Rene Schwarzenbach, Phil Gschwend, and Dieter Imboden.
Q. Okay. And it's called Environmental Organic Chemistry; is that right?
A. That's right.
Q. All right. It's the second edition?
A. Yes.
Q. And it's 2003?
A. Sure.
Q. Is this the textbook that you teach from?
A. This one I do use in my class.
Q. Okay.
A. Or I should say the students buy this one. I mostly actually teach out of the old one because it's just much more straightforward.
Q. Okay. But you -- you have your students buy the 2003 edition?
A. Because this is not -- the old one's not available. As available.
Q. All right. Did you utilize the 2003 edition at all in your work for this case?
A. I may have, because I have both copies on my shelves, yeah.

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(11:05:26-11:07:20)
Q. Okay. Can you identify where in the 2003 edition your approach -- or we could find an equation or a method by which we could answer the question that you tried -- that you purport to answer in your testimony?
A. Well, there are equations related to what I have developed, okay, and obviously this is a very big book and so there's an example of the type of equation I used here on Page 306. Also on Page 300, 299. And those are good examples.
Q. All right. Let me ask you -- well, first of all, I made some photocopies. So I'm handing you excerpts from the 2003 edition.
A. Wow.
Q. And I'd like to -- well, yeah, I'd like to mark that as the next exhibit, five, and move for its admission.
MR. McCONKIE: No objection.
MS. WALKER: Just one second, please.
(Exhibit 5 was marked for identification.)
MS. WALKER: So, Chris, do you just have Chapter 3, is that what it is?
MR. HOGLE: It's Chapters 3, 4, 5, and 7.
MS. WALKER: And seven?
MR. HOGLE: And seven.

Page 66
(11:07:31-11:08:29)

MS. WALKER: Okay. No objection.
MR. HOGLE: All right.
MS. WALKER: I'm sorry, just one more question. And it's the entirety of the -- of those chapters?
MR. HOGLE: I tried for it to be, yes. Yeah.
Q. All right. Could you turn to Page 138, please, of exhibit -- what number did we say it was?
THE REPORTER: Five.
MR. HOGLE: Exhibit 5.
THE WITNESS: 138?
MR. HOGLE: 138.
THE WITNESS: Okay.
Q. BY MR. HOGLE: Now, could the -- could you utilize the methods set forth on Pages 148 and to the top of the next page to develop the extent to which d-limonene in the water would enhance the solubility of the tar compounds?
A. Are you asking did I utilize this type of material?
Q. Could you. Could one?
A. Well, I did and could.
Q. Oh, you -- this is what you did do?
A. This is -- this is -- this process of

Page 67
(11:08:46-11:10:12)

relating the activity coefficient of a compound in water to its concentration solubility in water is documented here as well as in the 1993 text.
Q. Right.
A. And accounting for the molar volume of water, as is done here, so, yes.
Q. Okay. Okay. And on Page 139 there's an equation 5-13, do you see that? Page 139 of Exhibit 5. Do you have Page 139?
A. I'm not sure I do.
MS. WALKER: The numbers are on...
MR. HOGLE: The page numbers should be on the top right.
MS. WALKER: Yeah, and they change sides.
THE WITNESS: Yeah, I don't have Page 139.
MS. WALKER: I do.
THE WITNESS: And it goes from 138 to 140. Not in here. The page number's 138 and 140.
MR. HOGLE: Do you have Page 139?
MS. WALKER: Yeah, so may we have another?
MR. HOGLE: I didn't bring another copy.
MR. McCONKIE: And that's Page 139.
MR. DUBUC: You have it, Bill, now?

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(11:10:20-11:11:29)

THE WITNESS: Yeah, now I do.
MS. WALKER: We could just make another copy of it. While he's talking about it, if you don't mind.
MR. McCONKIE: All right.
MS. WALKER: We can make another copy of this page.
Q. BY MR. HOGLE: So since you didn't have that page, I got to make sure the record's clear and go back, because my earlier question was: Could you use the method and the equations on Pages 138 to the top of 139 to perform the -- to answer the question that you purport to answer in your testimony?
A. Yes.
Q. Okay. I just had to make sure that was clear, because for some reason 139 was missing.
Now, is there somewhere in your testimony that I can find an application of Equation 5-13 on Page 139?
A. Yes. Absolutely.
Q. Where -- could you point that to me, please.
A. In the supplemental testimony.
Q. And that is Exhibit 2.
A. Okay. So Equations 13 and 14 incorporate

Page 69
(11:11:41-11:12:46)

the information in Equation 5-13.
Q. Okay. Could you tell me what page you're on?
A. Of my supplemental?
Q. Yes, sir.
A. Page 20. As well Page 21, Equation 17 incorporates it.
Q. Okay. Anywhere else?
A. Probably.
Q. You said Page 21, Equation 17, right?
A. Yes.
Q. Okay.
A. Previous page -- well, top of Page 20, Equation 12. Now -- and Equations 9, 10, and 11.
Q. On the previous page, Page 19?
A. On Page 19.
So just to clarify, this energy effusion term --
Q. And what are you referring to?
A. -- in Equation 5-13, there's an exponent term with the energy effusion delta fus, that delta sub fus.
Q. Yes, sir.
A. Energy effusion, and then over RT. That is the same, basically, as this ratio of vapor

Page 70
(11:13:05-11:14:16)
pressure, the solid over liquid. And that's why -- it's the same information being used, but they don't look the same. So I just want to clarify that's why.
Q. Okay. I just want to make sure I get your references right. You referenced Equation 5-13 in Exhibit 5, Page 139, and you said that was the same -- or substantially the same, I guess, as what?
A. As -- let me be exact about this -- well, it's incorporated into pages -- Equations 9, 10 on Page 19, and Equation 12.
Q. On Page 20.
A. 20.
Q. Okay.
A. In fact Equation 12 is very closely related -- Equation 12 on Page 20 of my supplemental --
Q. Yes.
A. -- is very closely related to equation 5-13, Page 139.
Q. Okay. Now you said they're basically the same, and so when you say that you equivocate a little bit, I need to follow up and say, how are they different?
A. The Equation 5-13 in -- on Page 139 of the text expresses the concentrations of the compound

Page 71
(11:14:37-11:15:48)
in water as -- as concentration, as moles per liter. Whereas Equation 12 of my supplemental I'm expressing them as mole fractions.
Q. Okay. Other than that is there any difference?
A. Well, the mole fraction -- I mean, they're just algebraically rearranged differently, is one minor difference. And then the mole fraction times the activity coefficient, which is of the terms that show up in my equation, okay, are equivalent to the solubility terms that show up in this equation.
Q. Okay. All right.
A. So basically I've broken the concentrations down into the mole fraction and the activity coefficients.
Q. All right. And other than that there's no other difference?
A. I don't believe there is. I've only had a short time to look at this, so...
Q. Sure. But just to sum up then, the equation on 139 is an appropriate one to use, and you basically used that equation?
A. That's right.
Q. Now let me ask you another -- about another part of this textbook, Exhibit 5. Could you

Page 72
(11:16:24-11:18:01)
go to Page 238.
A. Yes.
Q. All right. Now, is this -- does this illustrative example exemplify an approach that one could use in a case like this?
A. I'm not familiar with this particular example, so I'd have to spend some time looking at this. Off the top of my head it looks like it's only concerning the organic part of all this. A hydraulic oil and Aroclor, which is a PCV congener. So I don't think it's directly applicable, but I don't know the example.
Q. Okay.
A. See they define this hydraulic oil as not being water based -- well, I don't know what it is. It's trialkyl -- trialkyl-phenylphosphate, and so it's -- it's a different animal than --
Q. Okay.
A. -- the raffinate.
Q. All right. Did you assume that the -- for purposes of your work -- that the tar compounds would stay in the d-limonene water solution as the tar compounds would in pure d-limonene?
A. No.
Q. Did you assume that the tar compounds

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(11:18:25-11:19:30)
would dissolve in water from the d-limonene water solution in the same way and the same extent that the tar compounds would dissolve in their hypothetical liquid form?
A. I need you to repeat that.
Now I know how you feel.
Q. Did you assume that the tar compounds would dissolve in water from this d-limonene mixture in the same way and in the same extent that the tar compounds would dissolve in their liquid form?
A. Yes. I think, if I -- let me make sure I know the question you're asking. But if you're asking me am I assuming that the compounds exist in their sub-cooled liquid state when they're in the d-limonene tar compound mixture, yes.
MR. HOGLE: Okay. Okay. Can we take a break?
MR. DUBUC: Sure.
MR. HOGLE: Real quick. I think I'm done, but I want to confer with these gentlemen to be sure.
MR. DUBUC: You planning to ask any questions?
MR. McCONKIE: A few.
THE VIDEOGRAPHER: We're going off the

Page 74
(11:31:23-11:33:01)
record, the time is 11:20.
(There was a break taken.)
THE VIDEOGRAPHER: We're going back on the record, the time is 11:32.
Q. BY MR. HOGLE: Handing you a document. Is that -- is that the -- is that the publication you cited in your initial testimony in Reference Number 1?
A. Yeah, I believe it is, although double check. Yes.
Q. Okay. And this is what you utilized, in part, to list the properties of d-limonene in Appendix B to your initial testimony, right?
A. That's right.
Q. All right. And remember we had some question and answer earlier today about the properties of d-limonene?
A. Right.
Q. Could you turn to Page 17, please.
A. Uh-huh.
Q. Okay. Under Portion VIII -- Section VIII, Drinking Water Considerations, it says:
"d-limonene is only somewhat soluble in water (13.8 milligrams per liter) and has an estimated octanol/water partition coefficient of 4.2.

Page 75
(11:33:15-11:34:04)
d-limonene is expected to rapidly volatilize from water to the atmosphere, with an estimated half-life for volatilization from a model river of 3.4 hr" -- that's hour, right? Hours?
A. Yes.
Q. -- "although adsorption to sediment and suspended organic matter may attenuate the rate of this process."
Did I read that correctly?
A. That's right.
Q. All right. And then further down the page on 17 under Section IX, the second paragraph reads:
"Given the physical/chemical properties of d-limonene, it is unlikely that d-limonene will occur in drinking water sources."
Do you see that?
A. Yes, but they're clearly referring to surface water drinking water sources.
Q. Okay. And then go to Page 18. Under Section X, Risk Characterization. The third sentence says:

Page 76
(11:34:17-11:35:41)
"d-limonene is expected to rapidly volatilize from dry soil, wet soil and water, therefore exposure through the drinking water routes is considered very unlikely."
Did I read that correctly?
A. Yeah. It's interesting because it's in contradiction of the statement that absorptions of the sediment will attenuate the rate of volatilization.
MR. HOGLE: No further questions.

CROSS-EXAMINATION
BY MR. McCONKIE:
Q. Dr. Johnson, my name's Paul McConkie, and I am here on behalf of the executive secretary, and I just have a few -- a few follow-up questions.
Now, you testified that you're not speaking as to the likelihood of contact with surface water or groundwater of this mixture?
A. That's right.
Q. So you've not evaluated the hydrogeology of the particular site for that?
A. That's right, I have not.
Q. If I could refer you to Exhibit 2 on Page 20 of your supplemental testimony. On Lines 15

Page 77
(11:36:17-11:37:45)
through 20 you do some calculations with regard to the retardation factors. Do you see that on Page 20?
A. That would be in the initial testimony.
MR. HERBERT: Oh, yeah, he's correct, it's in the initial testimony, Page 11.
MR. McCONKIE: Oh, okay. Sorry. Initial testimony, Page 11.
Q. Is it true that you used a value of 35 percent for moisture content in the equation for calculating retardation factor?
A. Yes, that's correct. That's a saturated -- I assumed it was a saturated system.
Q. Okay. And that was my next question. So that would represent -- that would represent a saturated condition?
A. Yes, roughly, right. It's a hypothetical, but yes.
Q. Right.
Do you -- do you know what best management practices are?
A. I know the term.
Q. Have you -- have you assessed any of the best management practices that are going to be employed out of this -- in this project?
A. I was not asked to do that.

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(11:38:07-11:39:28)
MR. McCONKIE: Okay. I think that's all the questions I have. Thank you.
MR. DUBUC: Redirect?

REDIRECT EXAMINATION
BY MS. WALKER:
Q. Okay. Dr. Johnson, I'm going to just ask you a few follow-up questions, if I may.
There was some discussion earlier on on this issue of vapor pressure and your statement in your initial testimony on page -- and I've forgotten the page, sorry.
A. Page 4.
Q. Page 4, right. Okay. If you would just explain sort of the difference between your approach towards vapor pressure in your first testimony and your second -- your supplemental testimony.
A. In the first testimony I wasn't focussing on the properties of d-limonene itself, its own transport. I was focussed on the effect of d-limonene on the transport of the tar compounds.
And so I wasn't really focussing on vapor pressure of d-limonene. And so I basically started with the argument being made by U.S. Oil Sands that d-limonene by itself would readily vaporize.

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(11:39:45-11:41:00)
And so I didn't focus on that, I let that be. And I said, but if that were the case, even if that were the case, you would have a rind of tar compounds accumulating on the mixture, on the organic mixture, and that would inhibit d-limonene vaporization. So that was my take on it, the first for the initial testimony.
And then subsequently it's become clear that the vapor pressure of d-limonene is only two meters of mercury at room temperature, which is 1-10th that of water. So it's going to vaporize much, much more slowly than water. And so that was a point I made today in our discussions.
And the gas density, the vapor density of d-limonene is four. So four times heavier than air. And so denser than air. And so it will literally hang around the site, okay. Hang around in the fore space of that process sand.
MS. WALKER: Okay. So, I'm sorry, Chris, were you going to admit -- admit this as an exhibit?
MR. HOGLE: No.
MS. WALKER: Okay.
Q. So this -- this document that we most recently were handed, which you referred to in your -- was that your opening testimony as, what was it,

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(11:41:13-11:41:57)
Reference 5 or something like that?
A. I've lost track.
Q. Yeah, me too.
A. So are you asking about this recent --
Q. Right. Where in your testimony did you refer to this?
A. Oh, on that same -- same Page 4.
Q. Okay. Same Page 4?
A. Referring to the properties of d-limonene.
Q. Okay. And so the -- the numbers for vapor pressure and vapor density you got out of this document; is that right?
A. That's right.
Q. Okay. And then I'm just wondering when -- when Chris was reading the statements out of this document, was he referring to d-limonene on its own or -- or I'm sorry, not was Chris referring to d-limonene, but was the document referring to d-limonene on its own or in the presence of tar compounds?
A. Was the -- are you referring to the NOI?
Q. No. I'm sorry.
So recently Chris was reading sections from this document just --

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(11:42:08-11:43:17)
A. Okay.
Q. -- minutes ago.
A. Yes. So that's -- this is -- this document strictly concerns d-limonene, not d-limonene in a mixture of a tar.
Q. Okay. So it wouldn't account for the rind effect?
A. No. And the document itself says that the rate of vaporization would be greatly decreased due to adsorption to seven.
Q. Okay. So the other thing is we had -- we've had this very thick 2003 textbook, and the much thinner earlier version, and I'm wondering, has the science on which you based your analysis changed from, was it 1993?
A. Uh-huh, the original.
Q. From 1993 to 2003?
A. Well certainly, you know, as with any science, things move forward, but the basic information is the same in both texts. The thicker, more recent text elaborates on some things, but the material that was pointed out in the 2003 version of the text is also present in the 1993 version.
Q. Okay. We also had a discussion about cosolvents, and if I understand you correctly you were

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(11:43:34-11:44:52)

saying your analysis was not about cosolvents?
A. That's right. The distinction being made here in both texts is that a cosolvent effect is expected above a volume fraction of ten percent, okay. We are far below that ten percent volume fraction. We're in the range where they discuss cosolute effects, and so that's why when the question was asked am I considering cosolvent effects, I answered no, because that's not the case. I'm -- I'm considering cosolute-type effects.
But it also has to be stated that this cosolute, cosolvent distinction, is illustrative. It's to show students the physical process that is taking place when a compound dissolves in water, and the physical process that takes place when another compound dissolves in water to enhance the solubility of another compound. And so these are general ranges that are being provided.
Q. Okay. So then I'd like to ask you about this EPA document. Was that an exhibit? This one, did you tag this as an exhibit?
A. We tagged it, yeah. Yeah, Exhibit 4.
Q. Yeah. And Chris asked you about the -- pretty much the first full line on Page 11. If you would just clarify your answer to his question there.

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(11:45:14-11:46:15)

He read that first -- or somebody read the first line. So it starts with "Our data."
A. You want me to read that?
Q. No, no, no. I just --
A. Okay.
Q. -- I just wanted you to expound on your answer when -- when Chris asked you about that line?
A. And can you remind me what my answer was?
Q. Oh, boy. No, apparently not.
A. Well, let me -- I do have a point to make about this.
Q. Okay.
A. And that is, that this generalization about when cosolvent effects, which again, the issue isn't cosolvency. But there's generalization about when cosolvent effects become important. So I guess the first point is that's irrelevant because we're not talking about cosolute effects in this case.
But second, it's generalized for compounds that range from very -- well, much less hydrophobic than the tar compounds we're talking about. So, for instance, Figure 1 is about compounds you would -- that are pretty dissolvable in water, okay. And I haven't had a chance to review this, but they're generalizing from a range of compounds, and

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(11:46:33-11:49:35)

that generalization probably doesn't hold for these much more hydrophobic compounds that we're looking at in tar.
MS. WALKER: Okay. So I'm close to the end but I just want to confer for a second to make sure we've covered everything.
MR. HOGLE: Okay.
MS. WALKER: So we would go off the record.
THE VIDEOGRAPHER: We're going off the record, the time is 11:48.
(There was a break taken.)
THE VIDEOGRAPHER: We're going back on the record, the time is 11:50.
MS. WALKER: Okay. I have no further questions at this time.
MR. HOGLE: All right. Just a few follow-ups, Dr. Johnson, to what you just said.

RECROSS EXAMINATION
BY MR. HOGLE:
Q. One of the things that you said was in your initial testimony in Exhibit 1, the answer that you gave on Page 4 regarding d-limonene by itself will likely vaporize/volatilize readily. And then you

Page 85
(11:49:51-11:51:11)

said, and subsequently, it became clear to you that the vapor pressure of d-limonene is only two meters of mercury at room temperature. You remember saying that?
A. Yes.
Q. Okay. If you go to Exhibit B of Exhibit 1, your initial testimony. Didn't you already know that the vapor pressure of d-limonene was two meters of mercury at room temperature?
A. Well, it's in there, but I hadn't thought about it much.
Q. Now, you said -- referring to the EPA document, Exposure and Risk Assessment on Lower Risk Pesticide Chemicals d-limonene. Remember there was some questions about that? And that's the first reference in your initial testimony, correct?
A. It's one of the references, yes.
Q. Okay. You said in answer to one of Ms. Walker's questions that this document says that adsorption to sediment would, quote, "greatly decrease volatilization." Do you remember saying that?
A. Yeah, I said that because you had read that statement.
Q. Actually, look at the statement, please. It says:

Page 86
(11:51:20-11:52:17)

"Adsorption to sediment and suspended organic matter may attenuate the rate" -- "may attenuate the rate of this process."

A. Yeah, so it would decrease the rate of the process.

Q. Okay. That's --

A. And -- and they're talking in a river context. When you're in a process sand, the water to soil ratio is much, much lower. You got a lot more sediment relative to water in the process sands than you do in a river setting.

Q. You relied on this in a groundwater context, right?

A. I relied on this simply for the solubility of d-limonene. There's no context.

Q. Okay. Now, you also said -- well, before I do that, could you go to the exhibit -- the exhibit for the 1993 edition of the Schwarzenbach -- yeah, what number is that?

A. Number 3.

Q. Yeah, Number 3.

A. Three.

Q. Go to Number 3.

You said in responses to questioning that

Page 87
(11:52:36-11:53:18)

you -- you're not considering the cosolvent effects, you're considering the cosolute effects, right?

A. That's right.

Q. Could you go to Page 97 of Exhibit 3. Now that deals with cosolutes, right?

A. Yes. Cosolutes, yes.

Q. Cosolutes, all right.

And then it says in that paragraph, quote:

"Finally, if the organic chemicals are present at low enough levels (less than ten to negative three volume fraction) that there is a low probability of even their hydration shells overlapping, we can expect no effect on the aqueous activity coefficients or (liquid) solubilities."

Right? It says that.

A. It says that, and that's a very large generalization, because they're talking about compounds that have a very large range in hydrophobicity.

I can tell you I've done experiments with polycyclic aromatic hydrocarbons and an agent that is

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(11:53:39-11:54:03)

analogous to d-limonene, natural organic matter, a humic acid, and seeing large increases in solubility in response to concentrations in this range, okay. Tens of milligrams per liter.

MR. HOGLE: No further questions.

MR. McCONKIE: I have no questions.

MS. WALKER: Do you want to say anything else?

THE WITNESS: I don't think so.

MS. WALKER: Okay. No further questions. Thank you.

THE VIDEOGRAPHER: We are going off the record, the time is 11:55.

(The deposition was concluded at 11:54 a.m.)

* * *

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Deponent's Certificate

I, WILLIAM JOHNSON, Ph.D., deponent herein, do hereby certify and declare the within and foregoing transcription to be my deposition in said action taken on April 20, 2012; that I have read, corrected, and do hereby affix my signature to said deposition.

DATED this _____ day of _____, 2012.

_____
Deponent

STATE OF UTAH)
) ss.
)

SUBSCRIBED AND SWORN to before me this _____ day of _____ , 2012.

_____
Notary Public residing in

My Commission Expires: _____

_____

Reporter's Certificate

State of Utah)
County of Salt Lake)

I, Vickie Larsen, Certified Shorthand Reporter and Registered Professional Reporter, in the State of Utah, do hereby certify:

THAT the foregoing proceedings were taken before me at the time and place set forth herein; that the witness was duly sworn to tell the truth, the whole truth, and nothing but the truth; and that the proceedings were taken down by me in shorthand and thereafter transcribed into typewriting under my direction and supervision;

THAT the foregoing pages contain a true and correct transcription of my said shorthand notes so taken.

IN WITNESS WHEREOF, I have subscribed my name this _____ day of _____, 2012.

_____
Vickie Larsen, CSR/RPR

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Deponent's Certificate

I, WILLIAM JOHNSON, Ph.D., deponent herein, do hereby certify and declare the within and foregoing transcription to be my deposition in said action taken on April 20, 2012; that I have read, corrected, and do hereby affix my signature to said deposition.

DATED this _____ day of _____, 2012.

_____
Deponent

STATE OF UTAH)
) ss.
)

SUBSCRIBED AND SWORN to before me this _____ day of _____ , 2012.

_____
Notary Public residing in

_____
My Commission Expires:

_____

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THAT the foregoing proceedings were taken before me at the time and place set forth herein; that the witness was duly sworn to tell the truth, the whole truth, and nothing but the truth; and that the proceedings were taken down by me in shorthand and thereafter transcribed into typewriting under my direction and supervision;

THAT the foregoing pages contain a true and correct transcription of my said shorthand notes so taken.

IN WITNESS WHEREOF, I have subscribed my name this 25 day of April, 2012.

Vickie Larsen

Vickie Larsen, CSR/RPR

WORD INDEX

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