CONSOLIDATED HEARINGS BOARD

IN THE MATTER OF Sections 2 and 3 and 6 (3) of the Consolidated Hearings Act, 1981, S.O. 1981, c.20;

— and —

IN THE MATTER OF Section 12(2) of the Environmental Assessment Act, R.S.O. 1980, c.140;

— and —

IN THE MATTER OF Sections 30, 35 and 38 of the Environmental Protection Act, R.S.O. 1980, c.141, as amended;

— and —

IN THE MATTER OF Sections 24 and 61 (2) of the Ontario Water Resources Act, R.S.O. 1980, c.361, as amended;

— and —

IN THE MATTER OF Section 28 (3) of, and Regulation 164 under, the Conservation Authorities Act, R.S.O. 1980, c.85, as amended;

— and —

IN THE MATTER OF Section 40(12) of the Planning Act, S.O. 1983, c.1, as amended; in connection with site plan control of the sanitary landfill site;

— and —

IN THE MATTER OF Section 22(1) of the Planning Act, 1983 in connection with a referral to this Board by the Honourable Bernard Grandmaitre, Minister of Municipal Affairs, on a request by the Regional Municipality of Halton to amend the Official Plan for the Town of Milton to redesignate a parcel of land comprising Part Lots 3 and 4, Concession 2 N.S. in the Town of Milton from "Agriculture" and "Conservation and Hazard Lands" to permit the construction, operation and maintenance of a landfill site, Minister's File No. 24-OP-0208-A01;

— and —

IN THE MATTER OF Section 34(11) of the Planning Act, 1983 in connection with an appeal to this Board by the Regional Municipality of Halton for an order directing an amendment to By-law 61-85 of the Town of Milton to rezone the lands situated at Lot 3 and part of Lot 4, Concession 2 N.S., in the Town of Milton from "Agriculture" to permit a regional sanitary landfill site and ancillary uses;

— and —

IN THE MATTER OF Section 15(1) of the Planning Act, R.S.O. 1980 ch.379 in connection with a referral by the Honourable Claude F. Bennett, Minister of Housing on a request by Tremaine Britannia Citizen's Group for consideration of part of the Official Plan for the Halton Planning Area with respect to Sections 1 to 5 inclusive, 7, 9 and 10 of Part III D3 Solid Waste Management, Minister's File No. OPC-0026;

— and —

IN THE MATTER OF Section 64 of the Ontario Municipal Board Act, R.S.O. 1980, c.347 as amended in connection with an application by the Regional Municipality of Halton for an order approving:

a) the acquisition of land for the construction, operation and maintenance of a sanitary landfill site to contain 7.96 million cubic metres of waste in the Regional Municipality of Halton and to do so by one of two alternative methods as follows:

(i) landfilling at the site referred to in Halton's Environmental Assessment as Site F in the City of Burlington;
(ii) landfilling at the site commonly referred to in Halton's Environmental Assessment as Site D in the Town of Milton

at an estimated cost of $12,775,000.00, and the borrowing of money by way of temporary advances not exceeding in the aggregate such estimated cost pending the sale of debentures, and

(b) the issuance of necessary debentures to a maximum of $12,775,000.00 for a term not to exceed fifteen years;

— and —

IN THE MATTER OF Section 193(5) and Paragraph 84 of Section 210 of the Municipal Act, R.S.O. 1980, c.302, as amended;

— and —

IN THE MATTER OF Sections 6, 7 and 8 of the Expropriations Act, R.S.O. 1980, c.148;

— and —

IN THE MATTER OF an undertaking of the Regional Municipality of Halton to provide facilities for the purpose of receiving, dumping and disposing of waste as required by section 137 of the REGIONAL MUNICIPALITY OF HALTON ACT, R.S.O. 1980, c.436, as amended, by acquiring the land for, constructing, operating and maintaining a landfill to contain 7.96 million cubic metres of waste in the Regional Municipality of Halton.

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OFFICIAL REPORTERS

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I N D E X

E X H I B I T S

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BEFORE: H. H. Lancaster, Q.C. - Chairman

Dr. D.J. Kingham - Member

Hearing conducted at The Oakville Granary Commercial Centre, 105 Robinson Street, Oakville, Ontario, on Tuesday, March 15, 1988

VOLUME 106

APPEARANCES:

T.R. Lederer and H.D. Hodgson	for the Regional Municipality of Halton (Proponent)
J.R. Tidball	for the Ministry of the Environment
T. Vigod J.F Castrilli	for the West Burlington Citizens Group
D. Estrin, F.E. Leitch and H. Dahme	for the Corporation of the Town of Milton
S.R. Garrod and A. Nurvo	for the Milton Area Citizens Coalition and several affected Milton area landowners
R.B. Tuer, Q.C. E.A. Cronk, F. Perrier and L. J. Griffiths	for National Sewer Pipe Limited
L.F. Longo	for Azova Investments Limited
M.J. McQuaid, Q.C. and C.J. Tzekas	for the City of Burlington
C. Mansfield	for the Ministry of Natural Resources
P. Renaud	for Cumis Limited

APPEARANCES (Cont'd):

C. Stevenson P. Hancock	for Framgard Holdings, Fosseri Investments Limited, Seriphos Investments Limited and Topic Investments
J.H. Olah	for the Halton Region Conservation Authority

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Per: C.F. Nethercut, CVR

Oakville, Ontario
March 15, 1988

--- Upon Commencing at 9:30

MR. LANCASTER: Thank you, please be seated.

ANTHONY J. CRUTCHER, (resumed):

JOHN M. PETRIE, (resumed):

EXAMINATION IN CHIEF BY MR. McQUAID, (continued):

Q. Mr. Petrie, yesterday we were going through B-617, the Site F hydrogeologic report, and I think we had got to the heading on page 40 entitled B.3.5, pumping tests.

MR. PETRIE: A. That is correct.

Q. For the pages as I see it, pages 40 through 47, you are going to be making observations on three pumping well tests, PW-1, PW-2 and PW-3 which you indicated on the drawing yesterday Trow had undertaken.

A. Correct.

Q. Could you pick up in the text and by reference to whatever exhibits you have produced, just tell us what your conclusions are with respect to your examination of these pumping tests?

A. I will start by referring to page 42 where I have a description of the interpretation of the pumping tests for PW-1. I will then go to PW-2 and 3 and then summarize the conclusions. At the bottom of page 42 under the heading pumping test PW-1 I note that a pumping test was conducted by Trow on PW-1 which as shown on Exhibit H-220, which we referred to yesterday as the working hydrostratigraphic drawing provided by Trow and as contained in this report at page 29, well PW-1 is indicated as being completed within the highly fractured shale. I might note that on H-220, PW-1 is indicated as TW-1, but it is the same well.

Q. Where do we actually see TW-1?

A. I'm on page 29 which is B.3.2 and as I move progressing left from the far right, it is the fourth installation in and the first one looks like HC9, the second one I believe is HC14, the third one is MB16 and the fourth one is TW-1.

Q. The fourth one from the right-hand column just under the word "discontinuity", and under the D of "Discontinuity Map"...

A. Yes.

Q. ...TW-1 was the nomenclature used at that point and it is equal to PW-1?

A. I have no concern with it.

Q. Is it also true of TW-2 and TW-3? If we go immediately...

A. Immediately to the left of TW-1 is

TW-2.

Q. Is that pumping well test 2?

A. No. That is an observation well as I understand it drilled adjacent to TW-1 such that they would monitor the water levels in that well when they were pumping TW-1.

Q. Is there a place on this H-220 where we see PW-2 and PW-3?

A. There is. If we start at the far left-hand side and progressing to the right, we have HC4 being the borehole on the left margin, HC3 being the next one and then a pair of wells indicated as TW-5 and TW-6. Above that is a notation, above TW-6 -- above TW-5 there is a notation PW-2. This again is a pair of wells, one in this case being TW-5 which was the pumped well and the adjacent well being TW-6 which was the well where additional water levels were monitored during the test interval. Immediately to the right of that pair of wells we see the heading TW-3 and TW-4. This is the second -- it would be PW-3, one of these, and the adjacent one is the observation well also drilled in conjunction with the pumping test conducted for PW-3. You will notice, referring to TW-5 and TW-6, being the left-hand pair of those wells, a thick red margin between the blue line and the top of hydrostratigraphic unit No. 3. The blue line was indicated during cross-examination and has been the top of the bedrock and the dashed line describes the top of hydrostratigraphic unit 3 and the red line therefore indicates the vertical portion of the rock that was open to pumping and in other words PW-2 -- PW-2 penetrated through the thickness of hydrostratigraphic unit 2 at that point and was terminated at the interpreted top of hydrostratigraphic unit 3 and the adjacent observation well indicated as TW-6 penetrated essentially the same vertical thickness of rock. It is my understanding that these wells were drilled with a surface casing installed from ground surface, being the green line at the top of the figure, and penetrated a short distance into the rock and below that surface casing the hole was drilled as open hole, i.e., there is no casing in the hole and the vertical integral indicated by the thick red line is that portion of the rock which is open to the pumping well.

DR. KINGHAM: That applies as well at what is called TW-1 where the thick red line is uncased?

MR. PETRIE: Correct, that is my interpretation. I am not entirely sure what the interpretation would be for TW-2 as the red line is not there, but it would be my expectation that it would be my expectation that it would be essentially a similar vertical interval, TW-2 being immediately adjacent to TW-1 or PW-1.

DR. KINGHAM: Is that the reason for your comment with respect to the aquifer thickness, your comment in the first paragraph on page 42?

MR. PETRIE: You are looking at the first paragraph on page 42:

> "For each of the pumping tests, the hydraulic conductivity was calculated using an aquifer thickness 0.3 m."

That 0.3 metres does not relate to the vertical extent of the red line. As Mr. Sobanski indicated in chief and again in cross-section, he had initially interpreted that within that vertical interval, i.e., the length of the red line you see on Figure B.3.2, within that vertical interval only 0.3 metres was contributing water to the well.

DR. KINGHAM: I asked the question more in reference to the last sentence in the paragraph than to the first.

MR. PETRIE: That is correct:

> "CRA considers it more appropriate to use the well depth below bedrock surface

as the aquifer thickness in order to calculate the hydraulic conductivity of that portion of the bedrock exposed to the effects of pumping."

DR. KINGHAM: Is that what you were referring to as the thick red line on page 29?

MR. PETRIE: That is correct. For the next pair of wells completed adjacent to the TW-5 and TW-6 pair, i.e., the pair indicated as TW-3 and TW-4, it is my understanding that those wells penetrated to a similar depth as TW-5 and TW-6 and there has been a deletion of a word and they have scratched out a portion of the bottom of the borehole TW-4. It is my understanding that both those wells intersect only the interpreted hydrostratigraphic rock unit No. 2 and do not penetrate into the hydrostratigraphic rock unit No. 3.

MR. McQUAID: Q. All right. We began discussing page 29 and from the text at page 42 where you directed our attention to the first pumping test, TW-1.

MR. PETRIE: A. Correct. Going over to the top of page 43 I indicate that this borehole, that borehole being PW-1, is uncased over an interval of 20.4 metres from an elevation of 87.4 metres to

107.8 metres, and I referenced the source of the information as being Appendix 10 of H-40A and that is the pumping test graphs provided by Trow and in the top right-hand corner, if we turn to Appendix 10, specifically the third page ...

Q. Give us a chance to catch up. Appendix 10?

A. Appendix 10 and the third page into Appendix 10, the top right-hand corner of the page shows pumping test No. 1, pumping well time drawdown for PW-1-86 and then a notation defining the uncased interval, that interval being 87.4 metres in elevation to 107.8. I have an overhead of that graph to which I wish to refer. I have Xeroxed the page we have looked at being in Appendix 10 of H-40A and this is the plot of drawdown data for the pumping well as I understand it. It is a log cycle graph on the vertical -- pardon me, on the horizontal, and we have across the top time in minutes -- if you look at the very bottom we have the notation time in minutes and the first log cycle being one to ten minutes and the second, ten to 100, ten to 1,000 and we have a fourth log cycle but no data points.

On the vertical axis we have the drawdown measured in metres. This is a graph of water level change plotted against time and it was measured during the pumping test interval, and we notice a sequence of black dots along this line being the water level change from the initial water level plotted against the time at which that water level measurement was recorded.

The significant point on this graph is the pronounced change at drawdown we get at the point of approximately 400 minutes. Now, from zero to 400 minutes the well drew down approximately seven and a half metres and then from 400 minutes onwards, the last data point recorded is at about 700 minutes and the well drew down from seven to 20-something metres. It is the pronounced break in slope that provides me some data regarding the hydraulic configuration of the bedrock at this point.

In order -- I needed to find out the elevation of this point here and the data provided on this figure relates water levels to the initial water level recorded in the well PW-1. On this figure one cannot infer what the exact elevation of that was so I then have to refer to the data contained in Exhibit H-84. Exhibit H-84 is the interrogatory responses to the Weir & Foulds submissions, and approximately the first half of that exhibit relates to Site D and I am referring to the second half which relates to Site F, and then specifically looking at an entry called Addendum H, construction records, pumping wells PW-1, PW-2 and PW-3.

There is an entry under the heading of PW-1 as I read from left to right and we have the screen position which for PW-1 indicates that portion of the rock which was open to pumping, and we have the water level elevation before and after pumping. Before pumping the water level elevation is recorded as 110.76. I will just make that notation on this overhead.

In red I have indicated in the top left corner of this overhead the 0.0, i.e., the static water level, I understand it is equal to 110.76 metres of elevation. We then have a drawdown, or we have over the upper seven metres of this interval starting at 110.76 and going down to about 103 metres, over that vertical interval we have a significant amount of water contributed to the pumping well and below that interval, being approximately 103 metres to the bottom of the hole, we have much less water contributed to the pumping well.

Now, can I elaborate on that? Were we to have the same amount of water contributed to the pumping well over each vertical metre of the rock exposed to the pumping well, I would have expected this graph to continue off to the right at approximately the same slope. I say approximately because one does expect some small changes in slope to reflect some small changes in hydraulic conductivity within the bedrock. What I see here is a very pronounced break in slope at this point which indicates to me that the bulk of the fracturing or the bulk of the water being contributed to the pumping well is derived from an elevation above this point, this point being about seven and a half metres below the static level I have indicated, and therefore it would approximately be at an elevation of 103 metres above sea level.

Q. Can I stop you there? Can you take your red marker and when you indicated what your expectation would have been had the contribution been more ...

A. ... uniform.

Q. You would have extended that first line, the upper line running from left to right more down to the right. Is that what I understand?

A. Correct.

Q. Could you put a dot there in red and put "if uniform" or "path if uniform"?

A. I have indicated on the right-hand side of the figure three dashes being a continuation of that upper portion of that curve and have put on "approximate path if uniform."

Q. I want to pick up in the text because you have used the figure of 400 minutes in your evidence, but at page 43 in the second paragraph you have entered in the text the number of 500 minutes of pumping. I don't know if there is any significance to that. Is it just a question of where you are pointing to the dramatic break?

A. Correct. I was reading the graph off the wall and I would prefer to use the number in the text being 500 minutes and nothing hinges on 400 to 500 minutes.

Q. Would you point out the 500-minute point?

A. I am putting my marker at 500 minutes and moving vertically down the scale.

Q. I see. Then, can you just tell us or amplify, there is a comment in the latter part of that second paragraph:

> "It is not known if the pumping rate quoted (2.5×10^{-4} m^3/sec) is averaged..."

and have you discussed that in your more recent discussion by looking at this?

A. The pumping rate is quoted at the bottom left-hand corner of that figure and we have an entry there being Q equal to 2.5 x 10^{-4} metres cubed per second and I believe it is approximately 3.3 Imperial gallons per minute as the pumping rate. If the well was being dried up as may be interpreted from the significant drawdown at about 500 minutes, and if there was no water being contributed to the pumping well I would have expected an entry somewhere on this table or in the text to indicate that during pumping the well essentially dried up and they had to terminate the test for the absence of water. I did not see that entry and I notice that the data point scale out to a time of approximately 700 minutes, and I can get that directly from the graph. It's approximately 700 minutes on this graph which one might interpret the pumping test -- one would interpret the pumping test went to at least 700 minutes. I am now referring back to the text of H-40, the Trow Site F report, and I am referring to page 52 of the Trow Site F report.

On page 52 of the Trow Site F report under the heading of 6.2.4, being the highly fractured shale unit, this section of the bottom paragraph begins pumping test No. 1 where they measured the hydraulic characteristics of the unit and the test was run for 24 hours and 24 hours is 1,440 minutes. If one was to look at this graph one would assume that pumping had continued to the time of 1,440 minutes which I would indicate is within this domain just here. In other words the additional 700 minutes of pumping, where the pumping time occurred following the last data entry point on this graph. It is my interpretation from that, recognizing there is no discussion in the text from Trow that the pumping rate was continuous through that period of time and the well pumped water for that additional 700 minutes and that water, being equivalent to about 3.3 Imperial gallons per minute or as indicated in the bottom left of the corner as being 2.5 x 10^{-4} metres cubed per second, it is my interpretation that that water was contributed for the most part from the upper and approximately seven metres of rock that drain into the well.

The situation I interpret at this point on the site is that the upper seven metres is more highly fractured and the lower where we have a well that is 20 metres deep, so we are looking at the lower 13 metres and has very little fracturing as interpreted by the fact that very little water is contributed to the pumping well at that point. The pumping rate is apparently maintained for 24 hours and that indicates to me that from the upper seven metres of bedrock we had a continuous draining of water into the open well such that it would cascade down the well to the bottom of the well where it was pumped out by the pump. In other words, the pumping rate is maintaining a flow rate that is probably equivalent to the drainage rate of groundwater flowing to the well.

Were the pumping test to have been terminated at 700 minutes and no further water could be withdrawn, one might arrive at quite a different interpretation, namely that the upper seven metres of rock had been dewatered and all the available water had been taken out of the upper seven metres of rock and you had effectively over-exploited the system or pumped as much water out as could be provided. We could just locate the elevation of 103 on the figure on page 29, the working drawing. I understand that Exhibit H-220 at one time had a vertical scale put on it and the copy which we initially obtained and which has been reproduced here at that time did not have the vertical scale on it.

Q. If I could stop you for a moment I find it very helpful to have the small version, but I wonder if the large version ...

A. I did not find it.

Q. I think we can carry on but we will get the original down because it also helps us and you may want to point things out on it directly, Mr. Petrie.

A. Right. Now, for information regarding the elevation, I am referring to B-620 which is just the hydrostratigraphic base drawing we referred to earlier. I note that as per the left-hand side of this drawing, observation well HC4, the bottom piezometer is screened at about 108 and I am just reading that from the figure. I could note that more approximately HC8, piezometer 2 appears to be screened at approximately 103. In order to provide a scale, a vertical scale on Exhibit H-220 as we have contained in our Site F report, I could take the elevation of HC8, piezometer 2 and extrapolate that across to the right-hand side of this drawing.

HC8, if I start from the right-hand side of Exhibit H-220, and as I indicated earlier the first borehole is 9, the second is 14, and I am moving left from the right-hand side, MB16 is the third, the fourth and fifth are the two test wells, MB13 is the next one, borehole 8 is the following one. The seventh installation from the left, and I notice that the third -- piezometer No. 1 ...

Q. You said seven from the left, but you meant seven from the right?

A. That is correct, the seventh installation from the right. As I go down borehole 8 I start at ground surface and then a green line, then a blue line and then I come to a small circle on the left and proceed further down until we come to the next small circle where I believe the number is 0.21 as indicated in the circle. I understand that that represents a tritium value but that elevation indicates the location or the elevation of piezometer 2 in borehole HC8. That is approximately at 103 if one were to extrapolate a line horizontally across the page from that point, and you will notice that only the upper one-third or so of the borehole, of that thick red line indicating TW-1 or PW-1, that the upper one-third or so of that red line is contributing water to the pumped well based on an assumed elevation of HC8, No. 2 of 103 metres above sea level.

Q. Looking at the text on page 43 you also relate this water level response to information from the WAT7 series of wells as well?

A. That is correct. Could I back up

and relate to one other item that is apparent from Exhibit H-220? At TW-1 or PW-1 as we cast our eyes vertically down the red interval, being the open interval exposed to bedrock, we have some colouring being yellow and I think it's a pale brown, yellow again and a thick sequence of pale brown and yellow at the bottom. Looking at the legend on the left, we see the yellow is indicated as unfractured to less fractured rock and the brown or colour contrasts are a bit vague, so shall we call it the non-yellow colouring appears to indicate fractured rock. The fracture pattern at the test wells, being PW-1, 2 and 3, was not provided in the appendices attached to Exhibit H-40. I am not sure how that interpreted fracture pattern at TW-1 and TW-2 was arrived at by Trow. Those wells were drilled in a method that does not yield a good interpretation of the fracture pattern. I am referring now to the top of page 41 in Exhibit B-617 for a discussion, a quick discussion regarding the methods used to drill those wells.

At the top of page 41 we read that the pumping wells were drilled using cable-tool methods and no stratigraphic or fracture frequency data was provided. I cannot elaborate on how Trow undertook an interpretation of the fracture frequency at that point of the site and I can only interpret the fracture frequency as I would see it in analyzing the pumping graph data which we have before you on the overhead from PW-1, and it is my interpretation that the upper seven or so metres is the more highly fractured or more transmissive providing the bulk of the water to the well and the lower portion of the rock provides a much less amount of water.

DR. KINGHAM: When you say the upper 7.5 metres, are you talking about the upper 7.5 metres of bedrock or of the entire well?

MR. PETRIE: I'm talking about the upper 7.5 metres beginning at an elevation of 110.76, being the standing water level, and perhaps we should relate that elevation.

MR. McQUAID: Q. Take your document out if you will, H-220, and put it up under the clip on the easel and then you can point to the place where you are actually focusing on.

MR. PETRIE: A. Trow have indicated that the standing water level prior to pumping in PW-1 is at an approximate elevation of 110.76. I am trying to understand exactly where that elevation is and if I could refer quickly to Exhibit B-620, and elevation of 110 is approximately at piezometer elevation -- at piezometer 3 elevation in HC8. So starting at the right-hand side of H-220, in order to locate HC8, I believe that was the seventh installation across starting at the right, and going down to -- I see the first circled entry on the left of that borehole immediately beneath the blue line being the top of rock is where I would interpret the elevation of 110 is approximately. Taking that approximate elevation and extrapolating it horizontally across the figure, we note that the bedrock -- I'm sorry, across the figure to well PW-1, I note the blue line intersects PW-1 at approximately that same elevation, the blue line being the top of rock. It would appear at this point that the water table in the rock sits approximately at the top of rock.

Q. All right. Back at page 43; you had asked us to backtrack for a moment to make those comments on the absence of an indication of how the well was actually drilled, or how they determined the fracture frequency, is that the accurate way of putting it?

A. Correct.

Q. You were saying in addition on page 43 in the last paragraph on that page that you also gained some support from observations on WAT7.

Could you explain that?

A. Correct. The drawdown data on WAT7 are provided in Appendix 10 of H-40A, that exhibit. We do not specifically need to refer to that graph, and it would have been more useful to refer to the interrogatory responses to Weir & Foulds, H-84, and to the page we referred to before giving the water level data at the observation wells and the pumping wells for PW-1.

Q. That is the same page you referred us to earlier?

A. The first page following Addendum H being the construction records, pumping wells, PW-1, PW-2 and PW-3. On the page beginning with PW-1, the second column over reads "Observation Well No." and as we follow down that column we come to an entry for WAT7 and that is suffixed by -1, -4, -5 and -6, they being four of the piezometers completed at the WAT7 well nest. Perhaps we should locate this on a figure. I am just looking for the overhead from Exhibit 617 being the location of the wells installed at this site. I am referring to Figure B.1.1 on page 19 and PW-1 is the pumping well located on the property boundary to the south and WAT7 is a multilevel piezometer immediately to the north. That horizontal distance I read from the pumping test appendices as 154 metres. Now referring to the water well data obtained from WAT7, a well nest completed 154 metres away from the pumping well, and again referring back to the interrogatories, H-84, the entry beside WAT7 No. 1, and if we refer to the far right-hand ...

Q. Let's pick that up if we can. We are in Addendum H?

A. Correct, Addendum H being the construction records for pumping wells PW-1, PW-2 and PW-3, the first page of that addendum which relates only to pumping test No. 1.

Q. We see in the fourth entry on observation wells WAT7-1, -4, -5 and -6?

A. Correct. If we move over to the very far right-hand column which is headed "Drawdown in Metres", that is the calculated -- measured change in water level achieved during the pumping test interval, the pumping test being conducted on PW-1. In order to get some understanding of this information I am referring back to a figure we had yesterday being Figure B.3.5 which is the hydraulic head profiles developed.

Q. Just bear with me for one second. The right-hand one is drawdown?

A. The far right-hand column being drawdown, the change in water level from the beginning to the end of the pumping test.

Q. You were going to relate that over the 154 metres difference?

A. That is the separation between WAT7 and the pumping well and now we are discussing in general terms the change in water level that resulted at WAT7. I have put before you an overhead we looked at yesterday, being Figure B.3.5 on page 34, Exhibit B-617, and I am referring to the bottom figure being the vertical profile at WAT7. If we look to the far left of this figure we see the sample intervals or the elevation of the piezometers at each of the sampling intervals at WAT7.

I might note that the WAT installations are numbered from the top down, so that the first little box is WAT7-1 and then 2, 3, all the way down to 12. You will note that 10 and 11 -- I beg your pardon, piezometers 9 and 10 are not shown and it has been indicated to the Board before at this hearing that those piezometers are plugged and they provide erroneous data and to that end we felt it appropriate not to locate them on this figure, but there are two installations at the elevations between 11 and 8 -- and

9, but they are not functioning.

If we notice the drawdown at WAT7-1 was 0.28 metres being the top installation and we have drawdown recorded at 4, 5 and 6. It is my understanding that for those piezometers for which no data is provided on that page we are referencing in Exhibit H-84, Appendix H thereof, if no data is provided no change in water level was observed. So, we have basically the most pronounced changes in water levels which occur at piezometer 7-4, -5, -6, and let me indicate them on the overhead.

I have indicated piezometers 4, 5 and 6 further to the left where the most pronounced change in drawdown was measured during the pumping at PW-1. We will note that these piezometers lie approximately from 105 metres in elevation to about 98 metres in elevation. I wish to relate those elevations back to the numbers we referenced earlier and developed from looking at the drawdown curve from PW-1, and I'm just putting that drawdown curve back up, as it is an overhead. We noted that at about a depth of about seven metres, or an approximate elevation of 103 metres in elevation, the bulk of the water was being contributed to the pumping well and referencing the data at WAT7, it would seem that the bulk of the response measured at this piezometer occurred at an elevation from about 98 metres below sea level up to 105 metres above sea level. That is not precisely the same elevation we interpret from pumping test -- from PW-1. However, I consider that over a horizontal separation of 154 metres that represents approximately the same vertical interval.

I will note that the deeper piezometers, being piezometers 7, 8, 10 and 11 at WAT7, did not respond to pumping and we might note also that the deepest piezometer is set at an elevation of approximately 82 metres. I now wish to relate that elevation to Exhibit H-220 which I have pinned up here before me and the elevation I was referencing was approximately 82 metres. Borehole HC14, piezometer 1 as indicated on B-620, that piezometer has approximately an elevation of less than 84, say in the 83 or 82-metre range. If we look for HC14 on Exhibit H-220 we will get an idea of the elevation for example of HC12. Fourteen is the second installation in from the right on Exhibit H-220 and if we go right to the very bottom of that installation we would note that it lies at an elevation below that of the pumping well at PW-1, and that is consistent with the data we have on the overhead before us, namely that the bottom of PW-1 lies at an elevation of approximately 87.4. I'm sorry, I had meant to start by referencing an elevation of 87.4.

Now, going through that exercise again, if we take piezometer 8, for example, at WAT7, it lies at an approximate elevation of 93 metres and 93 metres lies at or piezometer 2 of HC14 lies at approximately that location and going back to installation 14 on H-220 we see that the second piezometer from the bottom lies approximately at the elevation of the bottom of the pumping well and yet it showed no response to pumping from PW-1.

DR. KINGHAM: For us to have a quick reference to this, is it correct for us working from your overhead projected on the wall to assume that the bottom of the line PW-1 is 87.4 metres above sea level?

MR. PETRIE: I'm sorry, am I projecting this line to 87?

DR. KINGHAM: You say the uncased interval is 107.8 to 87.4 metres above sea level?

MR. PETRIE: Correct.

DR. KINGHAM: So when we look at our Exhibit H-220, the bottom of the solid line at PW-1, is that elevation 87.4?

MR. PETRIE: It is my interpretation

that that is so.

DR. KINGHAM: So we can take all of our numbers from that point?

MR. PETRIE: I have done that.

MS CRONK: Some of us couldn't see from back here and what was the witness saying was the bottom of the line?

MR. McQUAID: Q. Would you point out the bottom of that line?

MR. PETRIE: A. It is PW-1 being the bottom elevation of that well and it is into the yellow.

MS CRONK: Perhaps the record can show that as I understand it Mr. Petrie has pointed to the bottom of the line below the black line and not at the black line.

MR. PETRIE: Correct, the very bottom of the line indicated as TW-1.

MR. LANCASTER: Excuse me, Mr. Petrie, but here is a larger copy because we seem to have a couple around here.

MR. PETRIE: Thank you, Mr. Chairman.

MR. McQUAID: Q. I'm not sure why there is a difference in colour and perhaps you can explain that. Is that the way the Xeroxing came out?

MR. PETRIE: A. I'm not entirely sure. I think we see it is the same document. However, it may have been coloured or Xeroxed in black and white and coloured on two occasions, or two separate copies coloured differently. We obtained a copy coloured and had it photocopied directly by a colour Xerox machine. I am not sure there was any intention to distinguish the yellowy colour here as separating it from the green and the legends are the same. The only significant difference I see is on the left-hand margin of the copy which the Chairman has just provided me with where we have the elevations indicated on the left-hand side of the figure. On our Exhibit B-617, we did not have the elevations indicated. As I mentioned earlier, I believe that that was added during cross-examination and our copy was obtained prior to that point.

Q. Can you relate the discussion you have been having with respect to PW-1 and your indication that the water was contributed from that upper seven metres, and then you also obtained support for that position, as I understand it, from the WAT7 well which you have just explained to us?

A. Correct.

Q. Can you relate that now to what conclusion that gives you with respect to the Trow hydrostratigraphy, and I guess in particular one of the units, unit 4?

A. I'm referencing the second complete paragraph on page 44 of B-617 and here I have concluded that the uppermost portions of the bedrock respond more readily to pumping and further that CRA doesn't agree with Trow, and I have referenced page 52 of H-40, that the results of this test demonstrate the existence of a highly fractured shale, being unit 4.

Q. Again that unit 4, it is just below the B-620 where we have actually put the H-220 version so the exhibit is on top of it so if I can remove this, and looking at B-516, again we are focusing on that wedge-shaped unit No. 4 on B-516?

A. That is correct. This was the unit that Mr. Sobanski had originally interpreted as having a hydraulic conductivity value of 10^{-2}. Now if we can refer to the third complete paragraph on page 44 a mean transmissivity value of 4.1×10^{-5} metres squared per second was calculated by Trow from these data, being PW-1, and that is referenced on page 53 of H-40. Now, page 53 of Exhibit H-40 has a table which provide the geometric mean of the transmissivities as calculated by Trow, 4.1×10^{-5} metres squared per second. The transmissivity is what one reads directly from the slope of this graph, this graph being the graph provided on the overhead for PW-1. The formula for arriving at that transmissivity is shown in the bottom left-hand corner headed by a Jacob Approximation of T being the value for the transmissivity and the mathematics is not at issue and we have calculated a geometric mean value -- a geometric mean transmissivity value of 4.1 x 10^{-5}. In order to arrive at the hydraulic conductivity -- I should explain what transmissivity is.

Transmissivity is the measure of the volume of water that would flow through an aquifer, the total thickness of the aquifer, under an horizontal hydraulic gradient of one. We do not achieve hydraulic gradients of one in the test and there is no implication attached to that but that is just a definition of the word "transmissivity". In order to arrive at a hydraulic gradient we divide by the aquifer thickness. Dividing the transmissivity by an aquifer thickness, obviously the aquifer thickness is critical to the calculation of the hydraulic conductivity for these strata. Mr. Sobanski initially used a value of 0.3 for the thickness of the aquifer and that is referred to on page 42 of Exhibit B-617 and for each of the pumping tests Trow initially used an aquifer thickness of 0.3 metres and they took their mean transmissivity divided by 0.3 and generated the hydraulic conductivity data you see before you on page 53 of H-40, that value being 1.3 x 10^{-2} which is essentially the same value you see on B-516, being a summary of Trow's hydrostratigraphic units, and I see for rock unit 4, 1 x 10^{-2} is the hydraulic conductivity. From the discussion I presented this morning, I consider it inappropriate to use an aquifer thickness of 0.3 metres and I would obtain a more meaningful value of the hydraulic conductivity if I divide the transmissivity by a well depth below the bedrock surface. To that end one could take the total vertical interval of the bedrock which was uncased and assuming all of that vertical interval being approximately 20 metres is uniformly providing water, or one could take, and I am just referring back to the text, or one could take an aquifer thickness of seven metres, and I'm referencing back to B-617, page 44, the first sentence of the last complete paragraph:

> "For an aquifer thickness of 7 m, being the thickness of the bedrock contributing the bulk of the water to the well, a hydraulic conductivity of 2 x 10^{-4} ... is calculated by CRA."

Q. The hydraulic conductivity of 2 x 10^{-4}, that is taking the transmissivity of 1.3 x 10^{-5} and divided by seven metres?

A. That is correct. I wish to clarify a point as I got ahead of myself. If I could refer to the previous paragraph, the third complete one, I report initially that Trow has a mean transmissivity value of 4.1 x 10^{-5}. When I looked through some of the data they provided to arrive at that mean I felt that some of the wells could not usefully be interpreted to provide a measure of mean transmissivity. Specifically I refer to some of the wells which show very little drawdown, and I'm just trying to find those wells in particular.

If we refer to Exhibit H-40A, Appendix 10, the pumping test results, and I am referring to the page immediately previous to the overhead I have before you, and it should be the second graph in and the heading at the bottom right-hand corner is "Time Drawdown Data for MB16 Series of Wells."

Q. The second drawing in Appendix 10?

A. Correct. It looks vaguely similar to the drawing we have before you on the overhead. There are two wells monitored, the data for which is presented, and I'm looking at the one indicated by the open triangles and the legend at the bottom left-hand corner reads MB16-3. When I look at the data across the top of that figure I see very little drawdown recorded. I could read the total drawdown as being about 20 centimetres and again the 20 centimetres is recorded over 1,440 minutes of pumping.

Q. Are you reading the drawdown which is the indication you get from taking the more horizontal line from left to right?

A. That is correct and I am extrapolating that across to the axis on the far left-hand side ...

Q. Right.

A. ... and measuring a drawdown of approximately 20 centimetres. If you look at the mathematics at the bottom of the table referenced by the legend MB16-3 we see a T value, T being the transmissivity, equal to 3.8×10^{-4} metres per second. That is a high number relative to the other numbers generated for this site. I consider it inappropriate to use such a small drawdown to provide a high measure of transmissivity.

We are dealing with a fractured rock system and for the wells that did not provide good response, which I would interpret as being the wells which provided a very small measure of drawdown, I would consider we have a poor connection between that well and the pumping well, in which case I would not use this value of T equals 3.8×10^{-4} calculated transmissivity for MB16-3 as being a measure of the aquifer transmissivity.

To that end I took the transmissivity data for only those wells which show an obvious drawdown and as indicated on page 44, the third paragraph, second sentence:

> "For those observation wells which show an obvious drawdown (OW1-86, MB16-2, PW-1, MB13-2 and MB13-3) a geometric mean transmissivity of 1.3×10^{-5} m^2/sec is calculated by CRA."

That is a small amount lower than the value calculated by Trow and I attach no real significance to that difference other than I felt a very small drawdown could not be interpreted to reflect a highly transmissive aquifer in a fractured rock environment. Using that value I calculated as indicated in the last paragraph on page 43, using the value of 1.3×10^{-5} metres squared per second and dividing by a vertical thickness of seven metres, I calculate a hydraulic conductivity of 2.4 -- I beg your pardon -- 2×10^{-4}

centimetres per second and the last sentence contrasts that value with that calculated by Trow.

Q. I want to be sure I understand. The seven metres you use is that seven metres you have been explaining to us contributes most of the water ...

A. That is correct.

Q. ... from this pumping well test?

A. Correct.

DR. KINGHAM: Just to complete that picture, MB16-3 is the deeper well; is that correct, the deeper interval?

MR. PETRIE: No, I believe it is the shallower one. I beg your pardon, it indicates here it is the lower elevation. I am referring here to the drawdown graph on Appendix 10 of H-40A, MB16-3 which is located at an elevation of 97.9 to 95.9.

MR. McQUAID: Q. Would you like to put that drawing up, and would you refer to 620 or H-220?

MR. PETRIE: A. We have a new H-220 provided by the Chairman for which the elevation information is on the left, and looking at that information, that elevation being approximately 98 to 96 and reading off the left-hand side of this figure, and I will have to read closely because the numbers stop at 100, but I am marking on H-220, the Chairman's copy, the elevation.

MR. LANCASTER: Perhaps it's easier to work from the closer reference point which I asked you about before, the 87.4 metres at the bottom of PW-1. Isn't that a closer point for us to understand and on the Chairman's exhibit? The bottom of that line you told us was 87.4?

MR. PETRIE: Correct. So roughly we are going up ten metres vertically which would be halfway up this well. I shall just scale that off, ten metres. I have marked on TW-1 the approximate elevation of 98 metres and I have written the 9 and 8 and I note that that lies within the fractured interval defined at TW-1 and within the fractured interval indicated thus at MB16, MB16 being the third installation from the far right. I note that we have very little drawdown at that point and it is my interpretation that very little drawdown indicates a poor lateral fracture connection between the pumping well and the observation well and we are considering a fractured rock environment.

DR. KINGHAM: Is that or is that not consistent with the two slopes you have shown us on the overhead?

MR. PETRIE: That is correct. The change in slope at PW-1 which is approximately elevation 103, we are locating MB16-3 at an elevation below this break in slope.

MR. McQUAID: Q. The poor connection you are seeing at this elevation of 96 would be somewhere down on the dramatic slope we see at the right-hand side of the overhead?

MR. PETRIE: A. That is correct.

MR. McQUAID: Perhaps I should ask you to mark this overhead because Mr. Petrie has put some red markings on it.

MR. LANCASTER: B-622.

--- <u>EXHIBIT NO. B-622</u>: Copy of Overhead from Appendix 10 of Exhibit H-40A

MR. McQUAID: Q. For the record, that is the pumping well test PW-1 which was the third entry in Appendix 10 of H-40A, and you have added to it some markings as we have been discussing earlier this morning?

MR. PETRIE: A. That is correct.

Q. Now, that takes us to I guess the next pumping well test you analyzed or examined as we see at page 45.

A. That is correct. Here we address PW-2.

Q. Pumping well -- the analysis of pumping test PW-1 assisted you in reaching some conclusion about unit 4; is that correct?

A. Correct.

Q. If I understand this portion, looking at PW-2, that gives you some indication as to what units, 2 and 4?

A. Both unit 2 as defined by Trow and in Trow Exhibit H-40, the Site F report at page 53, there is a discussion concerning these two pumping tests, the two tests being PW-2 and PW-3 and it is indicated in the section headed 6.2.6, "Other Fracture Zones."

Q. Just at the bottom of page 53 of H-40?

A. That is correct. As I read through that section I do not notice that it is referenced specifically to their hydrostratigraphic rock unit No. 2, but as we saw from H-220, PW-2 and PW-3 were both screened in the shallowest portion of the rock encountered at the point at which they were drilled, PW-2 being on the far left and as shown on Exhibit H-220 this is consistent with the elevation described by Trow as being hydrostratigraphic rock unit No. 2.

Again I went through the drawdown curves for this test and noted that the transmissivity values calculated by Trow, and those calculated values are recorded in H-40A, Appendix 10, the following pages to the overhead we were initially addressing -- now, the seventh page over is headed "Pumping Test No. 2."

Q. The seventh page in Appendix 10?

A. Correct, and the next four pages thereafter.

Q. So 7 through 11?

A. I haven't numbered the pages.

Q. I think you might as well.

A. Certainly. Should we start then from the beginning? I am numbering the pages in Appendix 10, Exhibit H-40A, and the title page, should that receive a number?

Q. I didn't mark it. I have taken it as just the extract ...

A. Then comes page 1 and page 3 is Exhibit B-622 before you on the overhead. Page 7 is the first of the pages headed "Pumping Test No. 2" and 14 is the last page I have numbered in Appendix 10.

Q. All right. You were going to begin by addressing page 7?

A. In general terms, pages 7, 8 and 9. I have noted on those pages that the transmissivity data range from a value of 7.4×10^{-6} to 1.8×10^{-4}

metres squared per second and I have indicated that in the second paragraph on page 45 of Exhibit B-617. I have calculated from those data a geometric mean value of 1.1 x 10^{-5} metres squared per second and that is a geometric mean value of the hydraulic conductivity. I have not indicated in this paragraph of the report but I do wish to make an additional statement here. If we can turn to page 9 of the pumping test curves I wish to address the series of circles being data points across the top of that figure and the legend on the left indicates HC3-A is the data indicated by the circled measured points. I notice there are five data points but over at the far right after the period of time in excess of 1,000 minutes the data point there sits approximately at a drawdown of 20 centimetres. In referring back to H-220 we note that at borehole HC3-A at the bottom right-hand corner of that figure it has the defined elevation and HC3-A is also HC3-1, and I am referring to H-220, the second installation from the left, HC4 being first and HC3 is the second and that is the lowermost piezometer at the bottom of this well and, as indicated on page 9 of the pumping well graphs, lies at approximately an elevation of 110 which is the approximate elevation I read taking the scale from H-220. You will notice that this piezometer is screened in interpreted hydrostratigraphic unit 4, being the highly fractured shale, and you will recall that the pumping well is open only within unit 2 as indicated on Exhibit H-220, unit 2 being the fractured shale at the surface.

In order for one to measure hydraulic response at that depth below the elevation of the pumping well ...

Q. At a depth of 110.6?

A. Correct. We would then have to recognize there is a degree of vertical fracture connection across hydrostratigraphic rock unit 3. This response is significant in the fact that it occurs. However, I do caution that we have only five data points, and I'm counting the circles on the graph on page 9, and one cannot comfortably interpret that as a measured drawdown. However, the data are provided and I make a cautionary interpretation that 20 centimetres of drawdown at HC3-1, which is indicated by Trow to be screened within the highly fractured hydrostratigraphic rock unit No. 4, indicates a degree of vertical fracture connection across hydrostratigraphic rock unit 3 as Trow have defined it.

If you refer to the legend on the left-hand side, or the results, we have HC3-A and then a transmissivity value of T equals 1.8×10^{-4} metres squared per second and that again is a very high transmissivity value relative to the other values recorded for this test.

Q. What, if anything, do you conclude when you look at that higher transmissivity result of 1.8×10^{-4}?

A. It is my interpretation that that is not an appropriate manner to interpret that data, but HC3-A lies at a significantly different elevation and it indicates that the response indicates a degree of fracture connection and the very small drawdown recorded does not indicate a highly transmissive aquifer which one could interpret from the transmissivity value calculated. So, in arriving at the geometric mean value on page 45 of B-617 I have neglected that data point and have only referred to those data points which provide a more meaningful -- I beg your pardon, I believe I am in error. I have provided a range in hydraulic conductivity and I have provided a geometric mean and I shall have to calculate over the break exactly how I arrived at that mean. It was my understanding from looking at this quickly this morning that I had neglected that data point HC3-1 as not representative of an aquifer transmissivity for pumping well PW-2, but I notice in the text that that is not apparent. May I examine that at the break and report back?

Q. Can you tell me at what point in the text we should put a note or a question mark? What is it you are going to double-check?

A. The sentence that reads:

"CRA has calculated a geometric mean value of 1.1 x 10^{-5} ... from these data."

I wish to check the data.

Q. The second sentence of the second paragraph?

A. Correct.

Q. Do we need to drop this discussion in order for you to check that?

A. It would be appropriate.

MR. LANCASTER: We are now at a point, Mr. McQuaid ...

MR. McQUAID: I was going to ask.

MR. LANCASTER: I am sure you would like to continue with this.

MR. McQUAID: If it would be appropriate.

MR. LANCASTER: Fifteen minutes.

--- Recess

MR. LANCASTER: Please be seated.

MR. McQUAID: Q. Mr. Petrie, we were at page 45 and you had asked for the opportunity to double-check how you had arrived at the geometric mean value of 1.1 x 10^{-5} as we see it in the second sentence of the second paragraph.

MR. PETRIE: A. Yes, that is correct. Over the break I looked again at the data which I used to arrive at that value of 1.1 x 10^{-5} metres squared per second and as I indicated to the Board immediately before the break, I did not use the transmissivity data calculated for HC3-A, being the high transmissivity for the piezometer screened as Trow have indicated in the highly fractured unit. I did not use that data because I thought it was inappropriate to use that to calculate aquifer transmissivity. I would like to read a portion of the sentence into the transcript preceding the sentence that says:

"CRA has calculated a geometric mean..."

And the words I would like to read in start:

"Using the late time transmissivity data from TW-6-86(OW2-86), PW-2-86, HC3-B (HC3-85-2) and HC3-C (HC3-85-3) ..."

And the text would continue:

"...CRA has calculated a geometric mean value of ..."

The notations in brackets are the alternate designations for these wells and the notation not in brackets is the notation indicated in Appendix 10 being on pages 7, 8 and 9 of the pumping test data. I just inserted those brackets because elsewhere in the reports those various installations are referred to by a slightly different notation.

DR. KINGHAM: You don't mean for us to replace the first sentence in the paragraph or do you; you just wish it to be the beginning of the second sentence?

MR. PETRIE: Correct.

MR. McQUAID: Q. That clause actually gives you the entries from which you calculated the geometric mean value of 1.1×10^{-5}?

MR. PETRIE: A. Correct and the first sentence in that paragraph being on page 45, as Dr. Kingham indicates, provides the range in values indicated by Trow in Appendix 11 -- I beg your pardon, Appendix 10. I have taken a subset of that data, specifically the four wells we read into the transcript and calculated a geometric mean value.

Q. That gives you the T or

transmissivity and if you want to go to the K or hydraulic conductivity you divide by a depth?

A. Correct. In this case I divide by the eight metres, being the open interval of the pumping well at PW-2, and I find reference to the eight metres on page 8 of Appendix 10, page 8 being the drawdown graph for pumping well PW-2 and as indicated in the top right-hand corner the uncased interval being 7.6 metres to 15.6 metres, i.e., that hole was open over an interval of eight metres, and dividing the geometric mean transmissivity by eight which gives a calculated hydraulic conductivity of 1.4×10^{-4} centimetres per second.

Q. This is a conductivity for what section of the strata we have been discussing?

A. Exhibit H-220, PW-2 is indicated as the third well installation from the left of that figure being the thick red line over a portion of the bedrock and I shall read the interval from here, here being Exhibit H-220. The approximate elevation at the top being approximately 131 metres in elevation down to an approximate elevation of 123 metres in elevation.

Q. That would be in which strata as described on H-220?

A. On H-220 Trow have indicated that

that well straddles the full thickness of the upper portion of the bedrock being their hydrostratigraphic rock unit No. 2.

MR. HODGSON: Before we continue, we have managed to locate the original of H-220 and it is the most parenthetic exhibit I have ever run across, but perhaps we should now put it up.

MR. LANCASTER: It has the scale on it as it is.

MR. McQUAID: The one that is up there -- it is really a true copy because the left-hand side has the scale we added.

DR. KINGHAM: Is that version of H-220 going to be the final, official exhibit?

MR. HODGSON: That is the original working drawing H-220 that Mr. Beechinor was so worried about the Board getting and keeping.
Mr. Feenstra has just suggested it should be mounted in lucite and somehow made immortal because it is certainly immortal to people in the room.

MR. LANCASTER: We can send it to the museum when we're finished.

MR. McQUAID: Q. You had just described that was in unit 2 from 131 to 123 metres and your indication of the hydraulic conductivity is 1.4×10^{-4}.

MR. PETRIE: A. Correct.

Q. Could you relate that to the figures on the hydrostratigraphic schematic, B-516 just below there?

A. If I can lift it up. Hydrostratigraphic rock unit No. 2 has an assigned hydraulic conductivity of 1×10^{-5} centimetres per second. In referring to page 53 of Trow's Site F report, the bottom of page 53 in the section headed Section 6.2.6, "Other Fracture Zones", Trow do not provide a discussion of the hydraulic conductivity or the transmissivity of the pumping test generated from PW-2. It does not indicate in this portion of the text that this well, PW-2, is screened within their interpreted hydrostratigraphic rock unit No. 2 and I can only conclude that from Exhibit H-220. I also note that Trow conclude, reading the first sentence at the top of page 54 of Exhibit H-40 where Trow make the conclusion:

"The duration of the test ..."

being PW-2:

"... and its constant pumping rate of 2.5×10^{-4} m^3/s ..."

Which is approximately 3.3 Imperial gallons a minute, and that this test:

"... indicated a relatively extensive fracture zone in the weathered shale..."

And they refer to the drawdown graphs which we just referenced.

Q. You have given us your calculation of the geometric mean of the hydraulic conductivity and I would ask you to comment on the third sentence I guess in the second paragraph on page 45. You refer to that value supporting something you see at HC3?

A. Correct. Additional hydraulic conductivity data is available for borehole HC3 and that data is referenced in Appendix 11 of H-40A being specifically the hydraulic conductivity data generated from pressure packer tests or as it's sometimes called just a packer test, and additionally from the Hvorslev or slug tests. We did not review this data yesterday as borehole HC3 was not located on the cross-section we referenced, but if we got to Appendix 11 and the first page thereof...

Q. Appendix 11?

A. Of H-40A.

Q. That will be the one immediately after page 14 as we have marked it?

A. Immediately after the pumping test graphs, correct, and the first page of that data set, and the page is headed "Summary of Hydraulic Conductivities, Site F", and if we go down the left-hand side under the column headed BH, being borehole, we see HC3-85 and we also see under the heading OW being observation well Nos. 1, 2, 3, 4 and 5. If we go to the far right column headed "Packer Test K" which is indicating the values are in centimetres per second, going down that column to the second, third and fourth data entries we see the first one being 8.9×10^{-4} -- I'm sorry, the second one being 8.9×10^{-4}, the third being 8.7×10^{-4} and the last one, the fourth one being 9.1×10^{-4} centimetres per second. If we look at the elevation data under the column headed "Top of Screen, Bottom of Screen" being respectively the third and fourth columns from the left, we note this data is representative of a vertical interval of 124.8 and running down the column to the top elevation of 130.7. I wish to draw your attention to those elevations.

As I interpret this data, three pressure packer tests were undertaken over that approximate six-metre vertical interval being between approximately 125 and 131 metres in elevation, and now we return to H-220.

Now, looking at the vertical scale on the left for the point of 125 metres, I see that that approximates the bottom elevation of PW-2. Going over to the elevation of 130.7, or approximately 131, I see that that approximates the top elevation of PW-2. I can confirm that information by referring to the interrogatory responses, H-84, and I have left my page conveniently open at Addendum H, being the construction well records for PW-1, PW-2 and PW-3, and the second data page on that is headed PW-2 under the entry of "Pumping Well Number." The third and fourth columns over have the top of screen -- I beg your pardon, a screen level and a top elevation and a bottom elevation and I note the numbers are 131.3 to 123.6 which approximates the vertical interval over which the pressure packer test data were recorded at borehole HC3 in Appendix 11.

We should note the relative position of HC3 relative to PW-2 and I find that in the preceding appendix being the pumping test graphs, and I go to page 9 of those pumping test graphs.

Q. You are in Appendix 10 of H-40A?

A. Correct.

Q. Page 9 as we have numbered them?

A. That is correct. The number I wish to read from is under the heading at the left where we have Jacob Approximation and we have the formula for the T, a formula for S and the notation for Q being the pumping rate and then a small r and r is equal to 14 metres. That is the radial distance from the pumping well to the well in question, this page being HC3. The well nest at HC3 is located 14 metres away from PW-2 and we note that PW-2 was screened over the approximate interval of 131 to 123 and we note that the hydraulic conductivity data for HC3 over the approximately same interval is variably between 8.7 to 9.1 x 10^{-4}, or approximately 10^{-3}. I have rounded out the packer test values as they are high values times 10^{-4} and I have rounded it out to 10^{-3} for convenience. I note back on page 45 of Exhibit B-617 in the second paragraph that using the geometric mean transmissivity that I have calculated, specifically 1.1 x 10^{-5}, and dividing by an open interval of eight metres, being the open interval of the well, I have a hydraulic conductivity of 1.4 x 10^{-4}. The next sentence relates to what we have discussed, the pressure packer test results conducted at HC3 which I indicated was located 14 metres away from this pumping well and we have similar values here and they average 9 x 10^{-4}. The point of the exercise was the demonstrate the interpreted -- calculated hydraulic conductivity I provided from PW-2 is lower but consistent with pressure packer test data calculated from a very similar interval over essentially the same vertical interval at a point 14 metres distant.

Q. Relate that, if you would, to the schematic hydrostratigraphic interpretation of Trow.

A. I am now turning to B-516 and hydrostratigraphic unit 2 as defined by Trow having a hydraulic conductivity of 1 x 10^{-5} and the area in question we are discussing being PW-2 at HC3 and the values could range from a low of 10^{-4} to a high 10^{-4} values, an order of magnitude or more higher than the value assigned by Trow.

DR. KINGHAM: Something else I don't understand about these wells. What you have just told us is that PW-2 and HC3 are 14 metres apart. If you look at H-220 and at the blue line that shows the overburden at the very top, those wells are only 14 metres apart but the overburden is seven metres higher at HC3 than at PW-1?

MR. PETRIE: That is what the information on H-220 indicates, yes.

DR. KINGHAM: Does that have any effect on the pumping behaviour?

MR. PETRIE: I would have to refer -- I

beg your pardon. It may have some effect. I have not evaluated that. I can offer some commentary on that and when I refer to Appendix 11 of Exhibit H-40A, the hydraulic conductivity data which we just had, I notice adjacent to piezometer HC3-85 and adjacent to piezometers 3, 4 and 5, if I go over and look at the slug test data or the rising head data, the second column from the far right, I notice the values recorded there being 1.3×10^{-6}, 4.1×10^{-6} and 1.8×10^{-5}. The range in elevation over which that data are provided range variably from 128.7 to an upper elevation of 138.2 and we could refer to those elevations again on H-220 starting with 138.2, and that is essentially the top of the rock at borehole HC3 and 128, as I indicated before, that is approximately a little bit below the top elevation of the rock at PW-2. Therefore I can conclude that the data provided there, recognizing they were obtained from slug test data and not pressure packer test data, indicates that the upper portion of the rock at HC3 is probably of lower permeability than the next eight-metre or so sequence. I am recalling now that I believe Mr. Beechinor offered some comment on that in cross-examination in that having drilled HC3 they identified some fractures at the elevations in question being below about an elevation of 130 and they also noted I believe there was some water in the borehole at that elevation and that led them to conclude that at that elevation the rock may be more permeable and that was the reason for conducting their pressure packer tests over that interval. I believe the pressure packer tests were conducted in 1985 and the pumping test well was drilled and conducted in early 1986. I would conclude from that that Mr. Beechinor recognized the more fractured zone was in the interval below about 131 metres at HC3 and chose to drill his pumping well close to that in order to calculate or assess the hydraulic significance of that zone at that point.

Q. Going back to page 45 could you just relate your comment with respect to the difference between your CRA range of conductivity to that that Trow has and in particular comment on the latter part of the last paragraph on page 45 regarding the vertical hydraulic connection between the units?

A. Yes. We discussed this before the break and I noted the drawdown data provided in Appendix 10 of H-40, and in H-40 I will be referring to page 9 of the pump drawdown graph, but on page 9 we see a series of five circles drawn across the top of that graph and the legend on the lower left indicates that

that was the water level measured at those five points in time during the test interval for piezometer HC3-A which is equivalent to piezometer HC3-1, the deepest piezometer at the HC3 well nest. On H-220, Exhibit H-220, we note that Trow have located HC3, the deepermost piezometer and have defined it as lying within the highly fractured shale unit being unit No. 4 and sort of adjacent to the large black 4 indicated on Exhibit H-220.

On page 9 Trow have calculated transmissivity data for this well and give a transmissivity in the order of 10^{-4} metres squared per second and I noted that contrasted with the other values for transmissivity for HC3-B and HC3-C. It is my interpretation that because that well is screened at a significantly different vertical interval, we could not interpret that response to indicate a highly permeable aquifer as indicated by the transmissivity value I have just mentioned rather, and I shall read the last sentence from the bottom of page 45:

> "This response implies a significant degree of vertical hydraulic connection across the weakly fractured shale (Unit 3) and hence a higher hydraulic conductivity than that determined by

Trow for this unit."

There are two statements in that sentence if I can repeat them. The first says we have a significant degree of vertical connection across unit 3, and I shall indicate the position of unit 3 on H-220 and in pumping well located here, being PW-2, you see a water level change down here in hydrostratigraphic unit No. 4. I would like to point out that when that question was posed to Mr. Sobanski in cross-examination he concluded that the small amount of data available for HC3-A, being the five data points and the very small change in drawdown, one could not conclusively conclude that that was a response to pumping. I would agree with him. A very small change in drawdown and only five data points do not lead you to a large degree of comfort in interpreting a degree of hydraulic connection across unit 3. However, this is the only data we have at the site on which one can make any interpretation regarding the nature of any hydraulic response between unit 2, the uppermost fractured rock as defined by Trow, and unit 4, being the highly fractured bedrock unit at depth.

The second statement in the sentence reads:

"... and hence a higher hydraulic

conductivity than that determined by Trow for this unit."

That refers to unit 3, being the intervening rock unit as defined by Trow between the pumping well and piezometer HC3-A. In referring back to B-516, we note that the hydraulic conductivity of this unit, unit 3, being the weakly fractured massive shale unit, is reported as 1 x 10^{-7}. It is my expectation that were the hydraulic conductivity of unit 3, the value indicated by Trow, 1 x 10^{-7}, I would not expect to see any response in the unit 4 piezometers. I will repeat what I mentioned earlier. A very small drawdown does not lead to a conclusive interpretation that there is a hydraulic response across that unit.

I also would like to add that Trow provided two models for this site, model 1 and model 2. In model 1 they used a value of 1 x 10^{-7} for the hydraulic conductivity of hydrostratigraphic unit 3. In model 1 they used the same value for the horizontal hydraulic conductivity as for the vertical hydraulic conductivity. For model 2, as I introduced yesterday, they introduced a measure of anisotrop into this determination such that the hydraulic conductivity was one-tenth of the horizontal. That would indicate that for the model 2 calculations, the vertical hydraulic conductivity in unit 3 of the weakly fractured massive shale, being 1 x 10^{-8}, then we would expect even more to see no hydraulic response. I will repeat that sentence. Were the vertical hydraulic conductivity of the weakly fractured shale, being unit 3, were that to have a value of 1 x 10^{-8} I would not expect to see any response in a rock unit being rock unit No. 4 located at depth beneath that zone. The last portion of that sentence -- referring to page 45 of Exhibit B-617 -- because we have a degree of hydraulic or an implied degree of vertical hydraulic connection across unit 3, I would expect the vertical hydraulic conductivity of unit 3 may be higher than that determined by Trow.

Q. Going to the top of page 46 you make a general comment on the existence of the fractured zone within the weathered bedrock. What unit are you referring to there?

A. I am referring to Trow's defined hydrostratigraphic unit 2 and the first sentence on page 46 relates to that which I read earlier. I have taken the statement approximately from page 44 of Exhibit H-40 where the first sentence at the very top of the page on page 54 of Trow's report indicates that Trow conclude from the pumping test that the data indicate a relatively extensive fracture zone in the weathered shale. I have agreed with that interpretation and I note from Exhibit H-220 that the fractured shale they are referring to is indeed a vertical portion of hydrostratigraphic rock unit No. 2, being the fractured shale unit.

DR. KINGHAM: Could I ask you to clarify at that point? In light of our discussion of ten minutes ago, if that unit you pointed to is the weathered upper shale, then how is it that the unit immediately above it in HC3 has a low hydraulic conductivity? Is that unweathered or are you not able to answer that question?

MR. PETRIE: I'm not able to answer it. There is some information which leads me to some understanding, and again I refer to the hydraulic conductivity data, Appendix 11, where they describe on the first page of Appendix 11 in Trow's H-40A, and I see the fifth column from the left is headed "Geologic Material." As I come down to HC3 the first two entries are shale and I'm not addressing that and the next seven entries are described variably as fractured shale or weathered shale. The only other information I believe contained in the document addressing that question would be the borehole logs contained in Appendix 2 and what that contrast in permeability indicates to me is that within rock unit 2 at HC3 as defined by Trow there are some significant contrasts of the values for hydraulic conductivity. Specifically they range, and again I'm referring to Appendix 11, the first page, and I am looking at the data between an elevation of 124.8 and going all the way down to 138.2, or in other words all the values adjacent to the geologic material indicated as fractured shale or weathered shale and I see values that range from a low of 1.3 x 10^{-6} to a high of 9.1 x 10^{-4}. Rounding those numbers out I see a range of 10^{-6} to 10^{-3}, a three order of magnitude contrast in the hydraulic conductivity over essentially an eight vertical metre interval of rock, all of which is defined as I interpret from H-220 as being in hydrostratigraphic rock unit No. 2.

MR. McQUAID: Q. All right. Can we continue then to ask you to give us your observations and conclusions as a result of looking at pumping test PW-3 described on page 46 of the report?

MR. PETRIE: A. The text developed by Trow in addressing pumping test PW-3 is contained on page 54 of Exhibit H-40 and the first complete paragraph on that page is where they indicate:

"PW-3 was pumped at a low discharge rate of 3.0 x 10^{-5} m^3/sec ..."

If I recall that was about 0.2 Imperial gallons per minute but I don't have the calculation in front of me. They interpret from the pumping test that the amount of interference was small at WAT5 and then:

> "The projected cone of influence from the distance-drawdown diagram suggested that the cone of influence for this test would extend about 22 m from the pumping well ... this test result indicates a fracture zone within the weathered shale that has limited lateral extent."

Again I inferred from that that the weathered shale they were referring to was their hydrostratigraphic rock unit No. 2 and when I examine H-220, and I'm trying to decide and I can't see it quickly, but if it is TW-3 or TW-4 that is the pumped well. I note from Exhibit H-220 that TW-3 penetrates a greater thickness of the interpreted hydrostratigraphic rock unit 2 than does TW-4.

Q. I think you said earlier this morning that PW-3 was pumping well test 3.

A. If I said that I believe that that was an error. I beg your pardon. TW-3 and TW-4 relate to pumping test 3, but I'm not sure which well is which. I was under the impression that that data was available in Appendix 10. I have found a reference which indicates which of those wells is which. I am referring to Exhibit H-84 being the interrogatories to Weir & Foulds and again I am at Addendum H and again I am at the second page, the second page of data under Appendix H, and I note that for PW-3 we go to the next column "Observation Well Number" and going down we see OW3-86 and then in brackets (TW-4-86) so I would interpret that to indicate that TW-4-86 is an observation well and therefore the other well, TW-3,is the pumped well. In my review of this data I note that Trow has reported transmissivity values ranging from 2.6×10^{-6} to a high value of 4.8×10^{-5} metres squared per second.

Q. These are the range we see in the second sentence on page 46 under pumping test PW-3?

A. Correct. I note that we have a reported geometric mean value of 1.8×10^{-5} and I believe that that was a calculation I did as I do not see it in the Trow report, but I would like to check that over lunch to make sure that that is indeed my calculation and I have not taken it from an unreferenced place.

Running with a value or a geometric mean of 1.8 x 10^{-5} metres squared per second being the mean transmissivity available determined from the data available from pumping test 3, and recognizing that I will check that over lunch, and dividing by an open borehole length of five metres, we arrive at a mean hydraulic conductivity value of 3.6 x 10^{-4} centimetres per second. I can clarify where the five-metre vertical interval came from, and I would refer to H-84, Appendix H, the second page of data in that addendum. PW-3, and under the heading of "Screen Level" we have a notation that the top of the screen is 126.9 metres above sea level and the bottom of the screen is 121.9 metres above sea level for a vertical interval of five metres being the open length of the borehole. I have taken that five metres and divided that into the geometric mean value for the transmissivity and I arrive at a mean hydraulic conductivity value.

Q. Can you then indicate what you conclude as a result of that calculation of the hydraulic conductivity, the K value?

A. I have calculated a value of 3.6 x 10^{-4} for the hydraulic conductivity and I can relate that back to the hydraulic conductivity for hydrostratigraphic rock unit No. 2 which Trow indicate they have an assigned value of 1 x 10^{-5}. Again we have from the pumping test a mean value -- a hydraulic conductivity value in excess of one order of magnitude of that for the value assigned by Trow.

Q. All right. Then, could you explain what you are addressing in the second paragraph under PW-3 on page 46?

A. I am addressing a sentence I read earlier and the sentence was taken from page 54 of H-40, the sentence in the first complete paragraph, the last sentence of that first complete paragraph:

> "This test result indicates a fracture zone within the weathered shale that has limited lateral extent."

Q. Then you go on to indicate in the sentence, concluding sentence of that second paragraph:

> "The drawdown pattern from this test ... appears to demonstrate the existence of a relatively continuous fracture network in the moderately weathered and fractured shale (Unit 2)."

So your view is a relatively continuous fracture network compared to Trow's of a limited lateral network or extent of fractures?

A. I draw those conclusions from looking at the shape of the drawdown curves provided on pages 11, 12, 13 of Appendix 10 of H-40A.

Q. All right. Then, continuing on page 46 over to the top of page 47, you have conclusions with respect to all three pumping tests we have been discussing this morning?

A. That is correct.

Q. Could you just indicate or summarize for us what these three investigations indicate to you?

A. Well, three pumping tests were conducted by Trow at this site and in each case -- I beg your pardon -- for two of them, PW-2 and PW-3, they only intercept the upper five to eight metres of the bedrock respectively and for PW-1 I conclude that only the upper seven metres or so of the rock is contributing water to the well. In that case we have three pumping tests, each of which effectively stresses or provides a hydraulic measure of the upper less than eight metres of the bedrock at the three sites in question, the three sites in question, one being near the property boundary of the site, PW-1, and I am referring to an overhead we exhibited earlier, B.1.1 and locating the three pumping wells, PW-1 being here, for which it is my interpretation that the upper seven metres of the bedrock contributes water to the pumped well, PW-2 over here midway on the western side of the boundary for which I believe the number is eight metres and which contributes water to the pumping well and PW-3 located here and downgradient from the Bayview landfill which is screened over a vertical interval of five metres. At those three locations I interpret from the data that the transmissivity of the rock in each case is of the order of 1 x 10^{-5}, and I have quoted at the top of page 47 1 x 10^{-5} centimetres squared per second and I'm very sure that that should be metres squared per second. Yes, it should be, so could I make that correction?

Q. We should write the "m./sec" rather than centimetres?

A. Correct. For those three pumping tests the data lead me to calculate mean transmissivities for each of them in the order of 1 x 10^{-5} metres squared per second and I calculate the hydraulic conductivity for the rock at each of these cases ranging from a low of 1.1 x 10^{-4} centimetres per second ...

Q. A low of 1.1 because it's 1.4 in the text?

A. You are quite correct and I can repeat that statement. It is ranging from a low of 1.4

x 10^{-4} to a high value of 3.6 x 10^{-4} for a mean of 2.1 x 10^{-4}. To repeat that, we have three pumping tests each which give us very similar results for the hydraulic properties of the rock and each which provide rather consistent data regarding the hydraulic properties of the upper portion of the rock from three widely-separated tests.

Yesterday we looked at a variety of hydraulic conductivity data in Appendix 11 of the Trow report and indicated with a series of overheads the values ranged from as high as from about 10^{-4} to much lower values. We are then in a position of comparing the values obtained from the pumping tests with values obtained from the other test procedures adopted by Trow. It is my opinion that the pumping tests provide a better representation of the hydraulic properties of the bedrock over that portion of the rock that was pumped than do either packer tests or slug tests. The reason for that is, (1), the test period was conducted over a significantly longer period of time relative to a packer test or a slug test. The second is that we are moving a much larger volume of water compared to a packer test or a slug test. Thirdly, in response -- we can measure the response to pumping in adjacent wells and it is that response to pumping measured in adjacent observation wells that gives me a clear indication of lateral connection or fracture connection between one well and the other. I cannot make those interpretations based solely on slug test or packer test data, but from pumping test data I believe I can interpret a good measure of the hydraulic connection between various wells at the site and, secondly, because I am stressing a larger area of rock and moving a larger volume of water and conducting a test over a longer period of time, I believe the pumping test data provides me with a much better representation of the hydraulic properties of the upper portion of the rock at this site, or at least of the three intervals tested by pumping.

I would just like to go back to page 40, the first couple of sentences which provided a summary of the discussion of the pumping tests and I just want to make sure I have covered all the points I intended to make. On page 40 under the heading of B.3.5 "Pumping Tests", the first sentence:

> "CRA cannot support the conclusions developed by Trow from analyses of these pumping tests."

Specifically that relates to the identification of the highly fractured shale unit as determined from interpreted pumping tests. It is my contention that at PW-1 we are stressing the uppermost seven metres of rock and I wish to make a clarification on the number of seven metres and I will come back to it in a minute, but the uppermost seven metres of rock and as I note on Exhibit H-220, which provides the indication of the hydrostratigraphy at this point as determined by Trow, at a portion of the uppermost part of the rock at TW-1, it is indicated as being within hydrostratigraphic rock unit No. 3, the tight rock, and the lower portion is indicated as being in hydrostratigraphic unit No. 4, the more highly fractured unit. I wish to point out that there is no fracture log available for wells TW-1 or TW-2 nor indeed for the other pumping wells, TW-3, 4, 5 and 6. The only information I have regarding any fracture information is that provided on H-220 and it is not apparent to me how this fracture pattern was interpreted. The nature of drilling, in this case being a cable-tool rig versus the rotary drilling method they employed for their observation wells, does not lead one to conclude or does not lead one to produce substantial conclusions regarding the nature of fracturing at that point. There is no discussion in the text referencing the drilling of these holes such that had there been some observations made regarding the fracturing or lack of I might have expected to find it in the text. The only information I have is that available to me on H-220.

I mentioned earlier I wish to make a clarification regarding the seven metres of bedrock exposed to the pumping well. The need for this clarification arises because of my difficulty in assigning elevations to my copy of H-220, the same copy provided as Figure B.3.2 on page 29 of Exhibit 617. The difficulty arose because I could not feel comfortable with the elevations. Over the break I took the elevation data as recorded on the original copy of H-220 and that elevation data is provided on the left-hand scale and I have made notations on the copy I have here taken from the CRA report, page 29, and have indicated the elevation of the standing water being 110.76.

Q. Could you give those numbers to us because they can't see them at this distance?

A. I can point out that I can make a copy of this over lunch.

Q. You have done that on your version?

A. Correct.

Q. On that PW-1 hole you have entered

in red what the elevations are of some of the key points; is that correct?

A. Correct. The first elevation I have entered is the elevation of 110.76 and that is the standing water level measured -- the standing water level measured in PW-1 prior to pumping. I note that this standing water lies approximately two metres above the top of rock, i.e., inside the casing which is cased through the overburden materials. The next number I have entered here is 107.8. One-0-seven point eight is the top of the well screen or ideally the top of the open borehole as indicated in Addendum H of H-84, the elevation of 107.8 which is indicated as the top of the rock or the bottom of the casing. For PW-1 a length of steel pipe was inserted into the ground from ground surface to an elevation of 107.8.

In discussing the pumping test graph we obtained from PW-1 I noted there was a pronounced change in drawdown at an approximate elevation of 103. I have indicated that approximate elevation at this point here, 103. It coincides roughly with the base of a yellow section of fractured rock as delineated on Exhibit H-220 and I note that the yellow indicates unfractured rock. I have also located the elevation of 98. Ninety-eight was one of the observation wells for which water level data was provided during the test period of PW-1. I note that from page 2 of the graphs in Appendix 2 that that elevation ...

Q. Appendix 10?

A. Correct. That elevation relates to MB16-3, and I marked the Chairman's copy with 98 and I believe that that 98 isn't in exactly the same position but I will provide a copy of this, being my best representation of the pertinent elevations associated with this well, and I didn't mark the bottom elevation but put a line showing the bottom of the well and I will write that on now, the bottom of the well at PW-1 which is 87.4.

Q. What you are really doing is giving us another scale right on PW-1?

A. That is correct. It is my interpretation from taking this scale data I have just provided, I had indicated earlier that the upper seven metres of the rock contributed water to the pumping well. When I refer to these elevation data it may have been more appropriate to take it as the upper five metres or four-and-a-half -- round it out to five metres as contributing water to the pumped well. Were I to have used that value of five instead of the seven, I would have ended up with a hydraulic conductivity slightly higher.

Q. That is where we see reference to a discussion about that over on page 43 and I think you referred to the seven metres?

A. Correct.

Q. And also the mathematics was done over on page 44. Earlier I had asked you if you had got to your -- do you see the last paragraph on page 44:

"For an aquifer thickness of 7 m, ..."

A. Correct.

Q. You had divided the seven metres into the geometric mean of 1.3 x 10^{-5} and are you saying to be more accurate you could have divided the 1.3 by five metres?

A. Correct and I would have ended up with a marginally higher value for the hydraulic conductivity.

Q. Can you do the mathematics for us?

A. I believe Mr. Crutcher has anticipated the question. The value would be 2.6 x 10^{-4}. Mr. Crutcher, you divided by five metres? Dividing by five metres would have given a value of 2.6 x 10^{-4}. One would note that that is marginally higher than the value of 2 x 10^{-4} and one might also note that with respect to the summary statements provided on page 47, and I am referring now to B-617 and the top paragraph, the partial paragraph, we note that the calculated hydraulic conductivities range from 1.4 x 10^{-4} to 3.6 x 10^{-4} and changing that value, the value for the hydraulic conductivity at PW-1 from 2 x 10^{-4} to 2.6 x 10^{-4}, it doesn't change the range of values there and it would make a very small change to the mean value for the three values.

DR. KINGHAM: While you are considering the necessary changes and corrections, I don't know if your evidence turns on this but I would encourage you to reconsider the location of PW-3 which, according to H-84 is screened at the bottom at 121.9 and the top at 126.9 and if that is in fact TW-3 that you have shown on there then it is screened above the bottom and the top of the screen is in the overburden whereas if it was TW-6 to the left on H-220, it would be screened at 121.9 and would be screened in that weakly fractured weathered zone. You will also note on H-220 that those are the three wells which have the solid red line on them. If anything turns on it I would suggest we get it right at the front end instead of somewhere in the course ...

MR. PETRIE: It is a point I had not

noted and I stand corrected. I would like to check that over lunch but I believe as I observed the diagram and listened to the numbers you recorded that your observations are indeed correct. I don't believe anything turns on it.

MR. McQUAID: I wonder if this would be a convenient time to break. I realize it is a little early.

MR. LANCASTER: Fine. That will bring us back at 1:30.

--- Luncheon recess (12:15 p.m.)

--- Upon resuming at 1:30 p.m.

MR. LANCASTER: Please be seated. I see we have a panel of three.

MR. HODGSON: Get out of there, Feenstra!

MR. McQUAID: Mr. Petrie, you have provided me with a photostat of I guess it's the right-hand portion of page 29 from your report on which you have made a series of elevation entries.

MR. LANCASTER: That will be B-623.

MR. McQUAID: If you would like to put the same number on as the report then we could reference the page if you like, B-617-29A.

MR. PETRIE: It is page 29 from Exhibit 617.

--- <u>EXHIBIT NO. B-617-29A</u>: Chart, page 29 of Exhibit No. 617

MR. McQUAID: Q. The entries you have made, 110.76, 107.8, 103, 98 and the 87.4 metres above sea level, each of those are from the source material in Appendix 10 for the PW-1 hole; is that correct? You have summarized ...

MR. PETRIE: A. There was more than one source for this material. Some of it came from the interrogatories, H-84, Addendum H, I believe in that document, and some from Appendix 10 of H-40A, being the appendices to the Trow hydrogeologic report.

Q. The other question I would like you to address is a question Dr. Kingham put to you just before the break and that is to ask you if you can from reference to the material or the discussions you have had over the break to just locate the PW-3, pumping well 3 test hole on page 29, or H-220.

A. Over the break I was advised by Mr. Hodgson as he interpreted it or as Mr. Feenstra interpreted the initial Trow data that TW-4, being one of the boreholes referenced on H-220 is equivalent to or the same as pumping well No. 3. If I refer to Figure B-3.2 from page 29 or Exhibit H-220, being the same thing, TW-4 -- of the TW wells it is the fourth from the left being the sixth installation across from the left of Exhibit H-220. However, when we looked at additional data in Addendum H of Exhibit H-84, the interrogatories -- sorry, Addendum I.

Q. Where do we look?

A. At Addendum I. The first page is a location map referencing PW-1, the test at PW-1, and the second page reference is PW-2 and the third page is entitled at the bottom "Pumping Test No. 3, (PW-3)" and I notice as I look at that drawing near the very top -- I beg your pardon -- the far left top of the drawing we have an entry for WAT3 and following down a diagonal line passing the number 63 metres and we come to a borehole installation indicated as OW3-86, TW-4-86. Going further down to the right towards the middle of the page where we have the large black symbol for a pumping well we have PW-3, (TW-3-86). I suspect the data are in conflict and it is not apparent to me which well of the TW series indicated on H-220 is PW-3. I might note that at the bottom of the page we are looking at in Addendum I, "For the master plan, refer to Drawing 5 of the Site F report." I don't have a copy with me and I looked at it over lunch hour, but the TW wells are not located, only the PW wells and so I can draw no additional information from the notation at the bottom of that page.

Were we to take, as Mr. Hodgson suggested may be the case, TW-4 as being PW-3, if I go to Exhibit H-220 and locate TW-4, I notice that the top of rock at TW-4 appears to lie at an elevation of approximately 120 metres. That is the top of rock. I then see the borehole is open for some interval below that and that interval appears to be down to an elevation of approximately 115 metres. I notice also that that open elevation is juxtaposed to the number 3 and the number 3 refers to, on Exhibit H-220, Trow's hydrostratigraphic unit No. 3. That raises further questions in my mind as to just where this well is located. I would note that those elevation data I just read out, or which I just interpolated from Exhibit H-220, are not consistent with the data contained from Addendum H of Exhibit H-84. That is the addendum immediately in front of the figure I referred to in which we have the elevation data for the well screens as recorded in the pumping tests. I conclude that I'm not entirely sure what the record TW-4 located on H-220 refers to. There is no additional information in the text and there was no borehole log for this installation to which I could refer and I am unable to comment further on your question because I don't know which is which. I interpreted in the report, B-617 and as indicated on Exhibit H-220, that TW-5 and TW-6 were the pumping wells and they are as indicated on Exhibit H-220 screened or have an open hole within Trow's hydrostratigraphic unit No. 2, being the fractured shale. I suspect that because the wells were pumped and provided some water, I suspect Trow, if I could speak to them, they would suggest the two wells indicated on 220 may refer to the two pumping wells referenced. However, I am not particularly sure.

MR. HODGSON: If I could, first of all

obviously it is the responsibility of the Region to clarify this problem. At the moment we were able to establish over noon hour that in fact PW-4 is pumping well No. 3. However, we haven't as yet been able to clarify the appropriate elevations and it would appear there is some inaccurate datum plotted on H-220 and if the Board would allow us to work on this over night I hope we can clarify it all by tomorrow. I apologize.

DR. KINGHAM: The only reason we raised the point was in the event it would have a material effect on your conclusions and I will leave it to you and your evidence as to whether it does or does not.

MR. PETRIE: I appreciate you raising the point, but my conclusions were based on the interpretation I see before me on H-220 and the two TW series wells being TW-5 and TW-6 were the pumping wells and they are indicated with a bold red stroke as is TW-1 which I believe is PW-1. Were TW-4 to be the pumping well and indeed -- let me back up. If TW-4 as indicated on Exhibit H-220 is the pumping well, then I believe Trow may wish to evaluate this cross-section because I don't think it is appropriate to consider that they pumped their hydrostratigraphic unit No. 3 and I don't think that was the intention of this drawing or that one could interpret the data to indicate that that is what Trow may have undertaken.

DR. KINGHAM: It appeared quite obvious to us that if TW-4 was PW-3 then it was screened entirely in the overburden according to H-220 and that did not make sense to us.

MR. PETRIE: It does not make sense to me either.

MR. McQUAID: Q. On the other hand if PW-3 is TW-4, then what is the significance of that?

MR. PETRIE: A. The only information I have regarding TW-4 is the information we have before us on Exhibit H-220 which appears to show that the bedrock is at the lower elevation and it is screened or the bedrock is open at a lower elevation consistent with unit 3 as defined by Trow. However, the data for PW-3 in Exhibit H-84 provides different elevation data and I do not know which is which to that point. I would hesitate to draw any conclusions based on that confusion.

Q. Now just before the luncheon break you were at the point where we were discussing the summary that you had reached dealing at pages 46 and 47 as a result of looking at these three pumping tests. Can you tell us then are we looking at two pumping tests and what, if any, of the conclusions we see on these pages would still be applicable?

A. I believe we are looking at three pumping tests. I recognize from the previous discussion there was some confusion regarding the elevation of the open portion of the borehole for PW-3. However, irrespective of the elevation, it yielded water in a pumping test and it also indicated information regarding the degree of hydraulic connection to an adjacent observation well. I believe that interpretation does not hinge on whether the pumping well is screened in hydrostratigraphic unit 3 or 2. I have concluded that the data provides me with a measure of the hydraulic conductivity of the upper portion of the rock at the interval pumped and recognizing we are not exactly sure what that interval is.

Q. Could you go through the conclusions and perhaps number them as we go through as to in summary what these pumping well test data indicate to you?

A. On page 47 we have a summary of the data provided as I have interpreted it from the pumping tests. The hydraulic conductivities developed from these pumping tests range from a value of 1.4×10^{-4} to 3.6×10^{-4} centimetres per second for a mean value of 2.1 x 10^{-4}.

Q. That is your first summary conclusion?

A. Correct.

Q. That should be compared to, what was it, 10^{-5} on the Trow schematic?

A. On Exhibit B-516 we have a value of 10^{-5} being the hydraulic conductivity for the fractured shale unit and that is Trow's hydrostratigraphic unit No. 2. So we are in excess of an order of magnitude, rounding it out, an order of magnitude higher hydraulic conductivity as determined from these pumping tests with respect to the value assigned by Trow to that unit.

Q. All right.

A. The next summary is summary point No. 2 where we conclude that all three tests, and I am referring to the first complete paragraph on page 47, that all three tests demonstrate the existence of a permeable fractured zone within the uppermost portions of the bedrock and specifically three pumping tests were conducted and they each provide very similar measures for the hydraulic conductivity and I conclude that that hydraulic conductivity is representative of the value of the open portion or portion of the open part which was screened, being the uppermost portion of the bedrock, at each of those three locations.

The third point I wish to make being the second complete paragraph on page 47 is that I do not agree that the test results from PW-1 confirm the presence of the highly fractured shale unit, unit 4, as defined by Trow. I would make a different conclusion, that the results demonstrate the existence of weathered and fractured shale which mantles the bedrock at each of the three pumping test sites and note that this weathered and fractured shale has a mean hydraulic conductivity of 2 x 10^{-4} and further that this weathered and fractured bedrock mantle is more extensive than the moderately weathered and fractured shale unit, unit 2, as interpreted by Trow. The figure referenced in brackets is page 27 which is essentially the same figure we have behind us, being B-516. I think it would be more appropriate to examine that point in connection with the figure on page 27 of Exhibit 617.

On page 27 of Exhibit 617, Figure B.3.1, we would note that PW-1 would be located at approximately the position of HC8 along this cross-section, i.e., to the left of Highway 403 and at the downgradient extremity of that block of rock so shown on this schematic. PW-2 and 3 are located further up the site in the approximate area indicated by borehole HC4. The point of referring to that diagram is as I have interpreted the pumping test data to indicate weathered rock -- existing at each of those locations, PW-1, PW-2 and PW-3, leads me to the interpretation that weathered rock may extend across the site and beneath the till identified at the downgradient end of the site. To that end I make the statement on page 47, the last portion of the last sentence, that the weathered and fractured shale is more extensive than the moderately weathered and fractured shale, unit 2, as interpreted by Trow.

I could refer that statement back to the fracture frequency profiles which we looked at early on yesterday afternoon, and I am referring now to page 23 of our report, Figure B.2.2, where I noted that while the fracture pattern on the figure is rather erratic, there is a tendency towards a reduced number or reduced incidence of fracturing or highly fractured zones with depth and that one could conclude as I have done based on the pumping test data that the more fractured horizon at the surface has a degree of continuity across the site. This contrasts with the interpretation provided by Trow that unit 2 pinches out at that location and it does not extend laterally to the property boundary.

Q. Could you remove the versions of H-220 for a moment because I want to be sure? Now, we are really looking at page 27 with the notation that Dr. Rowe or Dr. Charlesworth put on it, and we have looked at B-516, but I want to be sure if we understand whether you are saying that -- you use the expression on page 47 the weathered and fractured shale mantles the bedrock at each of the three pumping test results which you have indicated on this exhibit, 516, extends from HC8 on the south to approximately HC4 on the north and actually they are not shown on B-516.

A. They are not shown and that is why I referenced the figure.

Q. Are you saying that it's unit 2 or something different from unit 2? Unit 2 is defined by Trow as moderately weathered and fractured shale, and we see it on page 27.

A. Unit 2 is defined by Trow as moderately weathered and fractured shale and based on my review of the data available to me I have difficulty in agreeing with the hydrostratigraphic interpretation as provided by Trow.

Q. Do you have an overhead of page 27?

A. I do.

Q. Could you write on that overhead PW-1 in the location of HC8?

A. Could I get a copy of Drawing 5 from Trow's Site F so I can be sure I have it approximately in the right correct location along the site? I am taking Drawing 5 from Exhibit H-40, being just the well locations on the map, and from Drawing 5 of Trow's report I have indicated in red the locations as I project them onto this cross-section, the location of PW-1 being projected approximately onto this cross-section immediately upslope from Highway 403, and PW-2 and PW-3 being projected onto the cross-section just downslope from HC4 and they are each projected at a similar location. I might point out that PW-2 is located to the west of the cross-section on one side of the site and PW-3 is located to the east of the cross-section on the other side of the property.

Q. Is it possible to draw on there then at a depth as well what the weathered and fractured shale -- what the pumping well test would indicate as to the weathered and fractured shale across that distance from PW-2 to PW-1?

A. It is not. On this cross-section we have additional data from HC6 and HC8 and when we get to our interpretation in part C I will indicate that the hydraulic properties of the rock there may be indeed different than one might interpret from the pumping test data at PW-1 and 3 and also at PW-2.

Q. Thank you. Then, going back to the text on page 47 I see a section under B.3.6 discussing tritium distribution.

A. Correct. The tritium, while it is a chemical parameter, I have included it in this portion of our critique of the Trow report because they, Trow and myself, as indeed have other researchers or investigators at this site, have used the tritium data as a measure of the hydraulic characteristics of the rock and now I will speak to Figure B.3.7 being page 48. This is approximately the same cross-section we have seen previously and we are placing on the easel Figure B-620 being the base hydrostratigraphy of the site as we interpret it from Exhibit H-220. I will point out on Exhibit B-620 we have borehole HC6 being the second borehole from the left and on the overhead before you we have HC5. HC5 and HC6 are at similar locations on the site with respect to the south property boundary and they are not located similarly with respect to the profile. I have projected HC5 onto this location instead of HC6 because the tritium data provided by Trow, they sampled two wells for the tritium distribution, being HC5 and HC8. On this cross-section I have provided all the tritium data as provided by Trow. The hydrostratigraphy definition of the site at HC5 is taken from Exhibit H-220 and at this point I am trying to recall is it my interpretation of reading H-220 that allows me to define the position of the rock stratigraphic units at HC5 or did Mr. Beechinor make those picks for us in cross-examination? I am under the impression Mr. Beechinor interpreted H-220 for the Board and gave the relative elevations of the rock units at HC5.

DR. KINGHAM: I am confused. You just told us you put the tritium values on HC5 from Exhibit 220 but they seem to be in the opposite order from that shown on H-220 unless they were changed around.

MR. McQUAID: You may recall when the exhibit was put in the point was made that it had been reversed when it was entered on 220 and they should be read in reverse order from what in fact they were entered as.

DR. KINGHAM: I understood that for HC8, but I guess I did not understand that for HC5, so it is for both.

MR. PETRIE: We can find the original

tritium data as reported by Trow in Appendix H-40A -- Exhibit H-40A and it is Appendix 12 and that is a rather large appendix.

MR. McQUAID: Q. I have it as Drawing 20 in H-40.

MR. PETRIE: A. Correct.

Q. In the first volume. It's the actual third or fourth-last page in the document.

A. I don't have my copy before me. I left it upstairs through the lunch hour.

Q. Here.

A. Thank you. I believe that data is consistent with the data in Appendix 12, and I'm just checking the data. I'm checking Drawing 20 in Exhibit H-40, which provides the tritium profile for boreholes HC5 and HC8, and I'm checking that data against one page of Appendix 12 in Exhibit H-40A. Looking at Exhibit H-40, Drawing No. 20 and starting at the bottom left we see HC5-85 and going up the profile the first entry is 4.57 and that entry is, as I see at the scale across the top, is the tritium units and going over to the page in Appendix 12 I see the same value beside HC5-85-1. Going further up the next number is nine and the next is 24.69 and the next number is 36.6. The only difference I see is a 36.61 in Appendix 12 and a 36.6 on Drawing 20. It's my opinion that that difference is of no significance.

For borehole HC8-85, starting at the bottom on Drawing 20, the first entry is 0.18 and going over to the far right column in Appendix 12 for HC8-85 I have 0.18. Going up the profile I see 0.17 and that is consistent, 0.21 and 1.03.

Q. That would seem to indicate that in fact both entries had been reversed on H-220?

A. Correct.

Q. They are correctly shown now on this page 48 of your report?

A. Correct. In response to your question, Dr. Kingham, I took the stratigraphic position of the rock units at HC5, being the elevation of Trow's unit 2 and Trow's unit 3 and Trow's unit 4 from H-220. I did not take the tritium data. I'm sorry, I did not mean to confuse you.

With reference to the tritium distribution, we see at HC5 the pattern one might normally expect in a groundwater flow system where there is infiltration from the surface moving laterally downward. I do not place much significance on the decreasing values, and the significance I place on the numbers by adding the tritium units is that at HC5 all the values exceed a value of about 2.5 tritium units. I'm just locating the value Trow used in their report as being the cutoff between modern water or post-1952 water or water that is older than that date. I see on page 70 of Exhibit H-40, and I'm referring to the first complete paragraph, and the first word is "Brown (1961)" and two-thirds of the way down the paragraph I see the sentence:

> "Therefore, pre-1952 atmospheric waters are calculated as yielding a present-day activity of approximately 2.3 T.U."

And T.U. is a measure of tritium units. Now that value of 2.3 T.U. was used in the present study to differentiate between groundwaters recharged prior to 1952 and those infiltrating after 1952. Using the number of 2.3, which I am in agreement with, I notice at HC5 all the tritium data exceeds the value of 2.3. It is my interpretation that the water at each of these well screens is younger than 1952, or essentially less than 35 years old. While there is a trend to decreasing values, it is not always -- one cannot readily back-calculate the relative age between 1952 and present from these tritium data. One can comfortably conclude that values in excess of 2.5 indicate water younger than 1952 and values of less than 2.5 indicate water older than 1952.

Going to HC8 I notice that all the values are less than 2.5 and I conclude from that that all the water sampled at the piezometers in HC8 is older than 1952. The significance of this data with respect to the hydrostratigraphic interpretation of the site as provided by Trow is apparent when one looks at the boreholes screened in the highly fractured shale, hydrostratigraphic unit 4, and I am referring to piezometer 2 at HC5 and piezometer 2 at HC8. Were the highly fractured shale unit to exist as postulated or exist as implied on this diagram B.3.7, having found post-1952 water at piezometer 2 in HC5, I would have expected to find post-1952 water at HC8 in piezometer No. 2. In other words, had water since 1952 migrated down into the highly fractured shale, I would have expected to see a value in excess of 2.5 for the tritium, i.e., water younger than 1952 at HC8 within that same unit, but I do not see it which leaves me to conclude that we don't have the hydraulic conductivity laterally at this elevation between the two boreholes indicated.

Given that that is the only tritium data that Trow collected, then based on the tritium data I cannot conclude that the tritium data confirms the hydrostratigraphy of the site.

Q. Do we turn then to page 49 and the section summary of hydrogeology?

A. Yes, we do. This summary starting at 49 and going to pages 50 and 51 summarizes all of Section B.3 which is the geologic data we looked at yesterday, specifically the fracture frequency profiles, the hydraulic data we looked at yesterday and this morning, the water level data, the gradients, the hydraulic conductivities, the pumping test data and the tritium, and I would like to go through each of the points raised on page 50 starting at the top. Point 1, the hydraulic gradients are directed downwards beneath the highly fractured shale indicating that this unit is not present as defined.

Secondly, the available hydraulic conductivity data do not indicate the existence of a highly fractured shale, unit 4, with a hydraulic conductivity of 1 x 10^{-2}.

Q. And you indicated nor does it indicate 10^{-3} or 10^{-4}?

A. Correct. Point No. 3, the available hydraulic conductivity data obtained from the slug tests and packer tests from depths in excess of ten metres below the bedrock surface, and that is unit

3, show a significant range in hydraulic conductivities. Value as high as 1 x 10^{-5} are encountered over a three-metre interval which is inconsistent with the existence of the weakly fractured shale, unit 3, as defined.

Point 4, hydraulic conductivities up to 1 x 10^{-3} centimetres per second are encountered in the moderately fractured and weathered shale, hydrostratigraphic unit No. 2. These values are significantly higher than the 10^{-5} centimetres per second assigned by Trow to this unit.

Point No. 5, the three pumping test results demonstrate the existence of a permeable zone with a hydraulic conductivity in the order of 2 x 10^{-4} centimetres per second at the surface of the bedrock. This zone is equivalent, and I would like to change the word "is" to "appears" if I may make that notation. In the second sentence under heading 5 on page 50, the first three words should read "This zone appears equivalent..." Now, completing that, this zone appears equivalent to the moderately fractured and weathered shale, unit 2 of Trow, but is interpreted to be more extensive than that indicated by Trow. On page 51, No. 6, groundwater containing elevated levels of tritium, and by "elevated" I mean in excess of 2.3 tritium units being post-1952 water, but groundwater containing elevated levels of tritium are encountered within the highly fractured shale, unit 4, at HC5 but not at HC8, indicating a poor degree of lateral hydraulic connection. This is inconsistent with the occurrence of the highly fractured shale, unit 4, as interpreted by Trow.

At this point we have reviewed all the geologic and hydraulic data developed by Trow from their fieldwork and it was my understanding that this data, the field data, provided the basis for their interpretation of the schematic hydrostratigraphy which I would like to highlight again, being Exhibit B-516. Based on my review of the data I cannot agree with this schematic interpretation.

Q. That as you say completes the examination of the geology and the hydrostratigraphy data which you have been explaining to us. Over at page 52 I see a section addressing the flow modelling.

A. That is correct. After Trow had conducted their fieldwork they then developed a groundwater model in order to, as I understand it, provide an interpretation of the groundwater flow patterns at this site. In doing so, reading from the top of page 52, Trow performed a number of computer simulations of the steady state groundwater flow system at Site F. By steady state we mean they did not impose any change in water levels on the system, the sort of thing one expects on a seasonal basis, they assumed -- and it's a method which hydrogeologists who evaluate such systems would commonly require, a steady state so that the groundwater flow system does not change with time. A general discussion of these simulations is provided in Exhibit H-40, page 61, H-40 being Trow's Site F report. I note there, and I am indicating to the Board on page 61 of the Trow report that after the second complete paragraph I shall read to you:

> "The hydrostratigraphic units described in Section 6.2 are the basis for the computer simulation."

Now Section 6.2 is essentially the section addressing Exhibit B-516. Having provided the discussion in support of this schematic the schematic then provides the basis for the computer simulation.

Continuing on on page 61 in that same paragraph:

> "The final model calibration was accomplished after more than 50 simulations, which included analyzing the effects of variable boundary

conditions, heterogeneity, and to a lesser extent anisotropy. The resulting computer simulation represents a reasonable approximation of the field data with respect to the geology, hydraulic conductivity, water table, and groundwater gradients (horizontal and vertical)."

I would like to point out that my reading of that led to some concerns. It is my position having interpreted the hydraulic data provided by Trow that the schematic we see before us as B-516 cannot reasonably be used as input data for a computer simulation representing groundwater flow at the site. However, I recognize that a model has been provided by Trow and in this section of the report, the report being our report, Exhibit B-617 and in Section B of this report we are providing a critique of the Trow report and while I recognize the basis for this model I cannot agree with I have also undertaken a review of that report.

Now, returning to page 52 of Exhibit 617 I note that the model Trow has produced in their Exhibit H-40, the one I referenced in the text in my reading a moment ago I have described as model 1. I vaguely recall yesterday I may have called it model A and if so I wish to clarify for the Board that when I am referring to model 1 I mean Trow's initial model reported in Exhibit H-40. When I refer to model 2, I am referring to the better fit model produced by Trow during the cross-examination and exhibited before this Board as Exhibit H-221. I note in the second paragraph on page 52 that the model used for the simulations is called Flonet. It is a steady state two-dimensional finite element model which for the given hydraulic conductivities and the prescribed water table simulates infiltration, water levels and flow patterns in a porous media. There are two points to note and the first is a prescribed water table. One of the conditions this model requires for its operation is a prescribed water table and that entails that the computer modeler enter in the position of the water table as part of the modelling exercise. In other words, the water table is entered into the system and cannot change during the computer simulation and we have said prescribed or fixed to define that process. So, this model requires a fixed water table.

The second point to note is the last two words of the sentence, porous media. A large number of computer flow models have developed for porous media and a porous media generally implies sand or clay or gravel as opposed to fractured rock. In fractured rock the pattern of groundwater flow is constrained by the position of the fractures. It is also governed by the gradients and the pressure head differentials in the system, but essentially the water can flow only along the fractures. In order to describe groundwater flow at Site F for a modelling exercise one might be tempted to use a model in which the fracture geometry would have to be entered, being the main control for groundwater flow at the site.

However, we recognize as did Trow that the fracture pattern at this site was exceedingly complex and it is quite unreasonable to produce a fracture flow model which would incorporate all the fractures at the site in order to provide a pattern for groundwater flow at the site. They did what many hydrogeologists do when faced with fractured rock, make a limited assumption we are dealing with porous media in which the groundwater flow can move in any direction possible given the governing hydraulic conductivities and gradient data.

Then at the end of the second paragraph is the comparison of the water levels at the appropriate node with those measured at the observation wells allows for an estimation of how well the model fits. We enter some data being the prescribed water table, the boundary conditions at the site, the hydraulic conductivities for in this case each of the layers Trow have defined and they run the model and in order to get an estimation of how well that fits they examine the output data with reference to the field data.

I make some concluding remarks at the top of page 53 and say that based on our review, and I will come back to each of these comments in turn but No. 1 the definition of the site hydrogeology cannot be supported. Secondly, the upgradient boundary, the boundary required by the model in order to complete the simulation, is inconsistent with the groundwater flow system proposed by Trow. Thirdly, the reasonable fit of both Trow's models 1 and 2 indicates that this groundwater flow system is complex. Now I will address each of these in turn.

MS CRONK: Excuse me, but before we go further, I had understood that this witness' evidence to this point with respect to this section of the report to refer to his analysis on behalf of his firm of the hydrostratigraphy at Site F and his review and critique of the work that Trow had done with respect to that issue. I note though that the next section of the report before you deals with the computer groundwater flow modelling done by Trow and at some length with the expression of opinions as to the appropriateness of the first model used by Trow and the second model used by Trow. A number of us listened with care as these witnesses were qualified and as their backgrounds were enunciated for you. I had not understood, without meaning any criticism of the witness, I had not understood Mr. Petrie being put before you and his qualifications presented to you on the basis that he was qualified to give opinion evidence on the matter of computer modelling of groundwater flow. There was some mention of that expertise with respect to Mr. Crutcher emanating from his work at the University of Waterloo when he trained there, but I do not recall, and I have just checked our notes and unless we missed it, nor was there any indication of that kind of expertise by Mr. Petrie.

Having said that, to the extent Mr. Petrie will be invited to express opinion evidence on the matter of modelling, I observe and submit that first he is not qualified to do so and, secondly, those qualifications were not advanced before you and, thirdly, I do not understand him to have been qualified to give expert opinion evidence on that matter.

MR. LANCASTER: Mr. McQuaid?

MR. McQUAID: Mr. Chairman, I certainly would be prepared to ask Mr. Petrie what his role has been in this analysis, but it is certainly my submission that this evidence can be received by the Board in the same way that the evidence presented by the Trow witnesses, both Mr. Sobanski and Mr. Beechinor who testified on various aspects of their model presented it. You may recall when the evidence was presented that Mr. Sobanski indicated they had worked with a modeler in their firm who had worked with them in their respective roles as engineers, hydrogeologists, and they had reached certain conclusions in a corporate or firm sense with respect to modelling as a result of that.

Now, similarly in this particular case the evidence, and I will ask Mr. Petrie, but he has worked with a modeler at the CRA firm and you will note at the back of the report that there is a third signature on the report at page 162, a Mr. Klaus Schmidtke, a professional engineer who I am informed is the modeler in the CRA firm, one or two modelers as I am given to understand who work on the computer simulations and modelling and so on, and just as in the case of the evidence produced by Mr. Sobanski and by

Mr. Beechinor, I think during the course of it there was an indication or an offer made that if necessary the modeler who actually worked on the program could be called and could answer questions Mr. Sobanski or Mr. Beechinor could not answer. Similarly it would be my undertaking to the Board that if we get into detail on the modelling or if there is something on the computer printout and the feeding of the information and so on that we have to get into then we would call Mr. Schmidtke and he would be available for cross-examination by my friends on that specific aspect.

In terms of interpretation and in terms of working on the model, I would ask Mr. Petrie to confirm, but certainly the information I have had is that he has been working with Mr. Schmidtke and another modeler in the firm in order to reach that synthesis between modelling and hydrogeology that we have been hearing about earlier in the proceedings.

MS CRONK: Before that question is put to Mr. Petrie, I will make two observations. First I rose to refresh certainly my memory and for the benefit of others the basis on which these witnesses were qualified. If Mr. Petrie or for that matter subsequently Mr. Crutcher are to express opinions based on the modelling work done by others, I think it important and I request that it be made clear who did the modelling work upon which those opinions are then to be expressed. Just as was the case with Mr. Sobanski and Mr. Beechinor, if they are depending on the work of others in their firm and from that work they themselves have drawn some conclusions, that is one thing and that is evidence of a particular type and at the end of the day you can assess what appropriate weight to attach to it. If it's work they did and they are drawing opinions from their own work, that is quite another matter. I have now heard that someone other than Mr. Petrie which was my understanding did the work and he is relying on someone else in his firm and will be expressing his conclusions with respect to the work but I would like to know who did the modelling and I thought I understood Mr. McQuaid to say that Mr. Schmidtke did it. That was my understanding and I'm grateful for that.

MR. McQUAID: I had better ask Mr. Petrie the role specifically between him and Mr. Schmidtke because that differentiation is being made and if I could I would like to address some specific questions to Mr. Petrie so you can have the background as to how this section of the report came into being.

MS CRONK: That is entirely appropriate from my perspective and I'm not objecting, but may I conclude my remarks. That is my first point; if there is a dependency issue I would like to know what the nature of that relationship is and who did the work and it may be of some assistance for you to know that, but secondly I note from the witness statement provided that it is indicated Mr. Petrie will be addressing the modelling undertaken for Site F by Dr. Rowe. As you can imagine from the remarks I have made I have some considerable difficulty with that proposition and unless again it is dependent and work and opinions formulated by someone else at Conestoga Rovers that this witness is now going to present. I have no objection to further questions as that is normal and usual when an issue of this kind arises, but I wish my concerns to be known clearly to the Board as to this witness' apparent lack of qualification to speak to these issues.

MR. ESTRIN: May I just say that I simply want to associate myself with those observations.

DR. KINGHAM: It strikes me that this kind of evidence is like a lot of the evidence we have had in the last year almost, it's somewhat like

Mr. Sobanski's evidence on modelling where he relied on someone else and it's like Mr. Stagl's evidence I think it was, or somebody who gave evidence with a computer generated simulation of a berm on which he acknowledged that he was not the expert who did it.

MR. HODGSON: That was Mr. Stagl.

DR. KINGHAM: We could make that comment with regard to many things, the tritium data and who collected it and who analyzed it and by what means. I guess we will have to have on the record clearly where we are on this issue in terms of what your role in it was and whether somebody else was involved and I guess that's your point and give it weight accordingly.

MS CRONK: Beyond that the issue is whether the witness is qualified to interpret the work done by others and I can put an argument with respect to Mr. Stagl on that issue but I will save that for another day.

MR. ESTRIN: I would like to emphasize that last point especially with regard to your last observation. It may well be that witnesses can purport to comment on work done by others in their firm, but in the witness statement filed here, Exhibit 615, point 6 on page 2 says that Mr. Petrie will address the modelling undertaken at Site F by Dr. Rowe. I think it is important to distinguish here that if what Ms Cronk says is right, and I believe she is right, there is nothing we have heard so far from Mr. Petrie that would indicate he has had any experience at all, or certainly any experience at all in contaminant modelling. Now Mr. Crutcher has told us that back in 1977 or '78 he did some work and he may have done some more recent work, but we have heard nothing from Mr. Petrie thus far about any experience at all in contaminant modelling and I share very much the second point of Ms Cronk's concern or objection. Unless Mr. Petrie is able to convince the Board through perhaps further evidence that he has this experience, then he should not be allowed to comment. Mr. Crutcher could be allowed to comment but I really have a concern about Mr. Petrie commenting.

DR. KINGHAM: I think we would have to wait and see what the nature of the comments are if we are to believe the second sentence under paragraph 6 on the witness statement at page 2 of Exhibit B-615, and that is a matter that we have yet to know.

MR. LANCASTER: Mr. McQuaid, do you want to proceed?

MR. McQUAID: Yes, Mr. Chairman.

MR. LANCASTER: With that in mind.

MR. McQUAID: Q. Mr. Petrie, I wonder if I could ask you to just begin by indicating your role in the preparation of this portion of the report, specifically the section beginning with groundwater flow modelling and what involvement you had in modelling specifically?

MR. PETRIE: A. Certainly. I wish to point out first that at CRA that we work as a team. Mr. Crutcher indicated yesterday morning he had overall responsibility for this project and I was responsible for the technical evaluation and hydrogeology. On our team we also had Dr. Klaus Schmidtke whose name appears on the signature page of this report, on page 162. In our initial review of this report, being the Site F report of Trow, we felt that there was insufficient data to support the hydrostratigraphic definition of the site, and I am referring now to Exhibit B-516. Indeed, if that hydrostratigraphic definition could not be supported, then it was our contention that the model per se was not based on sound -- supportable evaluation of field data and therefore its relevance in providing additional interpretation on the site was limited.

At that point in time we had not planned to use Dr. Schmidtke in great detail on this project because he was involved quite heavily elsewhere at the time. It was not until we got through in cross-examination -- I'm not sure if it was in chief or in cross-examination -- the second model, the one I have referred to as model B -- I beg your pardon, model 2 of Trow, being Exhibit H-221, was provided. Then we were faced with the situation of having two models, each based on the same set -- or on the same hydrostratigraphic definition for which we were unable to support. At that time we had Dr. Schmidtke undertake an additional review of the model. There are two aspects incorporating a review of a groundwater flow model, one being the mechanics of the model, and by the mechanics I mean the mathematics and how the terms are handled in the equations, et cetera. I do not wish to speak to that field as I am not qualified to speak to the mathematics of groundwater modelling. During my time at the university I have used models and I have played with their internal working parts, you might say, as part of the course work undertaken at the University of Waterloo; however I do not feel qualified to talk to the specifics or the mathematics of a modelling. The critique you have before you, being section B.4, relates almost entirely, as I recall, to the applicability of this model to the site. I wish to point out that a groundwater flow model is a tool, and as a hydrogeologist I have to evaluate all the tools at my disposal, in this case this specific tool, i.e., the Flonet model as employed by Trow was indeed incorporated into their report, and my critiquing of that report indicated to me that there were some question marks relating to the applicability of that model to this site. Specifically I refer to the hydrostratigraphic definition and some of the boundary conditions and the fact that two results were provided. All of this raise questions in a hydrogeologist's mind as to the depth of understanding of the hydrogeology of the site. Those questions do not relate to the specifics of the model, i.e., the mechanics or the mathematical -- internal mathematical manipulations.

In part B.4 of the document you have before you, starting at page 52 and going on, we review the applicability of this model to this site as reviewed by a hydrogeologist. I did this work in conjunction with Dr. Schmidtke, although in this portion of the work much of the work I am responsible for. In part C of this report we have a heading, if I can go to the table of contents, in part C, which is our interpretation of the Site F hydrogeology, we have a section headed C.4.0 being groundwater flow modelling, and I note from the table of contents that that starts at page 116 and goes to 138. In part C, in that section I just referenced, we had by that time obtained a copy of the model as used by Trow. What I mean by a copy of the model is that one can approach the author of Flonet and get a disc which provides the mathematical computations and what one has to get from Trow, and which Trow and the Region of Halton provide us, was the input data into that model. Specifically that relates to the hydraulic conductivities, the mathematical handling of this schematic, being figure B-516, and the values input onto the boundary conditions. That data was not readily available to us from Exhibit H-40.

Given that there were two models provided at that point in time, both which were purported to define the groundwater flow system at the site, we felt that we had to undertake a more elaborate evaluation. Therefore, in part C we ran the model. Now, in running the model, one can manipulate a variety of the input data and obviously that manipulation ought to be done in conjunction with a hydrogeologist. That hydrogeologist was myself and the input data that we entered into that model I felt appropriately represented the data that could realistically be used at this site. Thus, we did not run models that we felt did not represent portions of the cycle or cannot be supported by the hydrostratigraphy. That was one exercise of that work.

Dr. Schmidtke and myself sat down and laid out a grid of options which we would model, and the person who did much of the spadework, i.e., the entering and the regurgitation of the data, his name is Mr. Martin Adomait in our firm and he is a graduate from the University of Waterloo. He provided the output data to Dr. Schmidtke and myself, and together the three of us evaluated the relevance of the data we had evaluated.

A second part of the activities undertaken in part C relates to our manipulation of the model to provide for us a better reproduction of the groundwater flow system at the site. That was undertaken more in conjunction with Mr. Adomait and myself, as at the time Dr. Schmidtke was not available. At that time we modified some of the hydraulic conductivities, et cetera, in order that we could produce a different pattern of the flow system at the site. That work was undertaken, as I pointed out, under my supervision and again a hydrogeologist needed to be overviewing the project to know where the modelling was leading, were the input data appropriate, did it support the conclusions that had been provided in Exhibit H-40.

That was my role as the hydrogeologist in critiquing and later using these groundwater flow models. It is to those fields that I wish to speak to the Board. I am not qualified to speak to the mathematics of a model, nor indeed do I intend to, nor is there any reference to the mathematics of the model in the document provided.

DR. KINGHAM: If we have understood you clearly, it is to say that the model itself has its own internal workings as used by Trow and others, but that changing the input parameters would change the output of the model. You have not, and your company has not changed the model itself, the mechanism by which it works, you have rather changed the parameters, the hydrolic -- the hydrogeologic, excuse me, and got whatever answer corresponds to that input and you are not claiming any competence to speak on this case, on the inner workings of that model.

MR. PETRIE: That is correct.

DR. KINGHAM: I understand.

MS CRONK: With respect, I understood the witness to say a number of things but largely this.

He is a hydrogeologist and had input with respect to part B of this report with Dr. Schmidtke of their firm and with respect to part C for two different purposes and he explained two different purposes, he was the hydrogeologist, and I tried to take the words down accurately but overviewed the project and provided hydrogeology input. To the extent of that involvement and his qualifications to speak to hydrogeology issues I cannot have objections. To the extent though that it is intended that Mr. Petrie be asked to opine on, for example, the calibration of Dr. Rowe's model, just what the witness statement indicates, and to the extent he is asked to opine on the nature of the modelling undertaken by Dr. Rowe and its suitability at Site F, those are matters that in my submission and from his own admission are beyond his expertise. If they are matters confined to his hydrogeological interpretation of the site and what he considers to be relevant hydrogeological factors for use in the model, I have no objection and indeed could not have one but I will leave it there for the moment and to the extent there will be those opinions sought of him with respect to Dr. Rowe's work, I wish to reserve the right to object and I make the point clearly as the witness has that the actual modelling work was undertaken by other persons and he is speaking as he indicated to much narrower issues than I originally thought.

MR. ESTRIN: Having heard the witness I wonder if Mr. McQuaid is prepared to tell us which one of these gentlemen will be asked to support the propositions as contained in this report, for example on page 137, commenting on the applicability or non-applicability of a model such as Trow did. The statement is made at the bottom of page 137:

> "A generalized model such as Flonet cannot be used to describe a definitive groundwater flow pattern in the fractured rock at this site."

Mr. Petrie has told us -- we have heard no evidence about his experience in groundwater contamination modelling and he has told us he doesn't want to comment on the mathematics of the model. That leaves me to question who will we be hearing from to support that kind of a statement? Will it be Mr. Crutcher or will Mr. Petrie be asked about that? I'm still left with a grave concern here that there will be comments made about the applicability of the model as a whole, regardless of the mathematics or any input or output and he is saying it doesn't apply and he can't do it but which one of these gentlemen will be asked that question? Perhaps that could be clarified.

MR. McQUAID: I'm not in a position at this point to jump ahead to page 137 because I want to concentrate on the hydrostratigraphy and the focus of hydrogeology which Mr. Petrie has in front of you having worked on the Trow model. With respect to Ms Cronk's position or concerns with respect to Dr. Rowe's comments, when we get to that point I certainly will not launch into that discussion without giving my friends an opportunity to raise the issue at that point in time and we can readdress the issue. Similarly with respect to 137 and Section C, I don't want to say I haven't read it or haven't discussed it with the witnesses as I have, but that is perhaps this evening's work and tomorrow's work and I will be pleased before we get to that point to indicate to Mr. Estrin who will be testifying.

MR. LANCASTER: I think those are the critical points so I think we can wait until that time.

MR. McQUAID: I have heard a sotto voce voice from the left that perhaps this would be an appropriate point for the break. I don't know if it is or not.

MR. HODGSON: We just had one.

MR. McQUAID: We are about to launch

into a new section so it's a matter of best timing from the point of view of all concerned.

MR. LANCASTER: We are a bit distracted at the moment so this would be a good time.

MR. McQUAID: Thank you.

--- Recess

MR. LANCASTER: Please be seated.

MR. McQUAID: Q. Mr. Petrie, just turning to I guess page 52, 53 of the exhibit, the report, would you explain to the Board first of all what is being addressed when you are discussing the hydrostratigraphic definition which begins at page 53?

MR. PETRIE: A. The first item being addressed is has the hydrostratigraphy at the site been sufficiently well defined that one can use it as input data to a computer model? As I indicated in the previous section, part B.3 and by reference to Exhibit B-516, I do not believe that the hydrostratigraphy at the site is sufficiently well defined that that definition can be used as input to a groundwater flow model. In order to provide additional discussion on that -- could I back up? When we first reviewed this report, and I'm now taking out Exhibit H-40 and turning to page 60 of that report, we have a figure headed Figure 5, and I'm referring to page 60 of H-40, but

Figure 5 is the finite element grid and on that figure we see a sequence of lines running across the site. From this figure I interpret that this is the area of the site that was modelled by Trow.

We will note that Site F is indicated at the top of the figure as a horizontal line and the borehole locations are indicated at the line across the top of the model which I have interpreted to be the ground surface. I note the borehole locations go all the way down to HC16 at Hamilton Harbour and extend upgradient from the site. The vertical dimensions of the model as indicated on the left go to an elevation identified as minus 30 being 30 metres below sea level. When we first reviewed this figure we had some difficulty trying to locate where the wells were within the vertical profile on this figure and where were the hydrostratigraphic zones as defined by Trow on this figure. In other words, we were looking at B-516 being the hydrostratigraphic units and the finite element grid on page 60 of H-40 and we could not relate the two.

We were then provided in H -- one of the interrogatories, I believe H-85, and provided a definition and I would refer to a figure I am placing on the overhead and this is not in our report, B-617, and it is a figure taken from the interrogatories H-84. This figure appears in two places within H-84 and the one at the very back of the figure, the very last page which is approximately the same figure, and I don't believe it's the one I Xeroxed, it has slightly different markings but I note a few points on this figure.

We have the borehole piezometers marked in small circles if you look under any one borehole and you can see a series of circles going down the hydrostratigraphic sequence and this provides the location for the piezometer at that borehole, the borehole being referenced at the ground surface. You will also note a sequence of horizontal layering as indicated by the legend at the top right where we have the hydrostratigraphic units and the uppermost stippled one being the till unit and the blank area being the fractured and weathered shale, and reading down the legend the third is the discharge zone till, the fourth the weakly fractured massive shale unit which is equivalent -- which is Trow's unit 3, the fifth one being the highly fractured shale unit which is unit 4 and then another blank sequence at the bottom being unit 5, the moderately fractured shale unit. This is a black and white figure in the form provided to us and there has been an indication, and I am now referring to a point just downgradient from HC14 where it appears that something has been whited out where we have a vertical line and a sloping sub-horizontal line. It is my interpretation at that point that that indicates a break between the two dark units, the one on the left extending left from that white line and further left to below HC4 which is the highly fractured shale unit being the hydrostratigraphic rock unit No. 4. To the right of that whited-out line we have a dark coloured unit extending all the way down to Hamilton Harbour and I understand that to be the discharge zone till which is hydrostratigraphic unit 1B.

DR. KINGHAM: For the record you are referring to page 60 of H-84 and that is what you have on the overhead.

MR. PETRIE: I beg your pardon, yes, there are page numbers. You will note the heading is "Calibrated Hydrostratigraphy" and under the heading of "K" being in centimetres per second we have a number of units, a number of entries. I wish to indicate one thing; the highly fractured shale unit being the second unit from the bottom has a value of 1×10^{-3} and Mr. Sobanski pointed that out during cross-examination and it does contrast to the value of 1×10^{-2} he had earlier and the value of 1×10^{-3} he felt was more appropriate for this model exercise. I will note this model is also an isotropic model in which the value of the horizontal hydraulic conductivity in any one hydrostratigraphic unit is equal to the vertical hydraulic conductivity in any one hydrostratigraphic unit.

When a second model was provided by Trow during the cross-examination, CRA then undertook to obtain the computer disks for that model. To that end we evaluated or got a printout of essentially this figure you see before you on the overhead and we were able to read the elevations and the lateral distances for each node in the system, each node being a point where the sequence of black lines cross. The point of that is we wish to be able to relate the position of the hydrostratigraphic units in space to the ones that were provided for the modelling exercise.

I would refer now to the figure on page 54 of our report. I was unable to get a reasonable rendition of the colouring on this figure so I have not provided it as an overhead, but I wish to point out a few things. This figure extends from HC4 at the left-hand side of the diagram down to HC11 at the right-hand side of the diagram, and referring back to the overhead before us you will see the figure I have in my hand, being B.4.1 from page 54, it defines a distance extending from approximately HC4 down to HC11. You will note that the vertical elevation as indicated on the left goes down to an elevation of 70 metres above sea level and referring again to the overhead before you, 70 metres in elevation is approximately here, and I'm indicating a horizontal line. The figure you have before you from page 54 only represents a portion of the modelled domain evaluated by Trow. The reason we focused on this portion was specifically there is more hydrogeologic definition of this point of the site as defined by Trow and a greater density of piezometer locations at this point on the site as defined by Trow.

Of significance from the figure on page 54 -- I beg your pardon, before addressing myself to the colouring on this figure I wish to put back up again Exhibit B-620.

DR. KINGHAM: While you are doing that I will correct my last statement. While it is numbered page 60, what the witness has been referring to is found in Addendum G of H-84, the one in which he made reference to the white line.

MR. PETRIE: Right. There are two copies of that figure in this document, correct. It is

Addendum G, and that is exactly the figure I reproduced for that overhead before you. Turning now to B-620, this is the hydrostratigraphy provided by Trow which we reproduced and it's also the information as I indicated earlier from H-220. I wish to indicate on the left of the figure we have HC4 and we only go down to HC14. This is a computer-generated drawing and we are able to scrunch this drawing to the left and not change the vertical scale and in order that we could introduce borehole HC11 which is located significantly further downgradient to the right, and I am indicating off the extent of Figure B-620. The base figure you see before you as the coloured figure on page 54, the black and white writing so to speak is essentially Figure B-620 but it has been extended further downgradient to include HC11.

Now, on that figure we have superimposed some coloured layering. You will notice that the colouring has some pronounced -- shall I say "squiggles" on it? That squiggling, if I can use that word, is the shape of the lines you see running horizontally across the overhead, and I am just indicating a squiggly line. That line is defined internally from the generated output from a computer model we obtained from Trow. In generating the grid we see before you on the overhead there is a precise notation for each node in the system, an elevation and essentially a horizontal distance from a common axis. We took those points and entered them into our drafting system such that we were able to define those lines you see delineated by the coloured patterns on the figure on page 54.

The point I wish to draw your attention to is the dark brown layer which in the legend as we go down we see it is indicated as the highly fractured shale unit, the second coloured item from the bottom. We note that this highly coloured -- I beg your pardon, the dark brown being the highly fractured shale unit, unit 4, extends across the domain of the modelled zone and stops at a point, and in my drawing I notice it's 1,400 metres as indicated at the bottom of the drawing or approximately just downgradient from the discharge zone area indicated on the top of the drawing.

MR. McQUAID: Q. Could you turn that sheet around and point to where it is?

MR. PETRIE: A. I am noting the dark brown layer being hydrostratigraphic unit 4 extends across the field of the domain and stops at this point, and I'm indicating a distance 1,400 metres from the origin and I note it just approximates the downgradient extent of the discharge zone. I also note with reference to that dark brown zone, being hydrostratigraphic unit 4, it does not precisely coincide with the wording on that figure being "Highly Fractured Shale (4)" and the wording on that figure is taken exactly from Exhibit B-620 and we have the highly fractured shale here and those two vertical lines at HC4, the upper one being at 110 metres elevation and the lower one approximately 103, and we notice at HC4 that that highly fractured shale zone does not lie at the same elevation as the zone input into the model.

Q. Can I stop you for a moment because you have referred to the dark brown zone as the highly fractured shale unit No. 4 but when I look at the lower left-hand portion of the page I see the words written there "Moderately Fractured Shale (5)" and I see up in the legend under "Modelled Hydrogeology" that the dark brown or chocolate brown is highly fractured shale unit.

A. You are correct.

Q. Can you backtrack for a moment and make sure that we understand what is the significance of the colours and what is the significance of the writing that we see on the base map as it were?

A. I will start again referring to

B-620. The base map is approximately that which you see before you except that I have extended it off-site to the east -- downgradient towards the southeast to include HC11. On our automated computer drafting system, in order to undertake the exercise of condensing all of this field to the left without distorting the vertical elevation, the words you see on this figure all get taken off, so to speak, and the automatic condensing operation is undertaken and then these words are added on again. So, let's call that a black figure which would extend from HC4 down to HC11 and where you see the words "moderately fractured shale", "highly fractured shale", "weakly fractured massive shale", that wording is the definition of the site hydrostratigraphy as interpreted from H-220 and a half of which you see before you on B-620.

The coloured material is all overlaid on top of that and the coloured material or the coloured layers have been obtained from the computer modelling data such that we notice where we have the dark brown colour as indicated in the legend notating each of those colours, the dark brown layer is the highly fractured shale unit and we note, reading at the left-hand side, that the dark brown colour sits on top of what is described as the moderately fractured shale (5) unit. The point I'm making is that that portion of the rock which has been defined as highly fractured shale and defined on Exhibit H-220 is not the same portion of the rock mass that was modelled as highly fractured shale.

I don't wish to appear to be too critical of this because some of this is a function of the constraints imposed by the model. Specifically as we read it here I interpret that the grid size is approximately ten metres. Now what I mean by grid size, referring to the overhead, is these sub-horizontal layerings we have across here and the thickness of those layers is approximately ten metres. It varies across the site because we have the same number of layers at the far left-hand boundary, being the upgradient side, and they are condensed in thickness as we approach Hamilton Harbour, but approximately under the site each layer is about ten metres thick. So, the modeler is constrained on how he plots his grid on the base data.

The point I wish to make is that the highly fractured shale unit, being unit 4 as interpreted, is not coincident with the modelled highly fractured shale unit being the dark brown unit.

The second point of note in this figure

is the positioning of the downgradient extent of the highly fractured shale, and I am referring now to the point noted as No. 2 on page 55 of B-617. As I indicated initially, the dark brown layer that straddles the middle of the coloured figure terminates at a point about 1,400 metres across that figure and at a point of the downgradient extremity of the defined discharge zone.

As a hydrogeologist looking at this figure, the question that comes to my mind is one, what hydrogeologic controls did the modeler have available to him that allowed him to terminate the position of the highly fractured shale unit at the place indicated in that coloured figure and, secondly, I note, with reference to the numbers you see before you on the overhead, given that the highly fractured shale unit has a hydraulic conductivity of 1×10^{-3}, that is significantly more permeable than its bounding units, the bounding units being unit 3 which has a hydraulic conductivity of 1×10^{-7} and the underlying moderately fractured bulk shale which has a hydraulic conductivity of 1×10^{-6} and the unit being the discharge zone till, and you can call it the discharge end of the highly fractured shale, but that till has a hydraulic conductivity of 3×10^{-6}.

With reference to the coloured figure, we have a situation in which the dark brown layer is the most permeable rock zone at the base of the figure. Groundwater flow within that zone, and I am recalling these numbers to mind as I make these statements, but they would generally be expected to be horizontal through the dark brown zone. We have a situation in which the dark brown zone would drain the overlying rock, transmit the water laterally through that zone and then it comes to the point at the end of the zone, the end of the zone being described as I indicated at approximately 1,400 metres from the origin of this drawing, and water moving laterally in this dark brown zone comes to an end in that zone and the only place it can easily flow is in the direction of the lowest permeability being this unit here. In other words ...

Q. The green unit?

A. Pardon, I am referring to the green unit, yes. One would expect that groundwater flow laterally through here would then move vertically, given the geometry of the situation as described and given the relative hydraulic conductivity values incorporated.

Q. It would be along the dark brown to the point where it would go to the green at about

1,400 and discharge to the surface?

A. Correct. On the basis of the green pattern I see before me I would expect to have groundwater discharge at the point indicated as a groundwater discharge zone. My concern with that specifically as I indicated earlier is that I do not see geologic evidence or hydraulic evidence that allows me to interpret from Trow's information that their highly fractured shale terminates at the point of 1,400 metres. This is the only indication I have got that they have made this interpretation.

Given that interpretation, it is understandable why as they show with their groundwater flow model that one might expect a component of groundwater flow to discharge to the surface at the point marked discharge zone.

I now wish to refer to the second-to-last paragraph on page 55 where I reference infiltration. This computer model also provides a measure of infiltration as representative of the simulations undertaken. One can get an understanding of this from Exhibit H-40, and I am referring to the figure on page 62.

Q. Page 62 of H-40?

A. Correct. I'm sorry I did not make

an overhead, but it is the one of the groundwater flow model showing the sequence of lines with arrows on it. In the legend on the top left-hand side I see the lowest entry on the left-hand side I see an arrow and adjacent to that is "Contour Interval for Streamlines = 2 cubic meters 1 year (unit width)." The streamlines are those dark lines with the arrows on and you will notice that they generally start at the water table being the top of that plot and move approximately vertically or at other angles downward from there.

In order to arrive at a measure of the infiltration as provided by this model, one counts the number of those lines, if I can put it so simply, across the area of interest. In other words, at Site F I believe Trow counted from the figure you have before you, being 62 in H-40, and the domain of Site F that summing those streamlines or stream tubes allowed them to determine an infiltration rate of 13.7 millimetres per year for the model we have in H-40. I also note that in Exhibit H-221, being model 2 undertaken by Trow, when they undertook the same exercise they determined an infiltration rate of 1.2 millimetres per year.

Q. That is the model 2 or better fit model?

A. Correct. I am just looking at Exhibit H-221 and I don't see on that where the infiltration rate is provided. I believe it must have been given in the transcript, although I don't see it on the notes here either. Perhaps I could leave that point for now and I will confirm where that value of 1.2 millimetres per year for the infiltration -- my recollection was it was provided on H-221. I make the note again in the second-to-last paragraph on page 55 that:

> "CRA considers an infiltration rate of 1.2 mm/yr as unreasonably low."

I would like to for a moment look at what infiltration means with respect to the model domain we have at the site. The first point to note is that we have a grid that is approximately -- each layer is about ten metres thick and the model therefore cannot address groundwater flow that may enter the system and not penetrate as much as ten metres and discharge. However the value of 13.7 millimetres per year or 1.2 millimetres per year as I understand it is Trow's interpretation of the results of this model being the infiltration that passes through the water table and enters the groundwater flow system at the site and to discharge -- where they define the discharge zone to be.

On Exhibit H-221 I wish to refer you to the calibrated data provided.

Q. By that you mean the actual listing of the water levels as measured in the field?

A. I wish to compare the right-hand two columns on the second page of H-221, the far right-hand column which is described as run 9, anisotropic model and we have on the second to the left the little column being the calibrated model and the third column is headed "Field Measurement." The field measurements are the water level data obtained at the specific wells during the field program and the far two right-hand columns are the data generated by the model as read by Trow's modeler.

We note at the bottom of that figure we have a legend which says "better fit" with one small tick and "much better fit" with two ticks and adjacent to that we have a cross being poorer fit and double cross being much poorer fit. One point I wish to note, and it has been marked on my copy, and I believe we discussed it earlier but I will repeat it. For the uppermost set of data at each piezometer, and we can refer to HC1, piezometer 3, the field measurement entered or the field data here are 183.98 and you will note if you go across to the far right-hand two columns the same value is entered in there.

I am referring at that point to the prescribed water table level at HCl. At HCl the water table is entered into the model as a fixed condition and it cannot change and it's one of the requirements of this model. When you read the calibrated data you notice at each well nest there should be one entry for which the water level data does not change across the field -- does not change across the table being variably the field measurement, the calibrated model data or run 9 being anisotropic model data which I understand to be Trow's model 2 or the better fit model.

I understand the calibrated model being the middle column to be Trow's model 1 or the model that was introduced in Exhibit H-40. The point to note here is based on the comparison of the water level data apparent from this exhibit that a better fit is achieved at a number of locations, a number of piezometers at the far right-hand column. As I indicated, this model gives a very low value for the infiltration and Trow reported that both models provide a reasonable fit of the field data and yet show more than an order of magnitude variation in the infiltration. To a hydrogeologist that is significant in that the amount of water we would ever have to deal with at a landfill at this site will in part depend upon the infiltration into the rock or one's estimation of the infiltration into the rock prior to landfilling. Once landfilling is ongoing one would imagine that the infiltration into the rock from the landfill would be high.

To gauge an estimation of the infiltration is important if indeed this model can be relied upon to provide a realistic value. It is my interpretation that two models based on the same stratigraphic -- the same rock stratigraphic sequence but with different values of the hydraulic conductivity as they have been interpreted by Trow, that those two models which give a difference of infiltration rate of more than an order of magnitude indicates to me that the infiltration rate is very sensitive to the variations in hydraulic conductivity of the bedrock. I would note that for each of those flow systems -- for each of those models Trow concluded that they each provided a reasonable fit of the field data.

On page 56 we have the heading of B.4.3, the boundary conditions. By boundary conditions we are referring to the input data to the model which describes the domain of the site and here I am referring to, as Trow have employed, a no-flow upgradient boundary and at this point being the far left-hand side of the overhead from H-84, I am indicating the far left-hand margin of that figure and Trow had assumed that no water flowed across that boundary.

Q. Could you point that out again for us?

A. I am pointing to the far left-hand edge of the figure before you on the overhead. Trow in developing their model assumed that the hydraulic conditions along this vertical line were such that no groundwater flow crossed that line. We note that in their discussion in the text addressing this situation they felt, and I am referring to the quotations at the bottom of the page:

> "... the data also indicate a deep groundwater flow system in the bedrock that probably originates above the Niagara Escarpment north of Site (D)."

Q. North of Site D?

A. Pardon, north of Site F:

> "This flow system moves under Site F at depths (greater than 30 m) and

discharges in the vicinity of Lake Ontario."

Those words are from the Trow report and would indicate they expect the groundwater flow system to enter here and discharge at Hamilton Harbour. Initially we felt that was quite a point of concern and could distort the results generated by this model. We investigated that in part C of this report and found that our concern was not warranted. If you change the flow condition to one which we considered more appropriate, allowing water to flow into the system here, it did not interfere with the results generated in this domain here. I am referring to this domain being from roughly HC4 to HC11 and encompassing to a depth below the lowest of the piezometers and that is where we have the bulk of the data and obviously where any calibration of the model must concentrate on, that area.

Q. Turning over to page 57 and following there is a series of observations based on the calibration we have seen on the two models as I understand it.

A. That is correct and I can discuss briefly each of the points raised on page 57. Point No. 1; for the isotropic case, being the first model Trow ran, five calibration points out of 17 had a difference of three metres or more between the simulated and measured potentiometric surfaces. We note that this is a large percentage of monitoring points with a significant difference.

The second point for the anisotropic case, model 2, that one out of the 17 calibration points has a difference of three metres or more and referring to the point above where they had five with a difference in excess of three metres and one might conclude the better fit model is a better representation of the flow at the site.

Point three, the piezometer set in the highly fractured shale at unit 4, specifically at well nests HC4, 5 and 8, show poor fits with the field data for both models. I am referring back to Exhibit 220 where we have the numbers developed from the computer model and compared to the water level data from the field measurements.

Q. Are you talking about H-220 or H-221?

A. I beg your pardon, I meant H-221.

Q. This data and the difference you are talking about, if you look down the columns as I hold up page 2 of Exhibit 221, you have actually counted the differences between model 1, the calibrated model, and run 9, the better fit model?

A. Correct. We could note specifically for example at HC5, piezometer 1 which is completed roughly in the middle of this domain, we note the deepest piezometer is set within the domain of the highly fractured shale unit 4. Looking at the water level data for HC1 -- I beg your pardon, for HC5-1, we note under the heading for the field measurement on H-221 a measured water level at that piezometer at 114.97. Moving over to the calibrated model, the next column to the right, we see a water level of 112.84. That is the water level generated by the first model of Trow. Moving further to the right again we see a value of 116.01.

Q. What is the significance of focusing on unit 4, the highly fractured shale?

A. The highly fractured shale is as defined by Trow the most permeable rock unit at this site. It exerts a lot of control over the groundwater flow system at this site and with reference to the hydraulic conductivity values you see before you on the overhead, given that it is the most permeable unit as I indicated earlier, we would expect the bulk of the flow to converge onto this unit from beneath and above and thence pass laterally along this unit to discharge where this unit is defined as terminating. For the bulk of the flow to be passing in this unit, one would expect that the more precise -- can I rephrase that? One might expect that the most accurate, if that is the word, model data would be obtained within this layer and given that it is the layer that exerts the strongest control on the groundwater flow pattern for a model to provide a reasonable fit of the water level data at this site. It would be my expectation that for this domain before you the most permeable zone should have the best fit of the sequence of data we have available to us. I am referring back to point 3 on page 57 and would repeat that the piezometer set in unit 4, the highly fractured shale, show poor fits with the field data compared to both models.

We also note from the models that the upward or discharge gradients, and I am referring to point 4 at the bottom of page 57, that the upward or discharge gradients observed at HC11 are not reproduced by the models. You will note at HC11, and again I am referring to H-221, we have two entries for HC11 being piezometer 1 and piezometer 2. Piezometer 2 is the one which defines the water table elevation at this site and we have the same elevation obviously as the field data -- the calibrated model indicates and that the anisotropic model indicates. I am referring to the water level data at HC11, piezometer 1 where for the field measurement we have a much higher elevation, 92.09 at piezometer 1 compared to the piezometer 2 data being 89.48. The field data show within the vertical plane flow data or groundwater flow is directed upward and we notice under the heading of "Calibrated Model" that the relative water level data is such that there is a slight component of downward flow between HC11-2 to HC11-1. For the far right column, the anisotropic model, we also see a slight component of downward flow from the water table to the deeper piezometer which has an elevation of 89.14. It is my interpretation of this data that for the groundwater flow model as presented by Trow, it does not adequately reproduce the upward gradients measured in the field at this point.

In providing this data to the Board Mr. Sobanski alluded to the fact, and I believe I am quoting him, -- I will paraphrase him as I'm not sure of the quote but that a three-metre head difference between the predicted value, i.e., that which is reported from one or either of the models, and the field data is not such a bad difference given that one is modelling over approximately a 200-metre-thick vertical interval. I believe he mentioned that that was a small percentage error given the vertical thickness of the domain. I would like to point out that we are referencing in my review of this data, we are focusing on this small area here where the bulk of the data are available and I would also like to point out that the elevation of the water table, the upper surface on the overhead you have before you, is prescribed and entered into the model and cannot change. So, what we are really looking at is differences in water levels from points located quite close to a boundary which cannot change within the model, and I will read the wording we have at the top of page 58:

> "A three-metre difference between the predicted and measured potentiometric head values within a vertical distance of 8.38 to 28.09 m below the prescribed water table surface translates to a net difference of between 10 and 35 per cent."

Those values of 8.38 and 28.09 relate to the position of the piezometer here below the water table surface. We would be referring specifically to data obtained from H-221 for which there is a net error of three metres or more.

So, for those piezometers which have a difference of three metres or more, they are located variably at 8.38 to 28.09 metres below a surface for which the elevation cannot change and, recognizing we have a three-metre head difference over as little as eight vertical metres, it translates to a difference of 35 per cent.

Q. Is that three-metre difference, is that model 1 or model 2?

A. I would refer back to page 57, point 1 where there are five calibration points out of 17 that have a difference of three metres or more and point No. 2 for which one out of the 17 calibration points has a difference of three metres or more. The points in question lie within that vertical range below the water table and thus on my interpretation of the data, it leads me to conclude that the percentage error is in the order of ten to 35 per cent. I do not consider it appropriate to focus on the percentage error at a point here, but I am generalizing to the domain where we have the piezometers and for which we have the field data. I do not consider it appropriate to look at a percentage error in this point and relate it to the whole of the vertical interval model because we are not in a position to confirm any of the water level data over the lower, essentially half of the model and a large extent of the upgradient portion of the model.

The second complete paragraph on page 58 focuses on the vertical gradients. In order to provide a measure -- another examination of how well the model data has fit the field data, we reviewed the vertical hydraulic gradients. These data are provided on page 59 -- I'm sorry, the table on page 59 and it is headed "Summary of Vertical Hydraulic Gradients" and we have the well nest column on the left, the field measurements and model 1 and model 2 being the calibrated flow models as provided by Trow.

Q. Could you give us an example of how you calculated these, taking one of the well nest entries?

A. Correct. The field measurements for example at HC1-85 from piezometer 1 to 2 there is a hydraulic gradient of -0.233 and that is calculated by dividing the difference in water level elevation between piezometer 1 and 2 by the vertical separation of piezometer 1 and 2 and that value, -0.233, can be found in what is indicated as Appendix 1 or Appendix A if you read the tab attached to the back of the report where we have summarized the vertical hydraulic gradient data.

Now I wish to point out a couple of typographical errors on this table and they are all in the column headed "Field Measurements" for which we have the calculated hydraulic gradient data. I have before me or, Mr. McQuaid, do you have it, a handwritten sheet with two or three alterations on it?

Q. I asked you to do it but I don't have it.

A. I beg your pardon. I will have to make a small search and can I apologize for wasting the Board's time. I beg your pardon, I have it here.

Q. I asked you to take that column and to in handwriting indicate on this sheet I am handing to the Board and which I will ask the Board to mark, the four entries that should be changed on that field measurement column.

A. I beg your pardon, there are five.

MR. LANCASTER: B-623.

--- EXHIBIT NO. B-623: Corrected Values of Table B.4.1

MR. PETRIE: It would appear this data was incorrectly transposed from the information provided in the appendix and I took those data from the appendix and corrected them on B-623 which you have before you. You will note there is no entry under the columns headed "Model 1" and "Model 2."

MR. McQUAID: Q. Ideally at page 59, we should transpose those five entries to the typewritten entries we see, relevant entries we see opposite the well nest numbers?

MR. PETRIE: A. That would be appropriate. I also neglected to put in the comment regarding Appendix 1 being the vertical gradient data such that a negative value indicates downward flow within the vertical plane and a positive value would indicate a component of upward flow in the vertical plane and a 0.0 indicates that there was no flow in the vertical plane.

Q. What should we be looking at when we look at page 59, bearing in mind that your minus sign or negative sign indicates a downward flow in the vertical and a positive equals an upward vertical flow?

A. Recognizing what Mr. McQuaid has just said, as I indicated yesterday the hydraulic gradient data is really a synthesis of the water level data so it should provide us with the same set of information. It is another way of evaluating the water level data. To that end, as I indicate in the bottom paragraph on page 58, referencing approximately the middle where there is the sentence:

"At both HC5 and HC8, there is a much stronger downward gradient measured below the highly fractured shale (Unit 4) than that determined by the model."

So we could go to the table on page 59 and see that and at HC5 between piezometers 1 -- have I got that right? I have to refer to my drawing again here. I have a point of confusion addressing my comment on HC5 which I may review tonight, but I would look at HC8. We note there at HC8 between piezometers 1 and 2 that the vertical gradient is measured in the field as downward, 0.447, the 447 being the corrected value we just provided on Exhibit B-623 and comparing that to models 1 and 2, the downward gradients there are -0.151 and -0.051 and reading across that line it is apparent at those piezometers referenced that the downward gradient in the field is more pronounced than the downward gradient generated by the model. Also of interest as indicated in the last sentence on page 58:

"The downward gradients in the bedrock at HC14 are not simulated nor is the upward (discharge) gradient at HC11."

Let's focus at HC14 first turning to the table on page 59. At HC14 we have downward gradients for example at piezometer 2 to 3 as measured in the field and the value is -0.084, and looking across to the values at the right of the model we have a 0.00 and a +0.008. The model is indicating at that elevation, HC14 between piezometers 2 and 3 that there is essentially horizontal flow for model 1 and an upward component of flow for model 2 at that location but yet the field data indicates a negative value being a downward gradient of 0.084. The field data indicate a component of downward flow and the model data indicate a component of horizontal or slight upward flow depending on which column you refer to.

If I can refer to the overhead before the Board from Addendum H-84, at HC14, piezometers 2 and 3 are the middle two piezometers at this well nest, and I note that the field data indicates a component of downward flow where the model indicates a component of horizontal flow or subtly upward and again depending on which model scenario one reviews.

For HC11, if we can refer again to the table on page 59, the data at HC11 or the field data indicates an upward component of flow, i.e., a positive value of 0.153, and I note for the two modelled simulations provided the component of flow is approximately horizontal for model 1 being slightly downward at -0.002 and slightly more strongly downward in the second model being -0.020. I am referring now to HC11 and the field data show a component of upward flow at this point. There is a component of upward flow where the model data show essentially horizontal flow with a subtle downward component or a slightly more strong downward component at that point. Again it is my interpretation that the model data do not provide the most reasonable representation of the field data as evidenced by the water level data and the hydraulic gradient data.

I wish to point out with respect to how we arrived at the vertical gradients you see before you on page 59 for models 1 and 2. How we arrived at those gradients is we took the water level data on H-221, and you will note the water level on H-221 is referenced in each case to a specific piezometer, and we divided the water level differences by the separation of the well screens at that particular piezometer nest. The point of concern here is that the well screens do not lie specifically at a node, a node being as I indicated earlier where these black lines cross and the water level data as generated by the computer are specific to each one of these nodes and the well screens do not necessarily sit directly on a node. As I indicated earlier these layers are in the order of ten metres thick or so, such that you may have a well screen for example that fits directly on one node and the next one being -- I beg your pardon, the next -- if the well screen separation was 15 metres, one of those well screens sat on one node and the next well screen would be sitting between two nodes and one would have a choice then of which node to use to be representative of that data. Given that we had a small amount of confusion in trying to understand which well screen related to which node, for this table here where we are critiquing the data provided by Trow we took the water level data directly as it is before you on H-221 and divided the water level differences by the well screen differences where appropriate. I will relate that when we address part C of the report where we had the precise definition of each node where we were able to find the vertical gradients with respect to the nodal separations and not the well screen separations. It leads to some subtle differences and not meaningful, but I do wish to bring that point out now.

We conclude from that data that both Trow's model 1 and model 2 do not reasonably reproduce the groundwater patterns or pattern of groundwater flow in the highly fractured shale, being the most permeable unit in the stratigraphic sequence as defined where we would have expected to find the better fit within the system and, in addition, that the discharge gradients at HC11 are not reproduced by the model whereas the model does reproduce discharge gradients in the vicinity of HC14 which do not reflect the field data. As I indicated earlier, I felt the discharge gradients generated at HC14 were a function of the geometry of unit 4 such that it is terminated at a point not far downgradient from HC14 where groundwater flow was essentially forced vertically.

Q. On page 60 you have a section on sensitivity analysis.

A. Correct. In the first paragraph we make reference to the statement which I inadvertently forgot to quote in this report although I mentioned it earlier that Trow undertook more than 50 simulations of the groundwater flow system, and that statement is found on page 61 of H-40 and I noted that earlier. In the middle paragraph on page 40 -- I'm sorry -- the middle paragraph on page 61, H-40, the second sentence:

> "The final model calibration was accomplished after more than 50 simulations, ..."

In reviewing that we were not able to obtain from the report which simulations had been run and how it was decided that the final calibration was indeed the better one. Trow provided additional data to us in Exhibit H -- it is Exhibit H-85, the response to the Canadian Environmental Law Association which at this point in the day I am having trouble laying my hands on. I beg your pardon, I now have it.

I am referring in this exhibit, being H-85, to Addendum 3 and it is headed "Sensitivity Analysis, Site F, Groundwater Flow Model." It's within the first half of this document. The first three or four pages of that Addendum 3 provide the sensitivity analysis data that was requested and refers to a total of 11 simulations, and we noted in the text that they referred to 50. This data was provided in order that we could assess how by varying the various input data, what effect that would have on the calibrated output and to that end Trow have provided some additional figures which follow the four pages of text we have referred to in which they have provided the water level patterns or pattern of groundwater flow for the various calibrations they refer to, being 11 in total. What one cannot do easily with this data is infer the water level elevation at any one point and thus develop a table similar to the one we have on page 59 comparing gradients or again similar to the table produced in Exhibit H-221 being the water level data for various piezometers within any one calibrated run. One cannot develop that information from a review of these figures.

We do note that some of the options they have modelled are consistent with the statements in the text regarding this. For example, if I refer to the second-to-last page of figures there, it is headed No. 10 at the top right-hand corner and the wording at the top reads "Alt 9" which I understand is alternative 9, calibration, isotropic where they have changed some of the hydraulic conductivity data and it appears they have also changed the geometry of the highly fractured shale and one may conclude, and I hesitate to conclude too directly from this figure because I don't have the appropriate water level data, but the pattern of flow I see before me is not as reasonable a representation as the pattern we have for the final calibrated flow models. In order to undertake a complete sensitivity analysis it is easier for us in critiquing this model where we had available the specific data for those calibrations which is why during cross-examination we requested and were then provided with the model so we could undertake our own sensitivity analysis and which is reported in part C of this report.

To summarize our critique of the flow model as reported by Trow in Exhibit H-40 and H-221, we make the statements you see before you on pages 61 and 62. Point No. 1 is that the modelled hydrostratigraphy does not match the interpreted hdyrostratigraphy. No. 2, the downgradient limit of the highly fractured shale, unit 4, cannot be supported by the field data, yet the location of the discharge zone is very dependent on the lateral extent of this unit. No. 3, the infiltration rate is very sensitive to variations in the hydraulic conductivity, more so than the piezometric elevations. Point 4, the upgradient boundary condition is inconsistent with the flow system as described by Trow. Point 5, both the calibrated models 1 and 2 do not show a reasonable fit of the water levels in the highly fractured shale, unit 4, nor the discharge gradient at HC11.

Turning the page is item 6, the calibrated water level data for an additional two simulations only are provided in tabular form, and I am referring to H-85, and there is a table of two additional runs, two of the total in 50 and for those two additional runs and thus the sensitivity of the calibrated model to parameter changes cannot be adequately assessed.

We then make the statement that we do not agree that the site hydrostratigraphy is adequately simulated by these models. In general, the Trow simulations indicate that the hydrogeologic system at Site F is a complex system and is very difficult to model accurately.

Before going to the very last paragraph on page 62 I wish to provide some additional comment on the word "reasonable." If you turn to page 61 in point 5 at the bottom of page 61:

"Both the calibrated Models 1 and 2 do not show a 'reasonable' ..."

I have put that in quotation marks and the word was taken from Trow. In assessing a reasonable fit, one has to look at the pattern of flows, the gradients, the direction of flows and not specifically the water level comparison as one has before you in H-221. In other words to assess if a model provides a reasonable fit of the data I would not look specifically at water level differences at any one piezometer comparing field data to model data and I would have to look at the gradient data or the gradients calculated from that various water level data. One may have differences in water levels, but they may provide very similar flow pattern as that interpreted from the field or you may have kind of similar water level data as indeed Trow have provided but at some significant point the gradient data is inconsistent between the model and the field.

Turning again to page 62, at this point in our review we had critiqued the Trow model and found that because of the uncertainty of the simulated local flow regime, and this is the last paragraph on page 62, and the sensitivity of the infiltration rate, it is improper to incorporate the results of the modelling into a definitive design of an engineered landfill system. The results can be used to evaluate the comparative effectiveness of various engineered systems, and again we are referring to the landfill system, but not the actual effectiveness of the various alternatives. At this point, having critiqued the model, we find considerable differences between the field data and the model and considerable differences where the model fits with respect to the defined hydrostratigraphy as provided by Trow on B-516 and also that this schematic hydrostratigraphy does not reflect the hydraulic data available for the site. At this point we have a concern that the modelled data as provided, specifically infiltration data and its use in helping to assist in assessing the engineered landfill design at the site is based on a model which I consider does not reasonably represent the field conditions at this site.

MR. McQUAID: Mr. Chairman, if I could ask you to break at this point, I see we are very close to the end of the day and on page 63 you will see another section, groundwater chemistry.

MR. LANCASTER: I think it is appropriate we break for the day. We will adjourn until 9:30.

--- Adjournment (4:24 p.m.)

CERTIFIED CORRECT

C. F. Nethercut, C.V.R.

. . . . . (Page 25650 follows) . . . . .