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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
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(09:04:42-09:05:45)
1 April 20, 2012 9:06 a.m.

2 P R O C E E D I N G S

3

4 THE VIDEOGRAPHER: We are going on the

5 record, the time is 9:06.

6 This is the videotaped deposition of

7 William Johnson, taken in the matter of PR Spring Tar

8 Sands Project, Ground Water Discharge Permit-By-Rule,

9 before the Utah Water Quality Board.

10 This deposition is being held at 175

11 South Main, Salt Lake City, Utah, on April 20th, 2012.

12 My name is Max Nelson from the firm of

13 Tempest Reporting, with offices at 175 South Main,

14 Salt Lake City, Utah. I am the video specialist. The

15 reporter is Vickie Larsen from Tempest Reporting.

16 Counsel will now state their appearances

17 for the record and the witness will be sworn.

18 MS. WALKER: Good morning. I'm Joro

19 Walker for Living Rivers. And with me is Rob Dubuc.

20 MR. HOGLE: I'm Chris Hogle for U.S. Oil

21 Sands, respondent. With me is Ben Machlis and

22 representative of U.S. Oil Sands, Barclay Cuthbart.

23 MR. McCONKIE: I'm Paul McConkie

24 appearing on behalf of the executive secretary, and

25 with me is Rob Herbert of The Division of Water

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

1 Quality.

2

3 WILLIAM JOHNSON, Ph.D.,

4 called as a witness, having been duly sworn,

5 was examined and testified as follows:

6

7 DIRECT EXAMINATION

8 BY MS. WALKER:

9 Q. Just to be clear, this isn't a

10 deposition, it's actually testimony.

11 But that said, would you please state

12 your name for the record?

13 A. Sure. William Paul Johnson.

14 Q. And your profession?

15 A. Professor.

16 Q. Where?

17 A. University of Utah.

18 Q. Okay. And in what area?

19 A. Geology and geophysics.

20 Q. Okay. And if you would briefly state

21 your credentials.

22 A. My credential include a doctorate in

23 civil and environmental engineering at the University

24 of Colorado, Boulder. Post doctorate in -- at the

25 University of Arizona, Department of Chemical and

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(09:06:52-09:07:43)

1 Environmental Engineering and Hydrology and Water

2 Resources. And then professor at the University of

3 Utah.

4 Q. So how long have you been a professor?

5 A. About 17 years.

6 Q. And is that a full professorship?

7 A. Well, it's been a full professorship for

8 the past seven years.

9 Q. Okay. And did you prepare a report for

10 submission in this case?

11 A. Yes.

12 Q. And is that report dated January 20th,

13 2012?

14 A. Yes.

15 Q. And in most general terms, what is that

16 report about?

17 A. It is about developing the -- well,

18 performing some calculations to show d-limonene, in

19 addition to -- in the residual from the tar sand

20 processing will enhance the dissolving of tar

21 compounds into water.

22 Q. Okay. And does this report represent

23 your expert opinion about that subject?

24 A. Yes.

25 Q. And does it still represent your expert

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(09:07:53-09:09:11)

1 opinion about that subject?

2 A. Yes.

3 MS. WALKER: Okay. I move to enter that

4 report as an exhibit.

5 MR. HOGLE: No objection.

6 MR. McCONKIE: No objection.

7 (There was a discussion held off the record.)

8 (Exhibit 1 was marked for identification.)

9 MS. WALKER: Okay. That's marked as

10 Exhibit 1.

11 Q. So you just explained generally what the

12 report is about, but I think we need a little bit of

13 background, because some of the terms and the

14 references you were making are a little unclear.

15 So when you're talk about what you were

16 doing, can you provide a little bit more context?

17 A. Sure. I was reviewing the NOI provided

18 by U.S. Oil Sands, and some claims that are made in

19 the NOI struck me as unsupported. And so I did some

20 further research -- well, "research" probably too

21 strong a word -- calculations to see if those claims

22 could be substantiated. And so the report provides

23 some information that, at least weakens, if not

24 counters, those claims that were made in the NOI.

25 MR. HOGLE: I'm going to object and move

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(09:09:25-09:14:54)

1 to strike that last answer. He didn't reference the

2 NOI in either set of his testimony, and under the

3 scheduling order that we stipulated to he was required

4 to identify the work he did and the conclusions he

5 reached in his testimony.

6 THE REPORTER: Can I ask you to speak up

7 a little louder?

8 THE WITNESS: Sure.

9 MS. WALKER: Okay. Let's go off the

10 record for a second, please.

11 THE VIDEOGRAPHER: We're going off the

12 record, the time is 9:11.

13 (There was a discussion held off the record.)

14 THE VIDEOGRAPHER: We're going back on

15 the record, the time is 9:15.

16 MS. WALKER: Would you read back his last

17 statement, please.

18 (The previous answer was read back.)

19 Q. BY MS. WALKER: So did you review other

20 documents relevant to this proceeding?

21 A. Yes.

22 Q. And what would those be?

23 A. Well, documents that are referenced in

24 here are those that I didn't think interested parties

25 would be aware of, and so I focussed my referencing

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

1 on -- on those documents, because I'm bringing new
2 information into this.

3 Q. Okay. Let me rephrase the question a
4 little bit.

5 A. Sure.

6 Q. So were there other documents that you
7 reviewed that were provided by the applicant or U.S.
8 Oil Sands?

9 A. Yes.

10 Q. And what would those be?

11 A. Well, I can't remember exactly the
12 titles, but there was other information related to
13 U.S. Oil Sands in different reports that were provided
14 to me.

15 Q. Okay.

16 A. I can look that up if it helps.

17 Q. No, I think that's fine.

18 Okay. So I just want to make sure we're
19 clear on terms. When you speak of the residual
20 mixture, what do you mean by that?

21 A. The residual mixture is the organic
22 mixture that's remaining in the process sands. That's
23 a mixture of the bitumen that's extracted from the
24 process sand and the d-limonene or the solvent they're
25 using to extract the bitumen.

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

1 Q. Okay. And when you talk about bitumen,
2 do you call that something else often?

3 A. Yeah, we often call that tar, you know,
4 so I use tar as the catch-all term for the compounds
5 that comprise the bitumen.

6 Q. Okay. And can you just give us an idea
7 of what those compounds are?

8 A. Sure. There's a range of compounds in
9 that. Asphalt is a compo- -- predominant
10 component. Polycyclic aromatic hydrocarbons are
11 another component. These are all related organic
12 compounds.

13 Q. Okay. So why are you in a position to
14 address this issue?

15 A. Well, my doctoral research concerned the
16 solubilization and transport of polycyclic aromatic
17 hydrocarbons by agents that will increase their
18 solubilizing into water. And the particular agent I
19 was looking at was natural organic mater, which shares
20 significant properties with d-limonene.

21 Q. And so as a result of your evaluation or
22 calculations, what did you conclude?

23 A. I concluded that the d-limonene would
24 enhance the solubility of the tar compounds in water
25 that's in contact with the residual mixture. And I

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

1 concluded that the transport of the organic -- the tar
2 compounds would be facilitating, would be increased,
3 the mobility would be increased by the presence of
4 d-limonene.

5 Q. And why is that a concern?

6 A. It's a concern because if this material
7 were to come into contact with water, and if that
8 water had a potential receptor of these compounds, you
9 know, a number of scenarios could be envisioned, but
10 if there were a receptor, whether that's something in
11 the ecosystem or whether that's a human ingesting the
12 water for some reason, then that would be a toxic
13 concern. Toxicological concern.

14 Q. And why do we care about an increase in
15 concentration?

16 A. Because the toxicity's directly
17 proportioned to the concentration. So the dose
18 encountered by a receptor is increased with increased
19 concentration.

20 Q. And is there anything about tar that
21 makes it a matter of concern?

22 A. Sure, yeah. The polycyclic aromatic
23 hydrocarbons, a significant number of those compounds
24 are highly carcinogenic.

25 Q. But now I'd like to delve a little deeper

Page 13

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

1 into your testimony.

2 You said that you were testing an -- an
3 assertion. Would you just repeat that assertion
4 that -- made by oil sands?

5 A. The predominant one is that the
6 d-limonene will vaporize readily from the residual --
7 from the process sands.

8 Q. And what are the consequences if the
9 d-limonene doesn't evaporate readily?

10 A. So the addition of the d-limonene changes
11 the tar. First the tar is in a solid form, or a
12 semi-solid form. It's not mobile in its natural
13 state. It's been there a long, long time because it
14 doesn't dissolve readily into water, it doesn't flow
15 on its own. But when you extract this tar compound
16 with d-limonene, now you've turned it into a liquid
17 mixture, and that changes its properties.

18 And the property that I focussed on is
19 its -- its dissolution or dissolving into water, okay.
20 And so the d-limonene enhances that dissolution into
21 water.

22 And so now -- I'm not sure I answered
23 your question, because I think maybe you were
24 focussing on the vaporization.

25 Q. No, no. You answered my question.

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

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

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

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

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

25 Q. And are there any physical reasons that

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

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

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

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

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

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

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

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

1 d-limonene vaporization.

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

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

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

12 A. No, there's no such test.

13 Q. So you gave two reasons as to why in the
14 presence of d-limonene tar will dissolve to a greater
15 extent in water. Do you recall the first of these?

16 Just to repeat it so that we can provide context for
17 the discussion we're going to have.

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

22 MS. WALKER: Okay.

23 MR. HOGLE: Should we take a break?

24 MS. WALKER: Yeah.

25 THE VIDEOGRAPHER: We're going off the

Page 17

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

1 record, the time is 9:25.

2 (There was a discussion held off the record.)

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

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

11 A. Okay. So --

12 MR. HOGLE: Let me interpose an objection
13 here.

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

23 That's my objection.

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

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

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

Page 19

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

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

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

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

Page 21

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

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

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(09:31:36-09:32:28)

1 you greatly enhance the dissolution -- the dissolving
2 into water.

3 Q. Is there a way to verify whether the
4 presence of d-limonene in the residual mixture will
5 increase the concentration of --

6 THE REPORTER: I'm sorry. Is there a way
7 to verify whether the presence of the...

8 Q. BY MS. WALKER: -- d-limonene in the
9 residual mixture will increase the concentration of
10 tar compounds in the water?

11 A. Certainly. All that's needed is a leech
12 test to equilibrate to put in contact the residual
13 with water and monitor the concentration of these
14 kinds of compounds in the water over time.

15 Q. And did you see any such test in the
16 record?

17 A. Not that test. There was a leech test,
18 but it was done with hexane instead of water. And so
19 they took the residual material and they equilibrated
20 with hexane and measured the polycyclic aromatic
21 hydrocarbon compound concentration in the hexane.

22 Now, what they found were extremely high
23 concentrations of the polycyclic aromatic
24 hydrocarbons, which is -- if that were water you'd be
25 alarmed. But it was hexane, and you'd expect that

Page 23

(09:32:42-09:33:46)

1 from hexane, because hexane is acting like d-limonene.
2 It's extracting the tar compounds.

3 And so the apparent conclusion that was
4 drawn is that hexane was the inappropriate solvent to
5 test to represent water, which is correct, but then
6 there was no follow up.

7 Q. Okay. And did you submit further
8 testimony in this case?

9 A. Yes. I submitted a supplemental
10 testimony in response to comments by Mr. Handl.

11 Q. And is that testimony dated March 16th,
12 2012?

13 A. I believe it is. Can I look at your
14 copy?

15 Q. Yeah.

16 A. Would there be an objection?

17 Yes.

18 Q. And in most general terms, what's this
19 report about?

20 A. So this was -- I wrote this in response
21 to Mr. Handl's criticisms of my testimony. What
22 they -- what those criticisms boiled down to was that
23 the d-limonene has no effect on tar compound
24 dissolution into water. And so I wrote a response to
25 demonstrate that that criticism was incorrect and that

Page 24

(09:34:00-09:34:52)

1 in fact d-limonene has a major effect on tar compound
2 dissolving into water.

3 Q. And does this report represent your
4 expert opinion on that subject?

5 A. Yes.

6 Q. And does it still represent your expert
7 opinion on that subject?

8 A. Yes.

9 MS. WALKER: So I'd like to move to enter
10 that as an exhibit, please.

11 MR. HOGLE: No objection.

12 MS. WALKER: And this would be Exhibit 2.
13 (Exhibit 2 was marked for identification.)

14 Q. BY MS. WALKER: So what materials did you
15 review to address that second point? Mr. Handl's
16 testimony.

17 A. Yeah, Mr. Handl's testimony.

18 Q. I didn't mean to answer the question for
19 you. I meant -- okay.

20 And what I meant is what -- it's fine.
21 Okay. So can you briefly summarize
22 Mr. Handl's analysis that you were responding to?

23 A. Yeah. His analysis is that the
24 d-limonene simply dilutes the mixture, okay. The
25 residual organic mixture is comprised of tar compounds

Page 25

(09:35:12-09:36:17)

1 and d-limonene, or in his terminology, bitumen
2 compounds and d-limonene. And his assertion is that
3 that is simply a dilution of the tar compounds, and
4 therefore any tar compounds that would dissolve into
5 water would be lower than their normal water
6 solubility, according to Raul's, which is the equation
7 that he used.

8 Q. Okay. And your response to this analysis
9 was?

10 A. That it's incorrect because it's missing
11 two very important terms when you do a more complete
12 thermodynamic analysis.

13 Q. And can you explain that a little bit
14 more --

15 A. Sure.

16 Q. -- fully?

17 A. If you -- if you -- if you go back to the
18 basic thermodynamics and solve for the change in the,
19 basically the ratio of the concentration of the tar
20 compound in the water, pure water, versus water that
21 has d-limonene as a result of being in contact with
22 this residual, then you can calculate the ratio of
23 those two concentrations, and a value that is -- I
24 don't want to confuse things because I'm changing
25 the -- let me put it this way:

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

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

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

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

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

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

25 Q. So what happens when you correctly

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

1 account for those terms?

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

5 In this case I calculated a factor of
 6 2,000, pretty close to the factor of six -- or
 7 1400-ish that I calculated using a different method.

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

11 A. No, it absolutely does not.

12 Q. And is your analysis more accurate?

13 A. Yes.

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

16 MR. HOGLE: Okay.

17 MS. WALKER: Want to take a break?

18 THE WITNESS: I'm good.

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

22

23 CROSS-EXAMINATION

24 BY MR. HOGLE:

25 Q. You indicated that generally your report

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

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

5 A. Right.

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

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

14 Q. Okay.

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

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

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

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

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

1 by a human or animal?

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

4 Q. Okay.

5 A. -- that has a receptor.

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

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

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

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

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

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

21 Q. "Receptor" is usable amount of water?

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

23 Q. How would you define it?

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

(09:41:27-09:42:12)

1 ingesting or coming into contact with the water.
2 Q. Okay. But the water has to be in a
3 sufficient quantity for the organism to use, true?
4 A. Yes.
5 Q. And if in fact the -- the d-limonene does
6 not increase the solubility of the tar compounds, then
7 your concern is a nonissue?
8 A. If the d-limonene does not increase the
9 solubility of the tar compounds?
10 Q. Right.
11 A. Well, it -- that's a tautology, because
12 there's no "if" there.
13 Q. No.
14 A. The -- the d-limonene will increase the
15 solubility of the tar compounds.
16 Q. You make assumptions in your -- in your
17 work?
18 A. No, there's no assumption there.
19 Q. No. But you do make assumptions in your
20 work, correct?
21 A. Generally?
22 Q. Yes.
23 A. Yes.
24 Q. Okay. So you're capable of making an
25 assumption?

(09:42:20-09:43:07)

1 A. Yes, I am capable of making an
2 assumption.
3 Q. Can you assume for me that the d-limonene
4 does not increase the solubility of the tar compounds
5 in water?
6 A. It would be an incorrect assumption, but
7 for the sake of argument, yes.
8 Q. I'm not trying to make a point here that
9 it does or it doesn't.
10 A. I'm just trying to speak accurately.
11 Q. Thank you. But make that assumption for
12 me, please, would you?
13 A. Okay. For the sake of argument, I will
14 assume that.
15 Q. Now if it -- if it in fact does not
16 increase, the assumption is correct, you have that
17 assumption, then the concern about the inappropriate
18 or excess risk of a -- of a receptor receiving a
19 carcinogen -- carcinogen is a nonissue?
20 A. It's certainly much diminished.
21 Q. Yeah. I mean, your -- your concern
22 relies on d-limonene increasing the solubility of tar
23 compounds in water?
24 A. That's right.
25 Q. Okay. You have Exhibits 1 and 2 in front

(09:43:35-09:44:38)

1 of you, right?
2 A. Uh-huh.
3 Q. Exhibit 1 on Page 3 to Page 4 has a
4 summarization of your initial testimony, right?
5 A. Right.
6 Q. Is that a fair summary?
7 A. Should I review it now?
8 Q. Well it's your summary, so --
9 A. Please let me --
10 Q. -- if you need to.
11 A. -- review it.
12 Q. Sure.
13 A. Well, it's been a while since I looked at
14 this.
15 Q. And just for clarity, my question is: Is
16 this a fair summary of your initial testimony?
17 A. Okay. Yes.
18 Q. Did you review your -- both sets of your
19 testimony in preparation for today?
20 A. I wrote them, so...
21 Q. So the last time you reviewed them was
22 January 20th and March 16th?
23 A. That's right.
24 Q. Okay. Let me have you take a look at
25 Exhibit 2. All right. And then on Page 30 to Page 31

(09:45:08-09:46:19)

1 there's a summary of your supplemental testimony,
2 right?
3 A. Uh-huh.
4 Q. Is that a fair summary of your
5 supplemental testimony?
6 A. I'm just going to take a minute to
7 review. Yes.
8 Q. Okay. Now, in the summary that you gave
9 this morning you indicated that d-limonene will not
10 readily vaporize or will not readily evaporate under
11 air or transport the air, right?
12 A. That's right.
13 Q. Okay. And you gave that this morning in
14 the summary of your testimony.
15 A. (Witness nods head.)
16 Q. You have to answer audibly yes or no for
17 her benefit.
18 A. Sure.
19 Q. And that's an important part of your
20 testimony, is it not?
21 A. It's an important part -- what's the
22 important part is that d-limonene in the residual
23 mixture will not -- well, their claim, U.S. Oil Sands'
24 claim, that it will readily vaporize, is not
25 supported. And I bring up in my testimony one reason

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

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

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

1 itself will likely
 2 vaporize/volatilize readily to the
 3 atmosphere."
 4 That was your testimony, was it not?
 5 A. That was my testimony, but that statement
 6 comes out of the NOI. That's U.S. Oil Sands'
 7 statement.
 8 Q. You don't reference NOI -- the NOI in
 9 that statement?
 10 A. No, that's true. That's a mistake on my
 11 part, but that's where it comes from.
 12 Q. But I -- I read the complete answer to
 13 the question on Line 8, Page 4, did I not?
 14 A. Yes.
 15 Q. And that was your testimony?
 16 A. Yes. But --
 17 Q. And your testimony was under oath, was it
 18 not?
 19 A. Well, I don't know. Was it under oath?
 20 MS. WALKER: Yes.
 21 THE WITNESS: Okay. So, yes, it was.
 22 Q. BY MR. HOGLE: You don't know. Okay.
 23 A. But my point is that I -- I was not
 24 focussing on d-limonene in this testimony. I was
 25 focussing on the effect of d-limonene on tar

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

1 compounds. And so to me I did not emphasize the
 2 properties of d-limonene itself. That was not the
 3 issue I was addressing.
 4 Now on further, you know, understanding
 5 of the properties of d-limonene, I've realize that in
 6 fact d-limonene itself does not readily vaporize.
 7 Q. You said in your answer on Page 4,
 8 Line 9, you said your answer is based on the
 9 properties listed in Appendix B, correct?
 10 A. Yes, properties.
 11 Q. You wrote that.
 12 And Appendix B is on Page 31 of
 13 Exhibit 1, correct?
 14 A. Yes.
 15 Q. Okay. And these properties of
 16 d-limonene, there's no reference to the NOI, is there?
 17 A. No. And so again --
 18 Q. In fact your references are References 1,
 19 2, and 3, which are listed on Page 34, correct?
 20 A. Page 34. Yes.
 21 Q. Okay. Reference Number 1 is to what?
 22 A. Reference Number 1 is to a USEPA
 23 document.
 24 Q. Okay. Reference Number 2?
 25 A. Is to a Chemical Safety document.

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

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

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

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

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

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

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

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

1 seems to state.

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

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

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

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

13 A. I did not say that in my testimony.

14 Q. Okay. How about in your March testimony?

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

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

21 A. That's right.

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

24 A. Yes, the edition I used was 1993.

25 Q. Okay. And you consider that to be

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

1 authoritative in this area?

2 A. Uh-huh, yes.

3 Q. The title of it is Environmental Organic
4 Chemistry?

5 A. That's right.

6 Q. And do you teach using that?

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

8 Q. Which edition do you use when you teach?

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

12 Q. Okay. Is it 2003?

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

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

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

20 Q. Okay. And how long is that?

21 A. How long?

22 Q. Yeah.

23 A. How long is the book?

24 Q. Yeah, easy question.

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

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

1 going to look, and it's 680 pages.

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

5 A. No, but I could easily do so.

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

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

10 A. That's true.

11 Q. Okay.

12 A. Quite true.

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

16 A. Sure.

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

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

22 Do you see that question?

23 A. Sure.

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

<p style="text-align: right;">Page 42</p> <p>(09:56:51-09:58:07)</p> <p>1 bottom of Page 7. You see that?</p> <p>2 A. That's right.</p> <p>3 Q. And there's no reference to any</p> <p>4 literature, correct?</p> <p>5 A. Well, it references Appendix B.</p> <p>6 Q. Appendix B isn't literature. Appendix B</p> <p>7 is the properties of d-limonene, right?</p> <p>8 A. Well, that's -- let me check here,</p> <p>9 because I'm just looking at this quickly.</p> <p>10 The statement -- okay. So first of all,</p> <p>11 several statements are made. So which statement are</p> <p>12 you concerned about not being referenced?</p> <p>13 Q. I don't see any reference to a textbook</p> <p>14 or any published literature in your answer that starts</p> <p>15 at the bottom of Page 6 to Page 7, is there?</p> <p>16 A. Okay. Well, yeah, there is. So</p> <p>17 benzo(a)pyrene is shown there and it says from</p> <p>18 Reference 5. Now, let me check that I didn't identify</p> <p>19 the wrong reference. I don't think I did.</p> <p>20 Q. That's the Schwarzenbach, right?</p> <p>21 A. Yes.</p> <p>22 Q. Can you identify in the Schwarzenbach</p> <p>23 book where that is?</p> <p>24 A. Sure. The appendix of this text has</p> <p>25 properties of all these different compounds, okay. So</p>	<p style="text-align: right;">Page 44</p> <p>(10:00:13-10:02:02)</p> <p>1 A. Yes.</p> <p>2 Q. And that's the -- you use an updated</p> <p>3 edition for your classroom work?</p> <p>4 A. Only because they can obtain that updated</p> <p>5 edition much more readily than this previous edition.</p> <p>6 Q. Is there anything wrong about the updated</p> <p>7 edition, I mean --</p> <p>8 A. Yeah, it's massive.</p> <p>9 Q. Other than that?</p> <p>10 A. It's about two times thicker than this</p> <p>11 one, and I thought you'd have an easier time getting</p> <p>12 through this one.</p> <p>13 Q. I think it's sixes, from my perspective.</p> <p>14 But -- but it's not -- would you -- it's</p> <p>15 bigger, so would it have a more extensive discussion?</p> <p>16 A. Not in this subject. It goes into much</p> <p>17 greater detail on different organic compound reactions</p> <p>18 that aren't relevant here.</p> <p>19 Q. Okay. All right. Could you -- hold on a</p> <p>20 second.</p> <p>21 I'm handing you copies of excerpts from</p> <p>22 the Environmental Organic Chemistry textbook that you</p> <p>23 just identified. And could you verify that those are</p> <p>24 true and correct copies of Pages 90 through --</p> <p>25 A. 98?</p>
<p style="text-align: right;">Page 43</p> <p>(09:58:35-10:00:03)</p> <p>1 there's the appendix in benzo(a)pyrene.</p> <p>2 Q. What page is that, please?</p> <p>3 A. Sorry?</p> <p>4 Q. What page is that, please?</p> <p>5 A. Page 621.</p> <p>6 Q. Okay. And that is -- has the properties</p> <p>7 of benzo(a)pyrene. It doesn't have any equations</p> <p>8 there, does it, on that page?</p> <p>9 A. Not on the appendix, no.</p> <p>10 Q. Now, Page 7 we just -- you just indicated</p> <p>11 of your initial testimony, Exhibit 1, has a reference</p> <p>12 to Exhibit B. So you rely on -- not Exhibit B,</p> <p>13 Appendix B.</p> <p>14 You rely on Appendix B throughout your</p> <p>15 testimony, do you not?</p> <p>16 A. In a minor way.</p> <p>17 Q. Okay. But now you're saying that the</p> <p>18 properties of d-limonene as set forth in Appendix B</p> <p>19 you've come to -- come to question?</p> <p>20 A. No. No. These are correct. But the</p> <p>21 statement that it readily vaporizes is a subjective</p> <p>22 statement that is not reflected in this appendix.</p> <p>23 Q. All right. Now you mentioned that</p> <p>24 there's an updated edition of the Schwarzenbach</p> <p>25 publication, right?</p>	<p style="text-align: right;">Page 45</p> <p>(10:02:13-10:03:15)</p> <p>1 Q. 93. Looks like I don't have them all.</p> <p>2 A. It's 98, but yes.</p> <p>3 Q. Okay.</p> <p>4 MS. WALKER: Excuse me, do you want to</p> <p>5 check with the book?</p> <p>6 I'm sorry, Chris, are you saying that</p> <p>7 these are pages from the book he has.</p> <p>8 THE WITNESS: And they are. I recognize</p> <p>9 them.</p> <p>10 MS. WALKER: You recognize them, okay.</p> <p>11 Thank you.</p> <p>12 Q. BY MR. HOGLE: All right. So on Page 97,</p> <p>13 there's an excerpt here kind of in the middle of this</p> <p>14 bottom paragraph. It says:</p> <p>15 "Finally, if the organic chemicals</p> <p>16 are present at low enough levels --"</p> <p>17 Let me know if you're with me --</p> <p>18 A. I'm with you.</p> <p>19 Q. -- before I continue on. It says:</p> <p>20 "Finally, if the organic chemicals</p> <p>21 are present at low enough levels</p> <p>22 (less than ten to the negative three</p> <p>23 volume fraction) that there is a low</p> <p>24 probability of even their hydration</p> <p>25 shells overlapping, we can expect no</p>

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(10:03:26-10:04:36)

1 effect on the aqueous activity
2 coefficients or (liquid)
3 solubilities."
4 Do you see that?
5 A. Yes.
6 Q. All right. And then on the next page,
7 98, it says at the top:
8 "For the purposes of predicting
9 organic chemical fates in the
10 environment, we are primary
11 interested in cases where cosolvents
12 are present in relatively large
13 proportions (more than 10% by
14 volume)."
15 Do you see that?
16 A. Yes.
17 Q. Okay. Now, in the water, tar, d-limonene
18 mixture, the d-limonene cosolvent is less than ten
19 percent by volume, true?
20 A. Oh, I don't believe that's true.
21 Q. Okay. Could you go to your Appendix B in
22 Exhibit 1. Okay. You see the top there, it says,
23 "Properties of d-limonene," and then on Line 3,
24 "solubility and water equals 13.8 milligrams per
25 liter"?

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(10:04:43-10:06:02)

1 A. Yes.
2 Q. Okay. So doesn't that indicate that
3 it's -- it would be less than ten percent by volume in
4 the mixture?
5 A. You asked me what the volume fraction of
6 d-limonene would be in the mixture. That's the
7 organic mixture. And this is a solubility in water,
8 which is the raffinate, which is not the organic
9 mixture.
10 So the two don't -- there's no -- there's
11 no relevance of this solubility to the volume fraction
12 of the d-limonene in the organic mixture. So I'm
13 confused by your question.
14 Q. Go to Page 9 of your initial testimony.
15 So on Page 9 you're utilizing a calculation that
16 relies on the 13.8 milligrams per liter of d-limonene
17 in the solubility of water, right?
18 A. Oh, that's correct. Yeah, but that's not
19 the question you asked me.
20 Q. What is the concentration of d-limonene
21 in water?
22 A. 13 milligram -- 13.8 milligrams per liter
23 is the value that I was able to find.
24 Q. And what did you conclude would be the
25 concentration of d-limonene in the d-limonene water

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(10:06:19-10:07:12)

1 tar compound mixture?
2 A. Well, I didn't calculate the actual --
3 actually I did. I calculated 2.2 milligrams of
4 benzo(a)pyrene is a representative compound. Sorry,
5 ask the question again, I'm not sure if I heard it
6 correctly.
7 Q. What -- what did you calculate the
8 concentration of d-limonene to be in the tar compound,
9 water, d-limonene mixture?
10 A. Oh, okay. I didn't calculate the
11 concentration of d-limonene. I used the 13.8
12 milligrams per liter water that I was able to find.
13 Q. Okay. And that's less than ten percent
14 by volume of the mixture?
15 A. In water you're saying?
16 Q. In the mixture.
17 A. Well, okay. We have to make sure what
18 we're talking about.
19 When I refer to "mixture," I'm referring
20 to the organic compound mixture. And when we're
21 talking about the water, we're talking about what
22 Handl -- Mr. Handl calls the raffinate. And so are
23 you asking about the organic mixture or the raffinate?
24 Q. I'm talking about the d-limonene, tar
25 compound, water mixture. And you refer to that as the

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(10:07:27-10:08:20)

1 organic mixture, right? So we're talking using the
2 same terms?
3 A. We need to be more precise, because they
4 don't mix. The water largely stays -- there is some
5 minor amount of water in the organic mixture, but it
6 largely stays separate. And likewise the amount of
7 d-limonene and organic -- or tar compound in the
8 organic mixture, largely it all stays there. Some
9 d-limonene and some tar compound ends up in the water,
10 okay, but the two phases are largely separate.
11 So the reason I'm -- I'm trying to
12 understand your question is, I'm not sure which phase
13 you're asking about the volume for -- which phase
14 you're asking about; whether you're asking me about
15 the d-limonene in the organic mixture, or the
16 d-limonene in the water.
17 Q. I'm talking about the d-limonene in
18 the -- in the -- in post process, the post tar sands
19 extraction process --
20 A. Yeah.
21 Q. -- whatever that is.
22 A. Okay.
23 Q. All right. That's what we're concerned
24 about, right?
25 A. Sure.

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

1 Q. All right. So in that phase, whatever

2 that phase is, what is the concentration of d-limonene

3 in that mixture?

4 A. In the overall mixture of the d-limonene,

5 tar compound and water that comes into contact with

6 it, the d-limonene is by far the dominant component.

7 Q. What is -- what is the concentration?

8 A. I don't know. They haven't given that to

9 us.

10 Q. What did you assume it to be for purposes

11 of your calculation?

12 A. It's not involved in my calculation.

13 Q. Okay. You didn't consider that in your

14 calculations?

15 A. It's -- it's not relevant. It's the --

16 what we're focussing on is what's the concentration of

17 these things in the raffinate in the water.

18 Q. But you would agree, wouldn't you, that

19 the d-limonene would have to be present in relatively

20 large proportions in order for it to act as a solvent?

21 A. No. No, this statement in Schwarzenbach,

22 Gschwend, and Imboden is a generalization, okay. When

23 they say for the purposes of predicting organic

24 chemical phase in the environment, they're primarily

25 interested in cosolvents. Well, that's true when

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

1 you're considering hazardous waste clean up, okay.

2 And the issue of clean up of organic

3 solvents that are in the subsurface, their transport,

4 when there is another cosolvent present, is affected

5 not by the few orders of magnitude -- you know, three

6 orders of magnitude that I calculated, but by much

7 greater amounts, okay. That's what they're referring

8 to here. They're talking about massive changes.

9 Q. So you're saying in this context the

10 concentration of d-limonene can be less than ten

11 percent by volume?

12 A. Well, I haven't actually calculated that.

13 Have you calculated that?

14 Q. Of course not.

15 A. Okay. Well, you're doing a good job, so

16 I -- I'm not sure.

17 Q. Well, I'm not asking you if you've

18 calculated it. I'm asking you, in your opinion, what

19 you're saying is is that the presence of d-limonene in

20 the mixture can be less than ten percent by volume and

21 still create the increased solubilities that you're

22 talking about?

23 A. Yes. Absolutely.

24 Q. How much less?

25 A. How much less of what?

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

1 Q. Ten percent. How much less than ten

2 percent? What does it have to do --

3 A. Well, as stated in the text, there can be

4 cosolute effects, far below the ten percent, okay.

5 Q. But my -- my --

6 A. And remember that these -- these ten

7 percents, one percents, obviously those are round

8 numbers because this is a generalization of a process,

9 okay. The organic compound is referred to as being

10 hydrophobic because it's not compatible with the

11 structure of water.

12 And as stated in this text, you've done a

13 good job identifying the relevant material. As stated

14 in the text, the water has to form hydration cavities

15 to accommodate these hydrophobic compounds. And so

16 what is being discussed here is this generalization

17 that you need something on the order of ten percent

18 for a cosolvent effect to occur, where their hydration

19 shells overlap and the water has an energetic

20 advantage to pushing these molecules together,

21 basically, a so-called cosolvent effect.

22 But these are very rough numbers.

23 Q. Is the cosolvent effect the same as

24 aqueous solubility?

25 A. No.

Page 53

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

1 Q. How is it different?

2 A. Because when you're talking about a

3 cosolvent, you're add -- you're talking about addition

4 of a compound to the water in large amounts, okay,

5 like an alcohol to the water, in order to -- which

6 ends up solubilizing compounds that wouldn't normally

7 dissolve in the water.

8 So physically it's the same process we're

9 talking about, but at ten percent, you know, by volume

10 you're talking about huge additions, okay. You're

11 talking about the kinds of things you'd see in a

12 hazardous waste site where multiple compounds had been

13 dumped, okay.

14 Q. All right. Now you said -- we've been

15 going for a while. Can we take a break?

16 THE VIDEOGRAPHER: We're going off the

17 record, the time is 10:14.

18 (There was a break taken.)

19 THE VIDEOGRAPHER: We're going back on

20 the record, the time is 10:50.

21 Q. BY MR. HOGLE: Okay. We took a break.

22 Back on the record now. Dr. Johnson, to try to clean

23 up this a little bit. The point of your calculations

24 is to estimate the cosolvent effect of d-limonene to

25 increase the solubility of the tar compounds, right?

Page 54

(10:49:43-10:50:54)

1 A. Cosolvent effect?

2 Q. Yes.

3 A. No.

4 Q. But you do opine in your testimony that

5 the presence of d-limonene increases by a factor of

6 over 1440 the concentration of BAP, right?

7 A. Yeah, I calculated a factor of 1440.

8 Q. Okay. And it's the d-limonene that

9 causes that -- that increased concentration of BAP,

10 right?

11 A. Yes.

12 Q. And you would agree with me, wouldn't

13 you, that the most -- the maximum amount of d-limonene

14 that can exist in water is 13.8 milligrams per liter?

15 A. That is the solubility that I found, I

16 can't even remember the source, but it's in the

17 testimony, but yes. But that -- I wouldn't call that

18 the maximum amount, but that is the normal water

19 solubility of d-limonene.

20 Q. Okay. At room temperature?

21 A. Yes, I believe it was room temperature.

22 Q. Okay. And you would agree with me,

23 wouldn't you, that 13.8 milligrams per liter is less

24 than ten percent by concentration, by volume?

25 A. By volume. I would agree with you that

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(10:51:11-10:52:23)

1 13.8 milligrams per liter is less than ten percent by

2 volume.

3 But I need to clarify that the ten

4 percent is irrelevant, because I'm not speaking to a

5 cosolvent effect.

6 MR. HOGLE: Okay. Move to strike

7 everything following the answer that I got.

8 Could we mark the excerpt of the

9 Schwarzenbach textbook at Exhibit 3, please. And I

10 move for the admission of Exhibit 3.

11 MR. McCONKIE: No objection.

12 MS. WALKER: No objection.

13 (Exhibit 3 was marked for identification.)

14 Q. BY MR. HOGLE: Dr. Johnson, I'm handing

15 you a document that's entitled Environmental Research

16 Brief Solubility, Sorption and Transport of

17 Hydrophobic Organic Chemicals in Complex Mixtures. Do

18 you see that?

19 A. Yes.

20 Q. Is this the type of publication that you

21 rely on?

22 A. It's the type, but this concerns

23 cosolvent effects, and that is not what I'm addressing

24 in my testimony.

25 Q. Okay. But this is the type of -- of

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(10:52:37-10:53:42)

1 publication that you rely on in the course of your --

2 of your -- of your work, your profession?

3 A. This is one of a million.

4 Q. Okay. And you rely on publications like

5 these in your -- in your regular work, right?

6 A. Sure. Yeah.

7 Q. Could you go to Page 11, please. All

8 right, and I'm going to read from -- well, before I

9 get there, I'd like to mark this as Exhibit 4 and move

10 for its admission.

11 MS. WALKER: Do you have a copy?

12 MR. HOGLE: Oh, I'm sorry.

13 (Exhibit 4 was marked for identification.)

14 MS. WALKER: Thank you. Say the page

15 again.

16 MR. HOGLE: 11. But I guess I would mark

17 that Exhibit 4 and move for its admission, if there's

18 any objection.

19 MR. McCONKIE: No objection.

20 MR. HOGLE: Unless there's an objection.

21 MR. DUBUC: No objection.

22 Q. BY MR. HOGLE: All right. If we go to

23 Page 11, just under the graph there's a sentence.

24 Tell me when you're there.

25 A. I'm there.

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(10:53:54-10:55:10)

1 Q. Okay. There's a sentence that says:

2 "Our data and model calculations

3 suggest that solubility enhancement

4 for most organic contaminants is

5 likely to be small (less than 20%

6 Increase) as long as cosolvent

7 concentrations in pore water are less

8 than 2% by volume (or about 20,000

9 milligrams per liter)."

10 Do you see that?

11 A. Yes, I do see that statement.

12 Q. Okay. And it's true, isn't it, that the

13 d-limonene in a water solution would be less than two

14 percent by volume?

15 A. Yes, that's true. But this document

16 concerns very different compounds than the polycyclic

17 aromatic hydrocarbons that I was examining. And so

18 this generalization is for compounds that are much

19 more soluble in water.

20 MR. HOGLE: Okay. Move to strike

21 everything after "Yes, that's true."

22 Q. All right. Switching gears a little bit

23 here. What you did -- if you look at Page 7 of

24 Exhibit 1, your initial testimony.

25 A. Uh-huh.

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

1 Q. -- is you purport to derive the
2 hypothetical liquid solubility of BAP based on the
3 solid solubility; is that right?
4 A. No. I have data for solid and liquid
5 solubilities.
6 Q. Where's the --
7 A. Page 7.
8 Q. What's the data for the liquid
9 solubility?
10 A. What's the value?
11 Q. The data. You said you had data for the
12 solid and liquid, and I'm asking you about the data
13 for the liquid.
14 Okay. Where did you get that from?
15 A. These are from Schwarzenbach.
16 Q. Okay. Could you point me to where the
17 49.19 figure is from Schwarzenbach?
18 A. And it could be that I -- I used the
19 ratio of the vapor pressures to get these
20 solubilities. If they had one of them then I could
21 get the other one, and I don't recall off the top of
22 my head, but one of them would be in here.
23 So liquid solubility of the liquid is
24 given here.
25 Q. And what's the number given?

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

1 A. It's a log value and so it's 6.71.
2 Q. 6.71 what? Micrograms per liter?
3 A. That is moles per liter.
4 Q. Can I see that, because I -- I only have
5 one.
6 A. This?
7 Q. Yeah. So you're -- you looked at
8 Page 6 -- which page did you look at? 621 or 620?
9 A. I can't even see it from here, sorry.
10 621.
11 Q. 621. Okay. All right. I see the
12 benzo(a)pyrene, and under the -- what -- yeah, could
13 you interpret for me what column that's under?
14 A. That's under one, two, three, four, five,
15 six, seven, the eighth column from the left.
16 Q. And what is the label for that?
17 A. That is the negative log of the
18 solubility of the pure compound in water.
19 Q. And how did you --
20 A. As a liquid.
21 Q. Okay. And that's expressed in moles per
22 liter?
23 A. Yes.
24 Q. So how did you go about converting that
25 to micrograms per liter?

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

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

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

1 project down to room temperature to understand what
2 the solubility would be at room temperature.
3 Q. Okay.
4 A. But that's -- that's well established
5 thermodynamic --
6 Q. All right.
7 A. -- experimentally.
8 Q. So in order for a solid like the tar
9 compounds, right, naturally they're in a solid state,
10 as you've indicated. In order for those to be a
11 liquid they'd have to be super heated, right?
12 A. They are liquid -- it would be a
13 sub-cooled liquid at room temperature.
14 Q. It would be heated and then sub-cooled?
15 A. No. The term that's used to describe a
16 compound acting as a liquid, okay, but at a
17 temperature at which it would normally be a solid, is
18 called a sub-cooled liquid.
19 Q. Sub-cooled to what?
20 A. Sub-cooled below its melting temperature.
21 Q. Okay. And does that -- does that exist
22 in reality?
23 A. Yeah, the melting temperature exists in
24 reality --
25 Q. Well, sure.

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(11:00:54-11:02:40)

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

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(11:02:58-11:04:00)

1 But the equation that I provide is a
2 simple algebraic combination of different partition
3 coefficients in order to get the enhanced solubility
4 of the compound in the water. And it's well
5 substantiated in my own publication, publications by
6 Keri Chiou who is referenced in the excerpt here, and
7 other experts in organic compound solvent
8 partitioning.
9 Q. Is it in the Schwarzenbach book?
10 A. Is what in it?
11 Q. Does the Schwarzenbach book support your
12 algebraic equations?
13 A. It -- it does in the form of providing a
14 partition coefficient, and then the rest is just
15 simple algebra.
16 Q. Okay. That's on Page 125, Equation 7-1?
17 A. Yeah, that's a -- that's an example of
18 partition coefficient.
19 Q. Okay. Let me ask you about this one.
20 I'm handing you another textbook, and ask you if you
21 can identify that?
22 A. Sure. This is the newer edition -- one
23 of the newer editions of this textbook (indicating).
24 Q. Okay. And just --
25 A. 1993.

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(11:04:10-11:05:08)

1 Q. -- for the record could you give the
2 author and title of that?
3 A. The same set of authors, Rene
4 Schwarzenbach, Phil Gschwend, and Dieter Imboden.
5 Q. Okay. And it's called Environmental
6 Organic Chemistry; is that right?
7 A. That's right.
8 Q. All right. It's the second edition?
9 A. Yes.
10 Q. And it's 2003?
11 A. Sure.
12 Q. Is this the textbook that you teach from?
13 A. This one I do use in my class.
14 Q. Okay.
15 A. Or I should say the students buy this
16 one. I mostly actually teach out of the old one
17 because it's just much more straightforward.
18 Q. Okay. But you -- you have your students
19 buy the 2003 edition?
20 A. Because this is not -- the old one's not
21 available. As available.
22 Q. All right. Did you utilize the 2003
23 edition at all in your work for this case?
24 A. I may have, because I have both copies on
25 my shelves, yeah.

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(11:05:26-11:07:20)

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

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

1 MS. WALKER: Okay. No objection.
 2 MR. HOGLE: All right.
 3 MS. WALKER: I'm sorry, just one more
 4 question. And it's the entirety of the -- of those
 5 chapters?
 6 MR. HOGLE: I tried for it to be, yes.
 7 Yeah.
 8 Q. All right. Could you turn to Page 138,
 9 please, of exhibit -- what number did we say it was?
 10 THE REPORTER: Five.
 11 MR. HOGLE: Exhibit 5.
 12 THE WITNESS: 138?
 13 MR. HOGLE: 138.
 14 THE WITNESS: Okay.
 15 Q. BY MR. HOGLE: Now, could the -- could
 16 you utilize the methods set forth on Pages 148 and to
 17 the top of the next page to develop the extent to
 18 which d-limonene in the water would enhance the
 19 solubility of the tar compounds?
 20 A. Are you asking did I utilize this type of
 21 material?
 22 Q. Could you. Could one?
 23 A. Well, I did and could.
 24 Q. Oh, you -- this is what you did do?
 25 A. This is -- this is -- this process of

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

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

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

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

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

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

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(11:13:05-11:14:16)

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

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(11:14:37-11:15:48)

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

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(11:16:24-11:18:01)

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

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(11:18:25-11:19:30)

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

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(11:31:23-11:33:01)

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

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(11:33:15-11:34:04)

1 d-limonene is expected to rapidly
 2 volatilize from water to the
 3 atmosphere, with an estimated
 4 half-life for volatilization from a
 5 model river of 3.4 hr" -- that's
 6 hour, right? Hours?
 7 A. Yes.
 8 Q. -- "although adsorption to sediment
 9 and suspended organic matter may
 10 attenuate the rate of this process."
 11 Did I read that correctly?
 12 A. That's right.
 13 Q. All right. And then further down the
 14 page on 17 under Section IX, the second paragraph
 15 reads:
 16 "Given the physical/chemical
 17 properties of d-limonene, it is
 18 unlikely that d-limonene will occur
 19 in drinking water sources."
 20 Do you see that?
 21 A. Yes, but they're clearly referring to
 22 surface water drinking water sources.
 23 Q. Okay. And then go to Page 18. Under
 24 Section X, Risk Characterization. The third sentence
 25 says:

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(11:34:17-11:35:41)

1 "d-limonene is expected to rapidly
 2 volatilize from dry soil, wet soil
 3 and water, therefore exposure through
 4 the drinking water routes is
 5 considered very unlikely."
 6 Did I read that correctly?
 7 A. Yeah. It's interesting because it's in
 8 contradiction of the statement that absorptions of the
 9 sediment will attenuate the rate of volatilization.
 10 MR. HOGLE: No further questions.
 11
 12 CROSS-EXAMINATION
 13 BY MR. McCONKIE:
 14 Q. Dr. Johnson, my name's Paul McConkie, and
 15 I am here on behalf of the executive secretary, and I
 16 just have a few -- a few follow-up questions.
 17 Now, you testified that you're not
 18 speaking as to the likelihood of contact with surface
 19 water or groundwater of this mixture?
 20 A. That's right.
 21 Q. So you've not evaluated the hydrogeology
 22 of the particular site for that?
 23 A. That's right, I have not.
 24 Q. If I could refer you to Exhibit 2 on Page
 25 20 of your supplemental testimony. On Lines 15

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(11:36:17-11:37:45)

1 through 20 you do some calculations with regard to the
 2 retardation factors. Do you see that on Page 20?
 3 A. That would be in the initial testimony.
 4 MR. HERBERT: Oh, yeah, he's correct,
 5 it's in the initial testimony, Page 11.
 6 MR. McCONKIE: Oh, okay. Sorry. Initial
 7 testimony, Page 11.
 8 Q. Is it true that you used a value of 35
 9 percent for moisture content in the equation for
 10 calculating retardation factor?
 11 A. Yes, that's correct. That's a
 12 saturated -- I assumed it was a saturated system.
 13 Q. Okay. And that was my next question. So
 14 that would represent -- that would represent a
 15 saturated condition?
 16 A. Yes, roughly, right. It's a
 17 hypothetical, but yes.
 18 Q. Right.
 19 Do you -- do you know what best
 20 management practices are?
 21 A. I know the term.
 22 Q. Have you -- have you assessed any of the
 23 best management practices that are going to be
 24 employed out of this -- in this project?
 25 A. I was not asked to do that.

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(11:38:07-11:39:28)

1 MR. McCONKIE: Okay. I think that's all
2 the questions I have. Thank you.
3 MR. DUBUC: Redirect?
4
5 REDIRECT EXAMINATION
6 BY MS. WALKER:
7 Q. Okay. Dr. Johnson, I'm going to just ask
8 you a few follow-up questions, if I may.
9 There was some discussion earlier on on
10 this issue of vapor pressure and your statement in
11 your initial testimony on page -- and I've forgotten
12 the page, sorry.
13 A. Page 4.
14 Q. Page 4, right. Okay. If you would just
15 explain sort of the difference between your approach
16 towards vapor pressure in your first testimony and
17 your second -- your supplemental testimony.
18 A. In the first testimony I wasn't focussing
19 on the properties of d-limonene itself, its own
20 transport. I was focussed on the effect of d-limonene
21 on the transport of the tar compounds.
22 And so I wasn't really focussing on vapor
23 pressure of d-limonene. And so I basically started
24 with the argument being made by U.S. Oil Sands that
25 d-limonene by itself would readily vaporize.

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(11:39:45-11:41:00)

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

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(11:41:13-11:41:57)

1 Reference 5 or something like that?
2 A. I've lost track.
3 Q. Yeah, me too.
4 A. So are you asking about this recent --
5 Q. Right. Where in your testimony did you
6 refer to this?
7 A. Oh, on that same -- same Page 4.
8 Q. Okay. Same Page 4?
9 A. Referring to the properties of
10 d-limonene.
11 Q. Okay. And so the -- the numbers for
12 vapor pressure and vapor density you got out of this
13 document; is that right?
14 A. That's right.
15 Q. Okay. And then I'm just wondering
16 when -- when Chris was reading the statements out of
17 this document, was he referring to d-limonene on its
18 own or -- or I'm sorry, not was Chris referring to
19 d-limonene, but was the document referring to
20 d-limonene on its own or in the presence of tar
21 compounds?
22 A. Was the -- are you referring to the NOI?
23 Q. No. I'm sorry.
24 So recently Chris was reading sections
25 from this document just --

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(11:42:08-11:43:17)

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

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

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

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

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

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

1 that generalization probably doesn't hold for these
 2 much more hydrophobic compounds that we're looking at
 3 in tar.
 4 MS. WALKER: Okay. So I'm close to the
 5 end but I just want to confer for a second to make
 6 sure we've covered everything.
 7 MR. HOGLE: Okay.
 8 MS. WALKER: So we would go off the
 9 record.
 10 THE VIDEOGRAPHER: We're going off the
 11 record, the time is 11:48.
 12 (There was a break taken.)
 13 THE VIDEOGRAPHER: We're going back on
 14 the record, the time is 11:50.
 15 MS. WALKER: Okay. I have no further
 16 questions at this time.
 17 MR. HOGLE: All right. Just a few
 18 follow-ups, Dr. Johnson, to what you just said.
 19
 20 RE CROSS EXAMINATION
 21 BY MR. HOGLE:
 22 Q. One of the things that you said was in
 23 your initial testimony in Exhibit 1, the answer that
 24 you gave on Page 4 regarding d-limonene by itself will
 25 likely vaporize/volatilize readily. And then you

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(11:49:51-11:51:11)

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

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

1 "Adsorption to sediment and suspended
2 organic matter may attenuate the
3 rate" -- "may attenuate the rate of
4 this process."
5 A. Yeah, so it would decrease the rate of
6 the process.
7 Q. Okay. That's --
8 A. And -- and they're talking in a river
9 context. When you're in a process sand, the water to
10 soil ratio is much, much lower. You got a lot more
11 sediment relative to water in the process sands than
12 you do in a river setting.
13 Q. You relied on this in a groundwater
14 context, right?
15 A. I relied on this simply for the
16 solubility of d-limonene. There's no context.
17 Q. Okay. Now, you also said -- well, before
18 I do that, could you go to the exhibit -- the exhibit
19 for the 1993 edition of the Schwarzenbach -- yeah,
20 what number is that?
21 A. Number 3.
22 Q. Yeah, Number 3.
23 A. Three.
24 Q. Go to Number 3.
25 You said in responses to questioning that

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

1 you -- you're not considering the cosolvent effects,
2 you're considering the cosolute effects, right?
3 A. That's right.
4 Q. Could you go to Page 97 of Exhibit 3.
5 Now that deals with cosolutes, right?
6 A. Yes. Cosolutes, yes.
7 Q. Cosolutes, all right.
8 And then it says in that paragraph,
9 quote:
10 "Finally, if the organic chemicals
11 are present at low enough levels
12 (less than ten to negative three
13 volume fraction) that there is a low
14 probability of even their hydration
15 shells overlapping, we can expect no
16 effect on the aqueous activity
17 coefficients or (liquid)
18 solubilities."
19 Right? It says that.
20 A. It says that, and that's a very large
21 generalization, because they're talking about
22 compounds that have a very large range in
23 hydrophobicity.
24 I can tell you I've done experiments with
25 polycyclic aromatic hydrocarbons and an agent that is

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

1 analogous to d-limonene, natural organic matter, a
2 humic acid, and seeing large increases in solubility
3 in response to concentrations in this range, okay.
4 Tens of milligrams per liter.
5 MR. HOGLE: No further questions.
6 MR. McCONKIE: I have no questions.
7 MS. WALKER: Do you want to say anything
8 else?
9 THE WITNESS: I don't think so.
10 MS. WALKER: Okay. No further questions.
11 Thank you.
12 THE VIDEOGRAPHER: We are going off the
13 record, the time is 11:55.
14 (The deposition was concluded at 11:54 a.m.)
15 * * *
16
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Deponent's Certificate

1
2
3 I, WILLIAM JOHNSON, Ph.D., deponent
4 herein, do hereby certify and declare the within and
5 foregoing transcription to be my deposition in said
6 action taken on April 20, 2012; that I have read,
7 corrected, and do hereby affix my signature to said
8 deposition.
9
10 DATED this ____ day of
11 _____, 2012.
12
13 _____
14 Deponent
15 STATE OF UTAH } ss.
16
17 SUBSCRIBED AND SWORN to before me this
18 ____ day of _____, 2012.
19
20 _____
21 Notary Public residing in
22 _____
23 My Commission Expires: _____
24 _____
25

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3 County of Salt Lake)

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

7 THAT the foregoing proceedings were taken
8 before me at the time and place set forth herein; that
9 the witness was duly sworn to tell the truth, the
10 whole truth, and nothing but the truth; and that the
11 proceedings were taken down by me in shorthand and
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13 direction and supervision;

14 THAT the foregoing pages contain a true
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16 so taken.

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

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20 Vickie Larsen, CSR/RPR

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I, WILLIAM JOHNSON, Ph.D., deponent
herein, do hereby certify and declare the within and
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action taken on April 20, 2012; that I have read,
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_____, 2012.

Deponent

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) ss.
)

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

Vickie Larsen
Vickie Larsen, CSR/RPR

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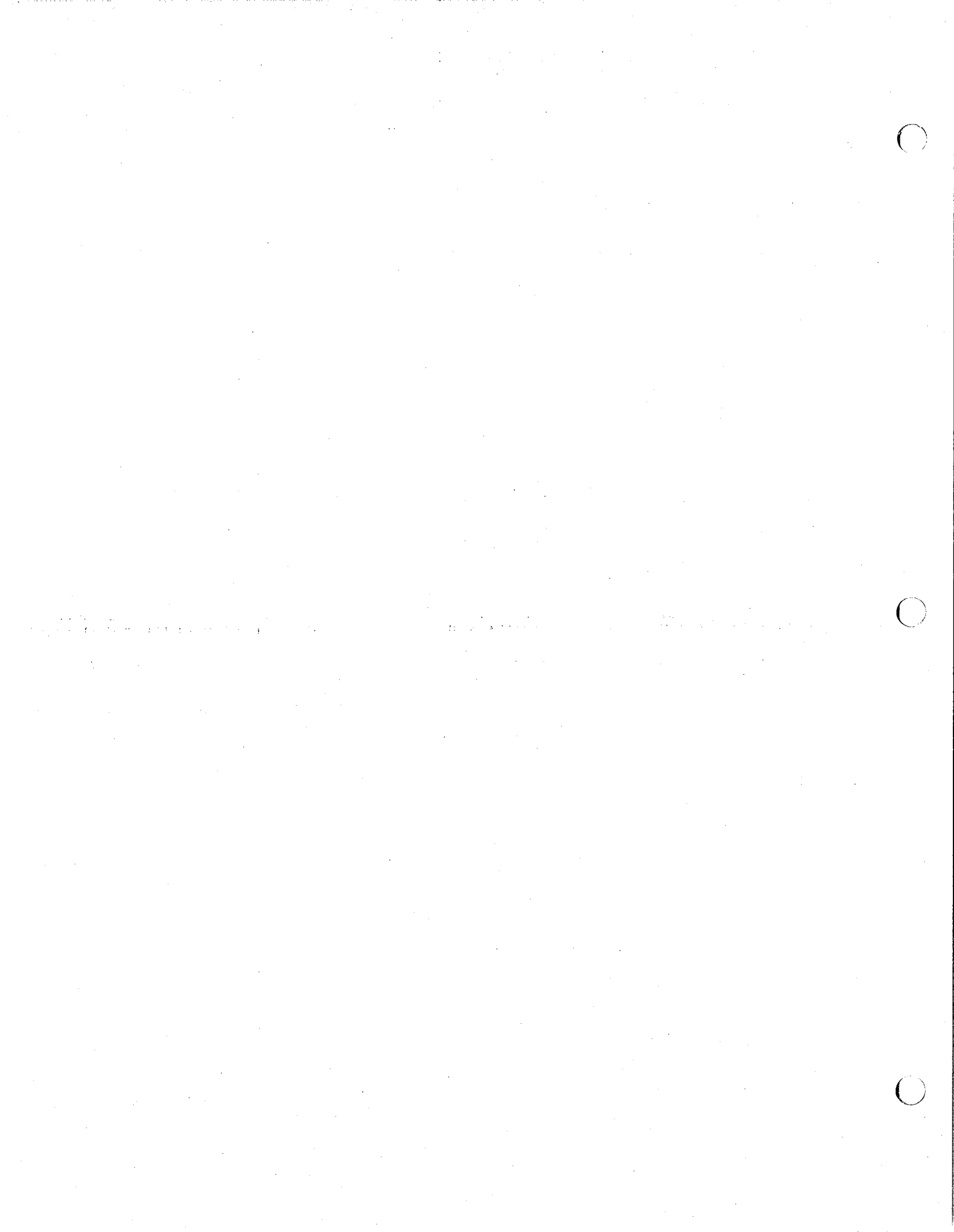
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