Court File No. 661/89
Court File No. 773/89
Court File No. 811/89

SUPREME COURT OF ONTARIO
(DIVISIONAL COURT)

B E T W E E N:

NSP INVESTMENTS LIMITED

Applicant

- and -

THE JOINT BOARD (ESTABLISHED UNDER SECTION 4 OF THE CONSOLIDATED HEARINGS ACT, 1981, S.O. 1981, c.20, AS AMENDED), THE REGIONAL MUNICIPALITY OF HALTON, THE CORPORATION OF THE TOWN OF MILTON, THE CORPORATION OF THE CITY OF BURLINGTON, THE WEST BURLINGTON CITIZENS' GROUP, THE MILTON AREA CITIZENS' COALITION, THE HALTON FEDERATION OF AGRICULTURE, WATKIN AND DOREEN MARTIN, WALTER TOMOSKY, THOMAS AND MARY-JEAN MARTIN, MICHAEL AND CYNTHIA REED, AND THE HONOURABLE JAMES BRADLEY, IN HIS CAPACITY AS THE MINISTER OF THE ENVIRONMENT.

Respondents

RESPONDENT RECORD OF THE CITY OF BURLINGTON

I N D E X

6. Order-in-Council, dated March, 1989.

7. Estimates of Exfiltration of Leachate from Site F:
(a) Exhibit H-40, A. Sobanski, p. 74;
(b) Exhibit H-40, A. Sobanski, p. 75;
(c) Transcript, Vol. 36, A. Sobanski, p. 7954-7955;
(d) Exhibit N-748, K. Cartwright, p. 5;
(e) Exhibit H-936, S. Feenstra, p. 16;
(f) Transcript, Vol. 92, D. Charlesworth, p. 21936;
(g) Transcript, Vol. 160, P. Bowen, pp. 38916 and 38920; and,
(h) Transcript, Vol. 134, J. Petrie, p. 32595.

8. Exhibit B-617: Evaluation of Halton Region Landfill Technical Studies, Site F, Burlington Hydrogeological Report, dated February, 1988, p. 4; and,
Exhibit B-618: Evaluation of Halton Region Landfill Technical Studies, Site D, Milton Hydrogeological Report, dated February, 1988, p. 110.

9. Transcript, Vol. 135: Evidence of J. Petrie.

10. Transcript, Vol. 114: Evidence of A. Crutcher and J. Petrie.

11. Transcript, Vol. 179: Argument of J. Tidball.

12. Transcript, Vol. 187: Argument of E. Cronk.

13. "Suggested Criteria for Acceptance of Landfilling": Written Submission of E. Cronk to Joint Board.

14. Transcript, Vol. 160: Evidence of P. Bowen.

15. Exhibit MR-906: Witness Statement and Report Evaluation of Hydrogeological Suitability by Terraprobe Ltd., dated July, 1988, p. 13.

16. Transcript, Vol. 46: Evidence of S. Feenstra.

17. Transcript, Vol. 172: Evidence of S. Feenstra.

18. Transcript, Vol. 175: Evidence of S. Feenstra.

19. Transcript, Vol. 186: Argument of E. Cronk.

20. Transcript, Vol. 191: Argument of M. McQuaid.

21. Exhibit M-962: Witness Statement of Dr. N. Eyles, dated September 22, 1988.

22. Exhibit M-438: Review of Hydrogeological Report on Site D, Milton, Proposed Landfill of Halton (Geocon), dated October, 1987, pp. 4-3, 8-1 and 8-3.

23. Transcript, Vol. 122: Evidence of J. Petrie.

24. Transcript, Vol. 160: Evidence of P. Bowen.

25. [Refer to Document at Tab 21].

26. Transcript, Vol. 174: Evidence of S. Feenstra; and,
Transcript, Vol. 175: Evidence of S. Feenstra.

27. Exhibit H-936: Witness Statement for Reply Evidence of S. Feenstra, dated August 23, 1988, p. 17.

28. Transcript, Vol. 131: Evidence of J. Petrie.

29. Transcript, Vol. 169: Evidence of S. Feenstra.

30. Transcript, Vol. 176: Evidence of N. Eyles and D. Charlesworth.

31. Exhibit E-928: Witness Statement of G. Hughes, dated April 21, 1988.

32. Transcript, Vol. 167: Evidence of G. Hughes.

33. Exhibit B-930: MISA - Policy and Program Statement, dated June, 1986.

34. Exhibit E-154: Ministry of the Environment Policy Manual, Water Management-Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment, dated August 22, 1986.

35. [Refer to Document at Tab 31].

36. NSP Application to Cabinet, dated March 22, 1989, para. 2 & 3.

Halton Region Landfill Technical Report
Site F - Burlington

The Regional Municipality of Halton

H-40

Hydrogeologic Report
Volume 1 of 3

September 1986

Trow Hydrology Consultants Ltd.

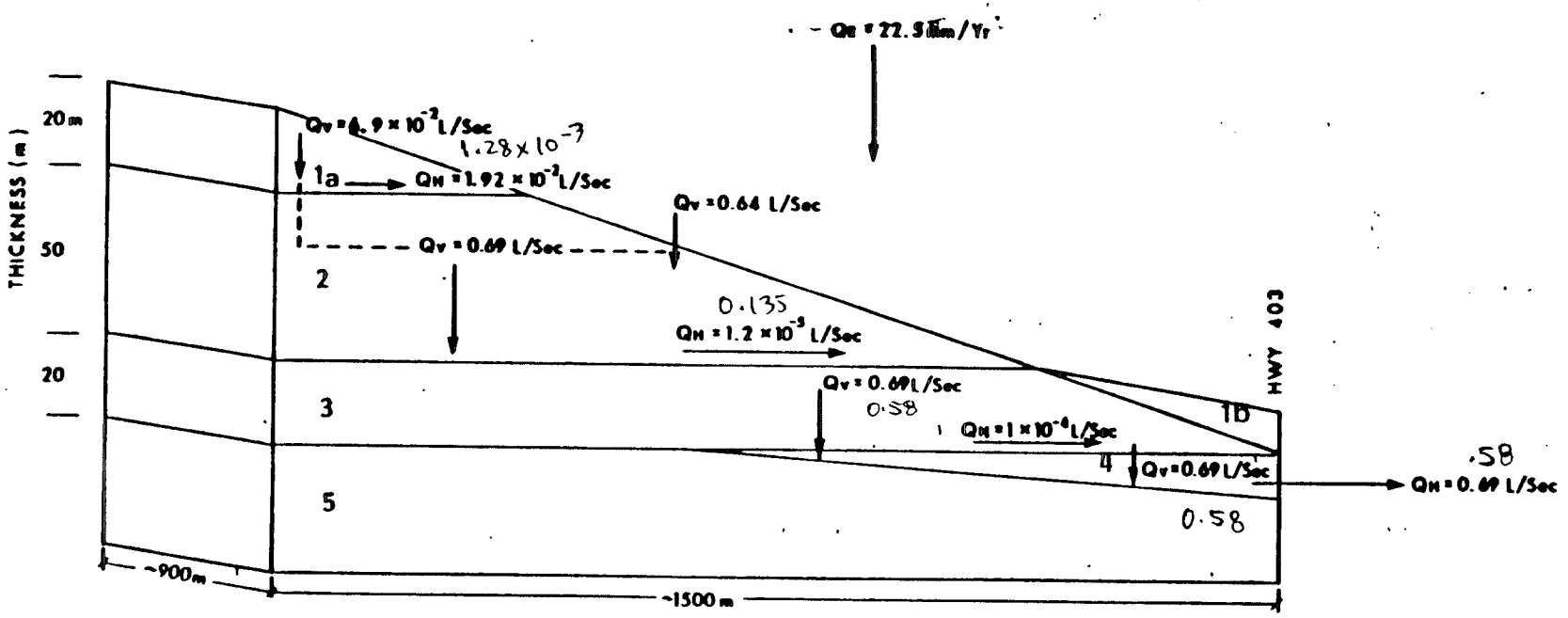
To calculate a groundwater recharge value, the groundwater flux capacity was calculated for the five major hydrostratigraphic units (see Figure 7). By applying the Darcy equation (Q = KiA) to the conceptualization, a flux capacity for each unit was calculated. These values represent the amount of recharge each element of the hydrostratigraphic system can accept. Average gradients and hydraulic conductivities were generally derived from mean values of field measurements. The calculated recharge rate was 22.5 mm/yr. The recharge rate was also calculated by the computer model. The resultant value was 13.7 mm/year. Since the model gives a more rigorous treatment to the hydrogeologic variables and their inter-relationships, it gives a better estimate of the groundwater recharge rate.

The following summarizes the approximate water balance for the site:

Precipitation	-	869 mm per annum
Evapotranspiration	-	511 mm per annum
Surface runoff	-	344 mm per annum
Groundwater recharge	-	14 mm per annum
Change in storage	-	0 mm per annum

FIGURE 7

SCHEMATIC OF WATER BALANCE



1) OVERBURDEN
   a) TILL UNIT
   b) DISCHARGE ZONE TILL
2) FRACTURED SHALE UNIT - HIGHLY WEATHERED AT SURFACE
3) WEAKLY FRACTURED MASSIVE SHALE UNIT
4) HIGHLY FRACTURED SHALE UNIT
5) MODERATELY FRACTURED BULK SHALE UNIT

have into the rock using both methods. I would have to check the exact source of that number. It is slightly different from the other one. I am not sure how that was calculated. I would have to check on that, but I believe it to be something of that nature.

You see, the other one was -- I would just have to check that to be sure. It is in the same order as the infiltration rate we were talking about into the rock. I think that would be close. I am not sure it isn't from two models. I would have to check that.

Q. All right, will you do that and we will pick that up on Monday?

A. Yes.

Q. Then, where there are figures, let me take you over to page 132. We see there that that 10,0000 metres cubed per year ...

A. I am sorry?

Q. You see that on page 132?

A. Yes, I do.

Q. As I understood that number before we got the model and went through it, that number was based on a factor that the shale would be 95 per cent -- I am sorry, the landfill on the

shale and the leachate collection system would collect 95 per cent of the leachate and five per cent would escape.

A. Yes, the number, the 10,000 cubic metres per year was derived from the model.

Q. That was from the model?

A. Yes.

Q. Well, is that figure then 10,000 cubic metres per year, another approach then to what you had originally estimated or what you currently estimated as being the leachate that would not be collected in the system?

A. That's right, the system with the downward gradient at the site that we cannot overcome.

Q. Can you translate that 10,000 cubic metres per year to gallons for us?

DR. KINGHAM: You might find the figures on the bottom of page 124 helpful.

MR. SOBANSKI: Thank you, Mr. Chairman.

It would be 4.1 gallons per minute.

MR. McQUAID: Q. Four point one gallons per minute times sixty minutes times twenty-four hours a day times three hundred

and sixty-five would give us the number of gallons per year.

A. I guess that should be 4.2, yes that would give you how many gallons a year. Whatever the conversion is.

Q. We can check that. Do you want to do that right now? It is about 2.2 million gallons per year as I understand.

A. Yes, that is right.

Q. So, the 10,000 cubic metres that we see over on that page per year is in Imperial 2.2 million gallons per year?

A. Yes, in that order.

Q. Now, one model says that you are going to have 2.2 million gallons per year, and the other model you are saying has a tenth of that per year.

A. In that order.

Q. The 2.2 million gallons per year, I tried to put it into layman's thought and someone tells me that the tank trucks we see filling up with Shell Oil or an Esso station may be 4 or 5,000 gallon tanks.

A. Yes, in that order.

Q. So, if we took 4,000 gallon

tanks into 2.2 million, I have worked out 550 tank trucks a year.

A. It is not going to be trucked from the site though.

Q. I just want to get an idea of how much leachate is getting out of this site. You can check my mathematics, but do 2.2 million by 4,000 gallons, it is 550 tank trucks a year, or about a tank truck and-a-half a day.

A. Yes, that is right.

Q. All right then, going over to page 133, where we see dates here, times of 60 to 100 years and so on, I gather those times would change as a result -- you don't know what the figures are, but I gather you are just saying it is going to be longer.

A. It would be longer.

Q. Now, let me go back if I can to the discussion we had about the model and the new run that has been done here on H-221. We had the discussion back at Figure 5 when we were doing the grid discussion and I took you around the grid to ask you what the various inputs were. I think they can be summarized that no flow on the left, no flow on the bottom, Hamilton Harbour,

calculate would be about 2.3 millimetres per year in the new model.

Q. About 2.3?

A. About 2.3, a very low value. It is a little difficult to say exactly because of the way the flow-lines are distributed. Something in the order of two millimetres, I agree with you very low, but again, half-an-inch a year is very low too.

Q. All right, just to give us some background as to what it was you are trying to determine in your report when we go into this next section, can I take you back to page 26, page 27 in the report.

A. Yes.

Q. I see at page 26 here, paragraph (e):

"Computer model studies were undertaken to provide a more detailed analysis and understanding of the existing groundwater flow system at Site F."

And then there is reference to the model that was used:

"This program solves for the hydraulic head distribution and flow-line distribution within a two dimensional porous media domain."

Then there is reference to what goes into the calibration.

Now again, what you are trying -- you are now trying to -- you are going to the next stage in your analysis here at page 65. You are starting to look at the chemistry here in order to determine what effect it might have on the contaminant migration which might come off Site F, is that correct? You have got now, your hydro-stratigraphy and your model is saying "This is our flow-line distribution"?

A. We are not looking specifically at contaminant migration here. We are looking at two things here in groundwater chemistry.

One is the background chemistry which is required at most new landfill sites to see what the quality of water is like. Then we do have an analysis of the organic chemistry to look just briefly at whether or not contaminants may have migrated off-site. We sampled two nests of wells,

N-748

December 7, 1982 letter from Proctor and Redfern to City of Burlington re: Cartwright Report

Design Considerations

There are two aspects of the landfill design that need careful attention if the site is to utilize natural attenuation and assimilation. These are the design of the berm-rock interface, and the final cover.

Quarrying operations are planned, which will remove the upper several meters of the weathered shale. This zone is the most permeable, and the removal of this zone will reduce the amount of leachate that can be transmitted to the groundwater system. The maximum area of shale, especially in the southeastern part of the fill, should be available to accept leachate. The perimeter berm must be keyed deep enough into the rock to prevent leachate springs from developing at the toe of the landfill and still not prevent lateral migration of the leachate. A modified design similar to that suggested by Morrison Beatty on August 10, 1981, should be included in the final design.

Since the most permeable zone of the bedrock will be removed, the leachate that can leave the site through the groundwater system will be greatly reduced (probably to less than one inch of infiltration). Thus, the design and maintenance of the final cover are critical to maintaining the water balance. The cover will have to be designed to maximize surface runoff without excessive erosion and to inhibit infiltration. A heavy clay or layered type of cover will most likely be necessary. At present, most landfill covers do not seem to restrict infiltration to the degree required here. However, surveys are underway to assess existing covers, and considerable research is taking place on cover design. I am sure a cover can be designed for the site which will fulfill the need.

An internal leachate collection system should be installed in the landfill. During the operation of the landfill, it may not be possible to limit infiltration to the same extent as after closure. Thus, it is likely that the leachate collection system will have to be used during much of the operating life of the landfill. It

with a leachate mound of 1.9 m reflecting normal operating conditions for the landfill, the total exfiltration rate calculated for a zone of active flow (ie. the "weathered mantle") of 5 to 10 m in thickness would be approximately 10 mm/a and 20 mm/a respectively (Exhibit H-649). These estimates are considerably lower than those made by CRA.

47. The estimates of total exfiltration at Bayview made by GLL in 1982 were based on the difference between the estimated infiltration of precipitation into the landfill of 165 mm/a and a visual estimate of 69 mm/a for the volume of leachate flows from the leachate seeps around the landfill. There is a good possibility that the visual estimates of the leachate seepage are underestimates because the lower flow and diffuse seepages, even if large in area, cannot be estimated. If this were the case, the estimated total exfiltration would be lower than that suggested by GLL.

48. There is additional evidence which suggests that the zone of active groundwater flow (ie. the "weathered mantle") is either relatively thin or has a relatively low vertical or horizontal hydraulic conductivity. Either of these conditions will act to reduce the total exfiltration from the landfill compared to that estimated by CRA. The observation of no impact of leachate seepage into surface water streams at the Burlington and Bayview landfills with the toe-drain leachate collection systems in operation, and the small zones of groundwater contamination in the shale south of the Burlington and Bayview sites indicate that the rate of shallow infiltration from these landfills is relatively low. Similar conditions would be anticipated at Site F.

49. The estimated total exfiltration of leachate through CRA's clay liner for Site F during normal operating conditions with a 1.9 m leachate mound is approximately 8 mm/a (Testimony by Mr. Petrie, Transcripts v. 114, p . 27,588). There is no basis for total exfiltration estimates as high as 50 to 100 mm/a and the total exfiltration at Site F would more reasonably be in the range of 10 to 20 mm/a. The construction of a liner at Site F will reduce the total exfiltration, but the cost of the liner must be weighed against the benefit of the reduced rate of exfiltration. The operation of the toe-drain leachate collection systems at Burlington and Bayview demonstrate that the bulk of the total exfiltration is already intercepted in the form of shallow groundwater flow. The addition of a liner to these systems would have only reduced the already small volume of leachate which enters the groundwater system and which is not intercepted. At the current rate of total exfiltration of leachate from the Burlington and Bayview sites (ie. with the toe-drain collection systems in operation), neither site produces a significant impact on the surrounding groundwater or surface water environments. Similar conditions would be expected for Site F. There would be no

additional benefit to the addition of a liner, consequently, it is my opinion that a liner is not required at Site F.

CONCLUSIONS

50. It is my opinion that Site F is suitable for landfilling. There should be no significant impact on the groundwater or surface water environments due to landfilling at Site F. In the event that subsurface conditions differ from my interpretation of the site and these conditions allow the migration of groundwater contaminants off-site, no water supply wells would be threatened and the would be ample time for implementation of contingencies if they were required.

51. It is my opinion that Site D can be made suitable for landfilling. For conditions when the hydraulic trap is functioning, there will be no leakage of leachate from the landfill. In the event of failure of the hydraulic trap, leachate will escape the landfill and could result in contamination of the private wells believed to draw water from the granular units underlying the landfill. If the unweathered upper till is unfractured, travel times for contaminants to reach the private wells will likely be many years. Either failure of the hydraulic trap or migration of contaminants would be detected by monitoring before the occurrence of contamination at the private wells. Within this timeframe, contingencies such as the pumping of leachate from the landfill to re-establish the hydraulic trap or the purging of contaminated groundwater from the granular units could be readily implemented.

52. If the unweathered upper till is fractured, travel times for contaminants from the landfill to the private wells may be less than a year. In this event, it is unlikely that a typical landfill monitoring program could identify the failure of the hydraulic trap and permit timely implementation of appropriate contingencies before the private wells might be contaminated. It is my opinion that it is a reasonable possibility that fractures exist in the unweathered upper till. Given the threat to the private wells, it is my opinion that this possible eventuality should be avoided by alternatives such as design, installation and testing of the purge well system prior to landfilling, the connection of the residences to piped municipal water supply, or construction of a liner of re-compacted native clay silt till on the base on the landfill.

53. The existence of fractures in the unweathered upper till and possible rapid contamination of the UGU also magnifies the importance of even short-term (seasonal) failures of the

Q. Then we have -- I'm sorry, I said expected case but it's the worst case.

A. I assumed you meant that.

Q. Then we have the expected case at one millimetre per annum?

A. Yes.

Q. That is quite a range. I guess we really have to go to you as the hydrogeologist to determine what in fact the infiltration number is because we can't expect Dr. Rowe to give us that number.

A. I would be misleading you if I told you I could put my finger on any one of those numbers. You can do these calculations, but I don't think any hydrogeologist, certainly no one who has worked on water resources studies for any number of years would defend to the death any one of those numbers. It could be any one of those numbers, because there are so many uncertainties in arriving at those kind of estimates that I think it is self-evident from the kind of debate that has been going on here for some time on hydrogeology, that there are a lot of uncertainties on putting numbers on hydrogeology and any one of those numbers could apply.

Q. "Any one of those numbers" being

feel this is an inherent difficulty because of the lithology or the type of geologic materials that make up the site. Being fractured bedrock materials, again it is very difficult to characterize the extent and nature of fracturing. For that reason it is difficult to identify the groundwater flow paths and the properties of the rock, the hydraulic properties of the rock.

An important point to notice about Site F is that as it is designed there will be an off-site migration of leachate and the volume of this leachate may be in the order of 10,000 cubic metres per year or about 6,000 gallons per day. The pathway for the escape of this leachate from the site is known only in what I would call a general sense. That is, it is flowing downhill and away from the site. It will likely, most of this leachate, most of this 10,000 cubic metres will likely discharge within several hundreds of metres of the site. It will discharge to the ground surface and to surface watercourses in the area. Some of these subsequently flow through residential areas in Burlington.

It is my opinion that this leachate discharge represents an uncontrolled source or release of contamination to the environment. That when

Q. That suggests, though, that there may be reasonable numbers outside that range, numbers which perhaps aren't as probable but are still reasonable. Do you have a sense as to what the possible limits of that range are?

A. It is very difficult to know base on the information we had. As I said, I base my estimate of those rates on the river basin study and then examination of the amount of contamination at the adjacent site. Perhaps some rough idea of what the permeability, in a large bulk sense, of the upper shal bedrock may be in order to allow infiltration.

In giving an order of magnitude -- I shouldn't call it an order of magnitude -- in giving a range of estimates of about 10 to 20 millimetres I would say that precludes, that is in the order of one millimetre and it also precludes a number in the order of 100 millimetres, but it wouldn't preclude a number that might be as high as perhaps 30 to 40 or somewhat lower. Perhaps a little bit more than five, five or six millimetres per year. But again, based on the information I have, I feel that the 10 to 20 millimetres is the most probable rate.

Q. I take it, sir, that the uncertainty that exists with respect to this estimate

and that is for the packer tests undertaken at HC4. The packer tests undertaken at HC4 also generated a hydraulic conductivity value of 10^{-4}, and I don't have the specific number, but again from that packer test, and packer tests conducted at HC3 where 10^{-4} values were appropriate, and HC3 is immediately proximate to PW2 and so I was indicating that that was just one area.

With respect to exfiltration from a landfill into the rock at Site F, we suggested numbers that may range from 50 millimetres per annum to 100 millimetres per annum. Since being on the stand and learning more about this site I believe the 100 millimetres per annum is high. I believe the 50 millimetres per annum is a good number and it may be conservative.

MR. McQUAID: Q. What does that mean in the terminology we have been using so the Board is clear?

MR. PETRIE: A. It is my opinion that the exfiltration from the landfill at Site F to the rock is not likely to exceed 50 millimetres per annum and it may be less, but for the purposes of design considerations I believe a conservative number or good number, i.e., 50 millimetres per annum is an

above points are addressed following the definition of the hydrogeologic system and the conceptual engineering design.

From this assessment a hydrogeologically acceptable landfill site must meet the following minimum criteria:

1) Migration of contaminants from the landfill must be predictable and the impact from this migration must be determined to be acceptable.

2) The site must be able to be adequately monitored in order to verify the predictions on the behavior of the contaminant migration.

3) Feasible contingency plans must be developed such that if unacceptable contaminant migration results, as determined from the monitoring, this migration can be mitigated.

The following sections provide a discussion of these items.

C.5.0 SUITABILITY FOR LANDFILLING

C.5.1 INTRODUCTION

As described in Part A of this report, for a site to be considered suitable for landfilling it must meet three criteria. These are:

1) Migration of contaminants from the landfill must be predictable and the impact from this migration must be determined to be acceptable.

2) The site must be able to be adequately monitored in order to verify the predictions on the behavior of the contaminant migration.

3) Feasible contingency plans must be developed such that if unacceptable contaminant migration results, as determined from the monitoring, this migration can be mitigated.

Each of these criteria are now examined in light of the interpretation of the groundwater flow system presented herein by CRA.

above points are addressed following the definition of the hydrogeologic system and the conceptual engineering design.

From this assessment a hydrogeologically acceptable landfill site must meet the following minimum criteria:

1) Migration of contaminants from the landfill must be predictable and the impact from this migration must be determined to be acceptable.

2) The site must be able to be adequately monitored in order to verify the predictions on the behavior of the contaminant migration.

3) Feasible contingency plans must be developed such that if unacceptable contaminant migration results, as determined from the monitoring, this migration can be mitigated.

The following sections provide a discussion of these items.

C.6.0 SUITABILITY FOR LANDFILLING

C.6.1 INTRODUCTION

As described in Part A of this report, for a site to be considered suitable for landfilling, it must meet three criteria. These are:

1) Migration of contaminants from the landfill must be predictable and the impact from this migration must be determined to be acceptable.

2) The site must be able to be adequately monitored in order to verify the predictions on the behaviour of the contaminant migration.

3) Feasible contingency plans must be developed such that if unacceptable contaminant migration results, as determined from the monitoring, this migration can be mitigated.

C.6.2 PREDICTABILITY

In order to ensure that unacceptable groundwater quality impacts will not occur in the event of an uncontrolled landfill failure at this site, contaminant transport times are evaluated for each of the potential

DR. KINGHAM: Can we understand that in terms of the chloride profiles here that below the red line is essentially old water geologically?

MR. PETRIE: We can understand that.

DR. KINGHAM: Above the blue line is relatively fresh water?

MR. PETRIE: Recognizing that as water exfiltrates from a landfill at the site and moves generally downslope, it is going to pick up more mineralizations as it flows and the chloride levels would increase from left to right and the water would still be modern in the general sense.

In consideration of all I have learned from the new data provided since I have been here and the additional interpretations considered, in my mind the site is poorly defined and I feel it cannot be easily monitored and I cannot make predictions regarding the rate and patterns of contaminant migration that may occur at this site and with respect to the criteria we developed on hydrogeologic suitability, I believe Site F is not hydrogeologically suitable.

Now, we considered an alternative landfill design of a clay liner and that clay liner would consist of a lower sand blanket, a clay liner

itself and then a sand blanket and leachate collection system on the upper side of the liner and the refuse would be deposited above that again. We believe that that liner is a feasible alternative in order to make the site environmentally sound. It does in our mind give us greater confidence with respect to prediction and we have a greater capacity to monitor. We can monitor the sand blanket directly beneath the liner for a compacted, installed clay liner and we would have an understanding of its properties, its porosity and hydraulic conductivity, and would be able to make predictions regarding the rate of diffusion or the rate of contaminant transport through that liner and have a reasonable handle on the capacity for that liner to provide attenuation. Given that we can monitor the base of the liner, it provides us the capacity to monitor the site. Two questions or two points were raised during cross-examination regarding the liner and these we feel are design issues. One relates to the position of the water table vis-a-vis the liner and if the liner is at -- if the water table is at the base of the liner we have calculated one hydraulic gradient across that liner and if the water table is at the top of the liner we have a different hydraulic gradient across that liner. Thus the position of the water

table with respect to the top of the liner is yet to be evaluated and we feel is a design issue respecting the design of a liner.

The second issue raised is the geotechnical considerations with respect to installing a compacted clay liner on one part on rock, and that would be the portion of the rock which would be removed so you would be dealing with a more fresh rock surface and, secondly, the clay liner to be installed on infilled material, infilled into the stream fillings so you would have two base materials on which the liner would be constructed. Those are geotechnical considerations and again can be addressed in a design aspect of that liner. We feel the liner does provide a feasible alternative to make the site environmentally sound.

DR. KINGHAM: Do you know of any case where an attempt has been made to put a liner on an incline on two different base materials and the liner has survived?

MR. PETRIE: I do not and could not speak to that.

MR. CRUTCHER: If I may add, I hope to be able to address that a bit more in the operations portion.

MR. PETRIE: To sum up again, the tritium and chloride data can be viewed as providing a measure of those portions of the rock which are more hydraulically active and ignoring some of the tritium data and it may be appropriate to do that and indeed it could be verified by additional tritium sampling and it would make it a less complicated picture or more consistent picture vis-a-vis the chloride and tritium for the more hydraulically active portions of the rock. We feel exfiltration from the landfill or -- 50 millimetres per annum is a good number, but in consideration of all of that I still feel there is difficulty in predicting the performance of the site and being able to monitor the site and there is some measure of uncertainty as to how effective purge wells would be to control contaminant migration should it occur and the liner alternative, and there are some design issues which must still be evaluated at greater depth, but we feel the liner provides us with the capacity to predict and monitor the site and, in that sense we believe the liner would make the site environmentally secure and more safe.

MR. McQUAID: Thank you, Mr. Petrie. Those are all my questions. Thank you, Mr. Chairman.

MR. LANCASTER: Thank you, Mr. McQuaid,

is there is a very large change in the permeabilities between the liner and the underlying material.

DR. KINGHAM: Okay. I don't intend on behalf of the Board to pursue this any further now. I wanted to make sure at least we knew where we were with the information that had been provided to date. I think we understand where we are with regard to the change in gradient and the assumed conductivity in the original design, the Trow/Hydrology Consultants Limited design. I think we understand from what you are saying that you would have us consider your hydraulic gradient of unity combined with the hydraulic conductivity of 10^{-8} to be considered as your worst case rather than an optimum case but you cannot give us a most reasonable or best case as of now?

MR. CRUTCHER: I would like to but I would like to work on the numbers to make sure we are comfortable with those numbers.

DR. KINGHAM: It's in your hands, Mr. Hodgson.

MR. HODGSON: Thank you.

Q. Mr. Petrie, could I go back to asking you some questions, please? Mr. Petrie, would you flip the flip chart up to a clear page, please? Okay. Now, would you draw me a hypothetical flow

system, et cetera, for a hypothetical landfill and would you start by constructing for me a liner that is 1.2 metres deep?

MR. PETRIE: A. What sort of scale do you want on the drawing?

Q. Let me draw one. Now, can we give this a number, please, Mr. Chairman?

MR. LANCASTER: H-653.

--- EXHIBIT NO. H-653: Flip Chart, Drawing of landfill with 1.2-metre deep liner

DR. KINGHAM: Although after your admonition of yesterday we wonder if Mr. Tidball's eyesight has improved dramatically overnight.

MR. HODGSON: I'm sorry, Mr. Tidball, I did not have you in mind. I was too close. I'm not used to performing.

DR. KINGHAM: The numbers are 1.2 metres on the bottom, 1.9 metres beneath the curve and 50 metres across the top.

MR. PETRIE: Can we label these?

MR. HODGSON: Q. The middle layer is the liner and you can give it a K, a vertical K of 1×10^{-8}. Now, imagine the situation, the hypothetical situation that goes like this: somewhere in the world we have got a bed of shale with an average vertical

hydraulic conductivity, just for the sake of discussion, of 1 x 10^{-5}. So perhaps you could label that bed of shale 1 x 10^{-5}.

MR. PETRIE: A. Sorry, which is the shale?

Q. Underneath the liner it is a K_v of 1 x 10^{-5}. I want you to imagine that before a landfill was built at this liner this bed of shale had hydraulic characteristics that permitted it to accept infiltration of 100 millimetres per annum. Could you write that down at the bottom, 100 millimetres per annum infiltration of the shale in its natural state before anybody landfilled at the site?

MR. McQUAID: Before we go too much further, Mr. Chairman, I think I am correct when I say that if there is going to be an assumption given to a witness either the assumption has to be agreed to in some way by that witness or by some subsequent witness or by the evidence that is being presented because if we just have assumptions of Mr. Hodgson, without connection to evidence, we really don't have anything that is going to be of probative value to the Board. So, I would like to have it somehow connected to the evidence instead of just a theoretical, hypothetical assumption, "Assume this somewhere."

MR. HODGSON: Mr. Chairman, given the difficulties we are having working with first principles to figure out mathematical relationships I would have thought that I would be permitted some leeway by the Board to just construct a hypothetical. For the purposes of this objection at this point in time can I please go back to the witness and see if I can in fact nail this one down?

MR. LANCASTER: Proceed.

MR. HODGSON: Q. Mr. Petrie, in your calculation at page 156 on Exhibit B-617 you have hypothesized a horizontal hydraulic conductivity of 2 x 10^{-4} for fractured shale?

MR. PETRIE: A. That number was derived from pumping tests. I did not hypothesize.

Q. You would like the Board to accept that as a reasonable number for the horizontal conductivity of the fractured shale at the proposed Site F?

A. That could be.

Q. Am I correct that I heard you say last week in your evidence that if the horizontal conductivity is 2 x 10^{-4}, that the vertical conductivity of the same shale could be anywhere from one to two orders of magnitude lower?

A. I don't recall making that statement.

Q. You said it at least twice. Do we now have to go back to the record?

A. I recall Mr. Tidball asking that question. He asked would I consider the rock as anisotropic and my answer to that was yes. He then asked if I would consider an order of magnitude an appropriate number for the degree of anisotropic and my recollection was yes. He then asked if I would consider two orders of magnitude and I'm not sure -- I did not give a definitive answer.

Q. You would agree to one order of magnitude lower?

A. It was not unreasonable.

Q. In fact it's possible in a shale environment, an anisotropic shale environment that the vertical conductivity could be as much as two to three orders of magnitude lower than the horizontal hydraulic conductivity?

A. It could be when we are dealing with a highly heterogeneous media.

Q. For the purposes of our discussion would it be reasonable to assume that shale with a horizontal K of 2×10^{-4} has a vertical K of 2×10^{-5}?

A. It is not unreasonable.

MR. HODGSON: Does that satisfy you, Mr. McQuaid? Can we relate that to the document?

Q. Now would you change the shale up there to 2 x 10^{-5} and would you note that that is K_v, please?

MR. PETRIE: A. The entry on Exhibit 653.

Q. Just to nail down everything for Mr. McQuaid would you agree that 1.2 metres is the design thickness of the liner, Mr. Petrie, Mr. Crutcher is proposing for Site F?

A. That is as he has presented it, yes.

Q. Will you agree with me that 1.9 metres is the maximum height that the leachate will reach between drains spaced 50 metres apart over that liner?

A. As per the calculations you provide on Exhibit H-648, yes.

Q. You will? Thank you. All right, back to the hypothetical garbage dump on the hypothetical bed of shale somewhere in the world.

Your evidence at this hearing is that it is not unreasonable to think that the infiltration into

the shale at Site F could be as high as a hundred millimetres per year?

A. Under conditions of landfilling.

Q. With the landfilling. Would you agree with me that the infiltration rate without landfilling would be approximately the same amount?

A. The head characteristics in the system will definitely be different.

Q. Well, all right. For the purposes of this discussion I don't think we need to go -- more than go back to page 156 to your Example A. Your Example A is Site F without landfill; right?

A. That is correct.

Q. You have got an infiltration of 56.8 as the highest infiltration without a landfill -- sorry -- 45.4?

A. That is correct.

Q. Can we make the assumption on there that the infiltration rate is 45.4 millimetres per annum without a landfill, change the hundred millimetres to 45.4 millimetres per annum? Now, Mr. Petrie, would you agree with me that if you have shale with a vertical conductivity of 2×10^{-5} capable of receiving annually 45.4 millimetres per annum of recharge and you slap over top of it 1.2 metres of very

tight clay material with an average vertical hydraulic conductivity of 1 x 10^{-8}, that that will have an effect on the amount of water that reaches that shale?

A. Yes.

Q. In fact, is it not the case that the shale underneath will start to dry up a little bit?

A. This is similar to the question you put to me with respect to Site D such that if you removed one of the layers, what would that do to the system. You are now imposing a layer and changing the amount of fluid flow through that area. You then have to consider the inflow from the side in some fashion because the hydraulic heads or the gradients within the system, this system being the shale bedrock will change.

Q. Thank you. Would you take a blue pen, please? Would you draw an imaginary water table that is, say, an inch below that liner?

A. You mean a physical inch on this piece of paper?

Q. Yes. Do you need a heavier pen? I have a heavier pen.

A. It would help, yes.

Q. So, let us assume for our discussion that that was the original water table in

the shale before anyone came along and plunked down a liner. Is that a fair assumption?

A. That is your assumption. Yes, I can agree with it.

Q. Would you agree with me that after a liner was constructed over that shale at this imaginary landfill that that water table would in fact start to decrease?

A. If the sole input to the system was from the top it would definitely decrease. I would imagine it would decrease in some fashion. The balance would be flow contributed in some fashion from the side.

Q. It wouldn't increase, would it?

A. I have trouble imagining it increasing.

Q. Would you then give us what you say would be the change in water level of the water table underneath the liner after the landfill is constructed?

A. I did not say what the change would be.

Q. I know you didn't but would you draw up there either the same or a very slight change lower? You told us it wouldn't be higher.

A. I am agreeing it is unlikely to be higher.

Q. So it could be the same?

A. I suspect it would have to be lower.

Q. Would you draw something that is just slightly lower or whatever amount lower you would like the diagram to be?

A. We are not implying a scale on this drawing of any fashion?

Q. I am not worried about the scale. We are not going to win or lose this hearing by the scale on Exhibit H-653. I am just trying to get an illustration of the principle. Could you label the first water level before landfilling and the second water level after landfilling?

Now, we have a situation here, you would agree, where the liner sits over the water table and the water table doesn't rise up to the level of the liner?

A. In the situation you have described here that is what we have.

Q. Now, in that situation would you please tell the Board what will the vertical gradient be across the liner of the landfill with 1.9 metres of

head and a water table that is below the bottom of the landfill?

A. The water table below the bottom of the liner indicates to me that we have unsaturated conditions in some fashion in this area, this area being between the water table and the base of the liner. Under those conditions I have difficulty conceiving of a hydraulic gradient greater than one across this liner. Mr. Crutcher made reference to a flow discontinuity. One way of dealing with saturated flows of a portion of this liner and we are dealing with unsaturated flow immediately at the base of the liner and above the water table, one cannot apply the Darcy equation to unsaturated flow.

Q. Would it simplify things for you to bring the water table to the bottom of the liner?

A. To answer the question you put to me it would make a simplification, yes.

Q. Make the assumption the water table is at the bottom of the liner and calculate for us, please, the gradient across the liner.

A. For the assumptions you are requesting the change in head would be 1.9 metres divided by the length of the flowpath, 1.2 metres.

Q. If the water table is at the

bottom of the liner what is the head at the bottom of the liner?

A. If the water table is at the bottom of the liner ...

Q. Yes?

A. ... then the head at the bottom of the liner is equivalent to the elevation of the water table.

Q. Can we use zero for the purposes of this calculation?

A. If you wish, yes.

Q. What is the head at the top of the liner?

A. The head at the top of the liner as indicated by the pressure head in the middle of this system of drains is the 1.9 metres.

Q. Let me just understand. How do you calculate head differences? Do you have to calculate them based on a difference from the same point, the same datum?

A. Yes.

Q. We are trying to calculate the head difference at the bottom of the liner -- the top of the liner, sorry?

A. You have lost me. I don't

understand how you calculate a head difference at the top of the liner.

Q. Doesn't the head at the top of the liner have to be measured from the base to compare it to the head at the bottom of the liner?

A. There are two terms I think implicit in your assumption; elevation head and piezometric head. I am indicating a pressure head at this point is 1.9 metres. Sorry, should I go on?

Q. Yes.

A. The pressure head at the top of the liner is 1.9 metres in the mid-point between these drains. At the base of the liner we are saying it has a zero pressure head. There is a change across this liner of 1.9 metres in elevation head, in piezometric head.

Q. Just a second. Can you pretend that the base of the liner is at sea level?

A. It has a zero here if that assists in your pretensions.

Q. What is the elevation of the top of the mound with respect to sea level?

A. That would again be 3.1 metres in elevation.

Q. Isn't that the head difference

between the top of the mound and the bottom of the liner?

A. Could you repeat your statement, please?

Q. Isn't the head difference between the top of the mound and the bottom of the liner 3.1 metres -- I'm sorry -- the top of the mound and the bottom of the liner, isn't it 3.1 metres?

A. The top of the mound ...

Q. Just a second, my prompter is -- I'm sorry. The head difference between the top of the liner and the bottom of the liner is 3.1 metres?

A. The pressure head at this point is 1.9 metres.

Q. Doesn't the elevation at that point have to be measured with respect to the base?

A. You are looking at elevation head. I was indicating you had a change in head from 1.9 metres, that being the pressure head at this point in the top, at the top of the liner relative to the head that you have acquired by putting a water table at the base of the liner, at the bottom of the system. So over that flowpath of 1.2 metres we have a change in water level of 1.9 metres.

Q. Just give me a moment.

Mr. Petrie, to calculate the gradient don't we have to relate everything to the same point and to calculate the gradient across the liner don't we have to relate everything to the base of the liner?

A. I would calculate the gradient by the change in pressure indicated by delta H over delta L. Delta H being the change in head across the system, having a length of delta L.

Q. Isn't what we're calculating the change in piezometric head, not pressure head?

A. Pressure head at this point is 1.9 metres.

Q. What is the piezometric pressure at that point?

A. The elevation head at this point is 3.1 metres.

Q. Yes. So the piezometric pressure is 3.1 metres and the distance across the liner is 1.2 metres and the gradient is 3.1 divided by 1.2; is it not?

A. I hear what you're saying. I have a little difficulty in understanding what you're getting at.

Q. I'm getting at the gradient across the liner so we can figure out the flux across the

liner.

A. That I know, that is the next step. It's the steps you take to arrive at the gradient that we are discussing now. I beg your pardon, I believe I am in error.

Q. All right. Now, you explain it to us and the Board, will you, please?

A. Let us back up. If the water level was at this point here, this point here being the top of the liner, now I have the gist of your question correctly, we would have a 1.9-metre head change between the top of the liner and the base of the liner with a flowpath length of 1.2 metres. That is what I've indicated up there. You are quite correct, we ought to be looking at the elevation head difference. The elevation head difference as you have described this hypothetical situation is 3.1 metres over flowpath length of 1.2 metres.

Q. And that is the gradient across the liner?

A. For the system that you have proposed recognizing that the head of 1.9 metres occurs at the mid-point between the drains, yes.

Q. Thank you. All right. Now, can someone use their calculator to divide 3.1 by 1.2,

please? That 2.58 is the gradient across the liner in this hypothetical scenario where the water table is at the base of the liner?

A. That is the number I've calculated, correct.

Q. Thank you. If the Board wanted to know how much leachate could escape this hypothetical landfill by going across that liner they would multiply the vertical hydraulic conductivity of the liner by the vertical gradient across the liner, would they not?

A. That is correct.

Q. Would you do that, please?

A. I have units of centimetres per second.

Q. Why don't you give us an answer first? That is the Darcy flux now?

A. Correct.

Q. I have forgotten, Dr. Rowe had a notation for Darcy flux, V_a, let us keep -- V_a = 1 x 10^{-8} cm/sec x 2.58 equals?

A. Two point five eight x 10^{-8} cm/sec.

Q. Just so we can have apples and apples, to use that awful metaphor maybe for the last time, can you convert that to millimetres per annum,

please?

A. I get 8.14 millimetres per annum. I get 8.1363 to four decimal places.

Q. So now ...

A. Sorry, was it 8.14, is that what you're saying?

Q. No, that's what you said. That is acceptable.

A. Equals 8.14 millimetres per annum.

Q. Thank you. Now, I am sure we will have an opportunity to discuss this subject in the future but perhaps we could go back to where it is we left off this morning at 12:30.

Now, would you go back through the flip charts until you get to the last one I drew for you before the break this morning?

A. Is this the one?

Q. Yes, it is. That is H-650?

A. Correct.

Q. Now, Mr. Petrie, we are now looking at a situation, another hypothetical situation which has some elements of the flow model which you have set out on page 156. Namely, it has got shale with a horizontal hydraulic conductivity of 2×10^{-4}.

A. It is a schematic.

The tendency is to put as much information as can be humanly gathered before the Board and then say "See, it is acceptable." We would like to suggest that there is in fact an objective way of looking at this which applies across the board and it applies beyond Sites D and F and we would like to propose that in fact there are three criteria against which you should evaluate both Sites D and F. The three criteria are set out in paragraph 19 and they are:

> "(1) It should be demonstrated that any predicted leachate migration from the landfill will not impair the reasonable use of ground water on adjacent property.
>
> (2) It should be demonstrated that a monitoring program can be developed which will be capable of identifying any movement of landfill-derived contaminants."
>
> (3) It should be demonstrated that feasible contingency measures will be available to mitigate any impact on adjacent property that is identified by the monitoring program."

I put those three criteria or fairly close versions of

to the practicalities in a site-specific way, you can carry it to the absurd because a trivial amount of contaminants would be enough to breach the standard when in fact you could have evidence that there will be no impact of a negative kind at all even by a trivial loading of contaminants. In my respectful submission on the evidence before you that is the appropriate amendment to be made to the criterion and we have outlined it in the typewritten version we have given to you.

Mr. Chairman and Dr. Kingham, the next portion of our submissions relates to planning and I would ask that you entertain those submissions from Mr. Griffiths. I wonder if it would be appropriate to take a break firstly.

MR. LANCASTER: It is.

MR. GRIFFITHS: I will add I will be making reference to just a few volumes of the transcript and you might want to look up four volumes, 63, 64, 102 and 103. Those will be the only transcripts to which I will be making extensive references.

MR. LANCASTER: Thank you. We will break for ten or 15 minutes and get those.

--- Recess

SUGGESTED CRITERIA FOR ACCEPTANCE OF LANDFILLING

MOE

Groundwater

1. It should be demonstrated that any predicted leachate migration from the landfill will not impair the reasonable use of groundwater on adjacent property.
2. It should be demonstrated that a monitoring program can be developed which will be capable of identifying any movement of landfill-derived contaminants.
3. It should be demonstrated that feasible contingency measures will be available to mitigate any impact on adjacent property that is identified by the monitoring program.

Surface Water

1. It should be demonstrated that predicted leachate migration from the site will have no impact on surface water.

ESTRIN

1. It should be demonstrated by the proponent both through hydrogeological and conceptual design evidence called at the Hearing that any predicted leachate migration from the landfill will not impair the reasonable use of groundwater on adjacent property for the contaminating lifespan of the site.

CRONK

1. It should be demonstrated that predicted leachate migration from the site will have no significant adverse impact on surface water.

CRA

1. Migration of contaminants from the landfill must be predictable and the impact from this migration must be determined to be acceptable.
2. The site must be able to be adequately monitored in order to verify the predictions on the behaviour of the contaminant migration.
3. Feasible contingency plans must be developed such that if unacceptable contaminant migration results, as determined from the monitoring, this migration can be mitigated.

opinion of the suitability of Sites D and F for landfilling today? Start with a general overview and then go into a detailed analysis?

A. Okay.

Again, I feel that Site D is a containment site. It is one which is predictable in a hydrogeologic sense and I feel that it is, for that reason, better suited to landfilling than is Site F. Site F is not a containment site, it is one which, according to the present design, allows for offsite migration or escape of leachate and my primary concern at this time is the location and the nature of that extent, where it occurs and how long it will take to occur and the volume of leachate that will escape the site is not well understood.

Q. Can you go through the details of your analysis, if you would like to start with Site F first?

A. Mr. Chairman, I will be going through the information that I gathered or that I prepared in order to reach my conclusion about the geology of Sites D and F.

In many ways this is a summary of information that has been presented by previous investigators, the other people who have testified at

overall loading of contaminants from a wide number of sources to the environment.

In my view, the best technology for reducing contamination at Site F could consist of many items. One would be the installation of a low permeability liner as discussed by Trow in Exhibit H-40. This would result in a reduction of the amount of leachate discharge by greater than 50 per cent. In addition to that, of course, there would still be leachate discharge even though the liner would reduce the volume of that discharge.

To collect that leachate discharge, I feel it would be necessary to either install an extensive perimeter system or a deep drainage system to collect that discharge or a purge well system.

MS VIGOD: Subject to any final comments you have, those will be my questions.

MR. LANCASTER: Thank you, Ms Vigod.

CROSS-EXAMINATION BY MR. TZEKAS:

Q. Mr. Bowen, may I deal first with the infiltration rates that you have assumed for Site F? I gather from the tests that you refer to that there was really no direct way for you to know or estimate that infiltration rate.

Q. Now, I would like to turn to the area of site engineering if I may. You have indicated, you have set out in the report, some of the controls that you propose at Site F and some of the systems that you feel would be necessary to create a suitable site.

First of all, can you tell me what the estimate of a 50 per cent reduction in exfiltration with a liner is based on?

A. Again, that was obtained from Exhibit H-40. It is Trow's estimate, and I believe it was somewhat greater than 50 per cent, as I recall. It was based on an assumed permeability and thickness for the liner beneath the landfill and based on that assumed permeability and thickness of the liner, there was a corresponding reduction in the amount of leachate that would leak through it.

Q. I take it there is some concept of the liner that allows that figure to be used.

A. Yes.

Q. Did you do any independent work on that, Mr. Bowen, or are you adopting Trow's number on that?

A. I am simply adopting Trow's number on that.

Q. Would the existence of a liner at

Site F allow one to measure or monitor the performance or the levels of exfiltration in a more specific way?

A. Yes, if there were an engineered liner placed beneath the site that would permit, at least in a much more definite sense, within a much smaller order of variability it would permit one to calculate how much leachate leaves or leaks out the bottom of the site because what we would be doing is placing an engineered containment layer whose properties we know fairly well between the refuse and the geologic environment. The shale bedrock. Because we know its properties fairly well and have some idea of how much mounding we can expect within the garbage we can then calculate how much would leak out the bottom of that liner.

So, in short, it would provide us with a high level of confidence as to ultimately how much will leak out the bottom of the site.

Q. Moving then to the perimeter drain system, can you indicate to me or give me an estimate of how effective you think that drain system might be in picking up the leachate which does get through the liner.

A. I think it would have limited effectiveness because, as I have illustrated on Exhibit

WB-907, that in order to pick up the leachate which would leak through the liner, through the bottom of the site if it weren't lined, in order to pick up that leachate before it flowed out and through the active zone, that drain would have to penetrate pretty well the full extent of that active zone. It is my recollection the existing toe-drain does not do that.

Q. By "the existing toe-drain" you mean the toe-drain suggested by Trow?

A. You are right, I shouldn't use the word existing -- proposed toe-drain as proposed by Trow.

Q. In order to create any kind of effectivness with respect to the perimeter drain system that you are suggesting, what work would need to be done in order to, prior to the installation such as this?

A. In order to allow for its proper design?

Q. Yes, sir.

A. I think it would be necessary first to determine exactly how thick this upper active flow zone is. If indeed it is of some thickness, perhaps 10 or 15 metres or more, it would become rather an expensive proposition to cut a toe-drain or excavate

MR-906

Witness Statement and Report Evaluation of Hydrogeologic Suitability by Terraprobe Ltd.

surface and surface water courses within hundreds of metres of the site. These water courses subsequently flow through the Aldershot residential community. This leachate discharge would represent an intentional, uncontrolled source of contaminant loading to the environment. The design of the site could be altered to reduce this discharge by installation of a low permeability liner, and a purge well system or extensive perimeter collection system.

In conclusion, it is our opinion that Site D presents a more suitable and predictable hydrogeologic environment for landfilling than Site F.

Respectfully Submitted,
TERRAPROBE LIMITED

Paul W. Bowen, P.Eng.

will not reach the upper granular units -- reach the granular units, be they upper or the lower, depending upon which one exists at which particular point in space.

As a result of this, I categorically state that there should be no impact at Site D.

At Site F, however, the underdrain system is going to collect a significant proportion of the leachate, but some of the leachate is going to bypass the underdrain and this movement will occur into the underlying shale bedrock and it is my estimation that there should still be no significant impact as a result of this migration which will occur over a period of tens of years.

DR. KINGHAM: How do you define "significant" in each of these cases?

THE WITNESS: Significant mainly being in terms of the impact on groundwater by chemicals which would exceed drinking water standards. In the second scenario, the failure of the engineered systems with no implementation of contingency measures; in this case there would be a movement of leachate downward through the unweathered upper till, the lower part of the lower till, at Site D, into the granular units and movement toward the site boundary.

the shallow groundwater flow system, it would be the intention of the perimeter drain system to capture all or virtually, most or virtually all of that seepage. In other words, if one were to add a liner in addition to a perimeter drain system, one would have a certain redundancy in terms of reducing the amount of exfiltration from the landfill. Excuse me, reducing the potential offsite movement of contaminants through the subsurface.

Q. And at Site D?

A. What was the question for Site D?

Q. I have asked you which of the two sites was more likely, in your opinion, to require a liner and you told me that Site D was. You have explained the analysis that you have gone through with respect to Site F; what is it with respect to Site D that leads you to that?

A. With respect to Site D if there is significant fracturing through the unweathered upper till at Site D, then the construction of a liner would be one alternative to deal with that condition to prevent the rapid movement of any leachate out of the landfill in the event of a failure of the hydraulic trap.

Q. If there is not significant

fracturing in the unweathered upper till unit, but it were, after investigation, thought reasonably likely that the landfill itself would induce fractures, I take the liner scenario is one of the three responses you would suggest in those circumstances?

A. The liner option would be another response that could be considered.

Q. Mr. Feenstra, just two other matters very briefly. When you were last here last fall,you and I had a discussion concerning certain of the characteristics at Site F in comparison to Site D, the comparative merits of those two sites for landfilling. That led subsequently to discussions between you and my friend, Mr. McQuaid and Ms. Vigod and Mr. Hodgson. There is one aspect of the discussion that we had that I would like to take you back to and ask you whether, based on all of the information now available to you, your opinion has changed in any respect? Perhaps I could just read it to you and if you wish to see the transcript, by all means I will provide it to you. It is from Volume 44, Mr. Chairman, at page 10033, commencing at line 7 and the question to you, Mr. Feenstra was this.

"Q. Without taking you back to it, Mr. Feenstra, in light of the review and

conversations were. I simply want to know, No. 1, have you ever discussed the evidence that you proposed to give or have given about Site D with Dr. Cherry?

A. Yes, I have.

Q. Can you tell us, was there one conversation or more than one?

A. More than one.

Q. Have you discussed your evidence about Site D and your opinion about Site D with Mr. Ruland?

A. Yes, I have.

Q. Has there been one conversation or more than one?

A. More than one.

Q. Have you discussed your opinion with any other person you regard as a person who has qualifications that make it possible for you to learn something from them about the subject of, the subjects that are discussed in this witness statement?

A. If I mention names will they be called?

Q. No. I don't know if they will be called. I don't even care, and I don't want to know about any contents. Again, I just want to know who did you talk to? First at all, who at Trow did you talk

to?

A. Mr. Sobanski and Dr. Gill.

Q. Do you know anything about the qualifications of Dr. Gill?

A. I understand he is a geotechnical engineer.

Q. With respect to Mr. Sobanski and Dr. Gill was there one conversation or more than one?

A. There was more than one.

Q. Can you name any other persons with qualifications with whom you discussed the contents of this witness statement at any time prior to the commencement of your cross-examination on Monday?

A. Dr. Quigley from the University of Western Ontario.

Q. Anyone else?

A. I discussed aspects of it with Dr. Rowe from the University of Western Ontario.

Q. In those conversations were you interested in gaining their insights into the work you had done?

A. Yes, I was.

Q. Now, finally, the last little group of questions and that is Mr. McQuaid asked you whether or not you had described to me a testing program and

Mr. Chairman and Dr. Kingham, we are certainly aware and are quick to acknowledge that the general principles involved in the weighing of conflicting expert opinion evidence are matters with which this Board is familiar. This has been a very long hearing and it is our hope, sir, that by very briefly dealing with those general principles as they have developed in the case law, it may ultimately prove to be of some assistance to you when you come to reach your decision in this matter. We have prepared a case book for that purpose and I propose to refer to it only very briefly and indeed there are only three cases which I will ask you to go to directly and perhaps that could be distributed. I should say as well, Mr. Chairman, that the size of the case book should not be interpreted as reflective of the time which will be spent on the principles. I am mindful of the discussion which took place the other day and one half of this book is one case that is two hundred and forty odd pages, and rather than give you two pages and run the risk of a battle with Mr. Lederer, I have decided to give you the whole case. I appear to be one short.

The essential governing principles may be summarized in our submission as follows: first, in assessing credibility the law makes no distinction

when they are not legally trained to do so.

I would then refer you to the last paragraph at page 124:

> "Certain authorities have been helpful in assessing expert evidence which is in conflict. In Gallant v. F. W. Woolworth Co.,..."

and you will recall that is, I believe, the second tab of your book, yes, the second tab, it was said by the Saskatchewan Court of Appeal:

> "In the instant case, having found the experts equally credible and qualified, the trial judge should have considered all of the other evidence accepted by him and adopted that theory which was most consistent with that evidence and, therefore, more probable."

And then there is the particular passage I would commend for your consideration, beginning at the second full paragraph on page 125:

> "I have given careful consideration to the testimony of all expert witnesses. The evidence of a number of experts is a major issue in this case. I have looked at, inter alia, the following:

conflict in testimony given by different experts."

In my submission, that is precisely the case before you. There is a marked conflict on two material issues on the evidence of experts you have heard, namely as to whether a liner is required at Site F and, secondly, whether Site D as currently proposed before you is safe and suitable for approved landfilling.

Finally, if I could refer you to tab 8, to the last authority to which I wish to refer, and again it is for the assistance of general principles and I would ask you to go to page 13, and this has to do, Mr. Chairman, with the test that should apply or which should be applied according to the Courts when there is conflicting opinion evidence.

There are two tests suggested in the case law and this case suggests the approach that should appropriately be taken in my submission in this case. Reading from paragraph 19 in the first column on the left at page 13:

"Experts, particularly when called en masse, will almost inevitably disagree as among themselves. This imposes a further caveat upon the trial judge when

attempting to assess that evidence, which will usually relate to a discipline of which he will have very little knowledge. I have found useful guidance in two authorities. The first of these is Re Warwicker, McLeod v. Toronto General Hospital...."

and then he proceeds to quote the test suggested in that case.

"When a case is complicated by the introduction of opinion evidence, particularly in cases of a medical nature, where doctors invariably disagree, it is, I think, the duty of the judge to arrive at his own opinion after carefully weighing and considering the evidence of the experts, and availing himself of all the assistance they are able to give him, and himself to determine the question of fact in the light of that evidence, and it is not enough for him to say, 'I doubt and cannot resolve the doubt, because an expert says "I doubt".'

The appropriate approach to be taken by

to the aspect that Site D, as proposed with the hydraulic trap, was going to be a containment site in that flows would be into the hydraulic trap which has been discussed at some length. I refer the Board back in the exhibits to that Exhibit B-259 where there is really just no entry at all on the XY axis as to contaminants because of the fact that the flow would be into the hydraulic trap.

That was in summary the position before Mr. Feenstra returned and you had a situation where, as summarized on this chart, and I suppose I should add for the Board, you may recall in the evidence that Mr. Feenstra had really ruled out the second scenario and thought that it should be examined, based on the third scenario which was that there would be effective engineering and contingencies in place. As all practical matters, the third, the comments in the third scenario would really apply.

Now, it is my submission, that for reasons which I am going to explain, the Board should determine the position before the Feenstra hypotheses were put in and that they should not be accepted in determination and deciding between Site D and Site F. When Mr. Feenstra came in reply he filed his reply document and he provided three new hypotheses to the

Board with respect to hydrogeologic conditions at Site D. Those three hypotheses were one, fracturing in the upper till, two, the shadow effect, and three, fracturing resulting from excavation. I am going to deal with them in the reverse order.

The third one, fracturing resulting from excavation from heaving or whatever following excavation. That is dealt with in volume 169 page 42120 beginning at line 18 and this is in volume 169 page 42120 at line 23 he says:

> "Right now I am going to present some concepts that are largely in the domain of geotechnical engineering. As a geologist, hydrogeologist I am quite aware of the processes but I am not capable of doing a detailed evaluation of their significance of Site D, however I thought it was appropriate at this time to point out my concerns on this particular point"

I just ask the Board when you are looking at the Feenstra hypotheses to bear in mind that he is just putting forward a concern. Not something that is in his field. And bear in mind that we have evidence from Trow that Site D was suitable. We had Mr. Hiraishi, a

subconsultant, we had Mr. Bowen a geotechnical engineer who had been in attendance for portions of the evidence. We had Dr. Rowe. Dr. Rowe in his evaluation of Site D never indicated that excavation would in any way cause him any concern regarding the integrity of the materials. No question was put by Mr. Hodgson to Mr. Bowen or any other witness that had geotechnical background. So, we just have a concern of Mr. Feenstra thrown out at this point in the proceeding. That is in 169. It is my submission, that given the timing at which it was presented, the manner in which it is presented, the ability of the Region to have, address the issue, to have it put forward as just a concern -- "I thought it was appropriate to appropriate to point out my concern". In my submission this hypotheses is not worthy of any serious consideration by the Board in reaching a decision between D and F. The decision should not be based on this hypothesis.

The second hypothesis, the middle one was what was referred to as the shadow effect or summarized as the shadow effect. Now, can I refer the Board first of all to volume 173. I want to, and 174 I'm going to be looking at both. The first aspect I would like to discuss is related to this proposition as I understand it. The shadow effect suggests, the

evidence is I submit, suggests the flow was downward. There were some discussions about the absence of tritium in the upper granular unit and in volume 173 at page 43173 line number 7 Mr. Feenstra said:

> "There are some locations on the site where there is evidence of upward gradients from the bedrock into the overburden and in particular, I think it has been stated that there are gradients upwards from the bedrock up into the lower granular unit. We don't have a sufficient number of piezometers at the same location in both the upper granular unit and lower granular unit to make any true determination of what the hydraulic head differences are between the two"

And then he goes on to refer to some specific references, H-39, Trow acknowledges:

> " ... some upward gradients in some areas. When one plots all the information that is available, the boreholes, I believe, HC-1-85, 2-86 and 4-85, show the strongest upward gradients and they are right in the middle of the site.

So one could generalize that the gradients are predominantly downward and can be correct for the majority of the boreholes, but in a detailed consideration of the site itself, I think one has to take into account, upward gradients in some locations. I believe Trow acknowledges that there are upward gradients at some locations but a generalized discussion assumed there were downward gradients from the ground surface down to the bedrock.
It was on that basis that the contaminant migration models were performed."

At page 43182 line 9 I put the question to him:

"So, you are now sounding, it seems to me, a note of alarm that these upward gradients are going not to allow -- would not allow Site D to be approved.

A. On the contrary. On the contrary. The upward gradients are of benefit with respect to the potential decline in water levels in the upper granular unit. If there were no upward gradients, when

you cut off the recharge from above with the installation of a landfill, you would cut off the only source of recharge. From that point of view it is of benefit to have upward gradients."

Now at this point it is my submission Mr. Feenstra is indicating that the shadow effect would be insignificant in light of the upward gradients at the site. In addition, I think Mr. Estrin related to the Board a number of examples addressing permeability of the lower till. They are found in cross-examination of Mr. Petrie and there certainly is a reference I believe in chief where Mr. Petrie indicated that the till responded by producing water. The point of that is that if there is permeability in the lower till that would provide for the lateral migration of water into the area beneath the site in the event that the reduced recharge below the landfill caused the hydraulic trap to fill.

DR. KINGHAM: Can I just stop you briefly at that point. You just said a minute ago it is your submission that Mr. Feenstra is arguing it is insignificant if there are upward gradients. I see the words:

"From that point of view it is of

benefit to have upward gradients."
Is there another reference?

MR. MCQUAID: No sir I'm saying based on this answer, I'm saying based on this answer that the shadow effect should be treated as insignificant. He is saying that it will have a beneficial effect. I am saying therefore it is my submission...

DR. KINGHAM: I thought you held Mr. Feenstra's view.

MR. MCQUAID: I am saying the result of that sir. I'm sorry if I launched into a submission rather than a citation from the transcript. It is my submission that Mr. Feenstra is really saying the shadow effect would be insignificant in light of the upward gradients at that site.

In the evidence, in my submission, there are three mechanisms that indicate groundwater could be replenished to the area beneath the shadow, as it is characterized, there is upward flow from the bedrock which we have just been discussing. Two, lateral flow through the till. In addition, at volume 169 page 42130 line 21 Mr. Feenstra indicated that there would be an ability to pump water from the sides and to charge that area if it was necessary. He indicated that could be done as well. But, I think we have to

put the shadow effect as well as, as I say, the geotechnical hypotheses, and as we come to the third one, in perspective because at 43190, actually let me go to 43189 and I will go in sequence. Again we were discussing the shadow effect at line 3, I said:

"You have discussed this with Trow?

A. Yes I have.

Q. Did they share your view or not?

A. Mr. Sobanski does not share my view, no."

Then at page 43190 at line 9:

"At the present time we can't determine the magnitude of that effect. I view the likelihood of a significant effect, a significant shadow effect to be considerably lower than the likelihood of fracturing in the unweathered zone"

Then backtracking to volume 172 page 42856. This is in answer to a series of questions from Ms. Cronk. At line 19, actually line 20:

"That gets into a difficult question because, as I mentioned earlier, I am not sure we would ever be at the stage where we could confidently say there would be no effect due to the landfill.

I am not sure we could ever understand the system well enough to say that with a reasonable degree of confidence."

Then later on, and I'm sorry to jump back and forth but at volume 173, if I could ask you to go back to that 43193, this was the final series of questions that I put to Mr. Feenstra on this aspect. At the beginning or the bottom portion of 43192 I was putting to him effectively whether it is academic interest or whether he was being practical in putting this forward and at line 8 he said:

"I think in practical terms the case is that one probably won't know what the effect is until one builds the landfill.

DR. KINGHAM: I am sorry?

THE WITNESS: Until one actually constructs the landfill and monitors"

What we are seeing there, is in my submission, an admission that the concern that was being put forward, the hypothesis that was being put forward was really of an academic interest. It is something that nobody would know until they build the landfill in his submission. So, we have a hypothesis that is less than, considerably lower than the likelihood of fracturing in the unweathered zone. We have before

that in the order I am going, the reverse order or after that as he put the evidence in, a matter of concern. We have an indication here that one could never study it to the degree that one could ascertain what could happen conclusively. An impossible test at the outset of the consideration of any landfill site in this particular situation. It is my submission that the second hypothesis, as Mr. Feenstra has put it here, is really of an academic consideration. A concern has been put forward for reasons, in my submission, of, I suppose, of trying to assist the Board in the Regional position, of the difference between Site D and Site F. I believe we have to look at what the possible effects of the shadow effect might be. If we were to look at H-39 which is the Trow report, page 98 figure 9 provided the contaminant concentration for the breakthrough profile for contaminants at the base of the upper till under the condition for a failed landfill. It was noted in evidence that the contaminant breakthrough time of approximately 25 years. As I would submit, the shadow effect which cannot be conclusively determined or studied, which is obviously very subtle, one has lateral flow from the till or upward groundwater flow from the bedrock, probably, presumably, based on the evidence but we

would have 25 years before contaminants exiting the base of the landfill would reach the base of the upper till if this effect was of real significance. It is my submission that by the measurement of water levels that have been indicated, it could be monitored effectively, that a very academic consideration was being brought forward at the end of the proceeding, which in my submission does not assist the Board in allowing for the determination of the issue between the two sites that are being proposed.

In my submission, as we are going through this what seems to have been happening is, just see if I can pick up a reference. Sir, I wonder, there is a reference, I can't quite put my finger on it now. I am at the point where I am going to go to the first, the fracturing hypothesis and I am going to be a little while with that one. I wonder if I could just ask for a little earlier break than usual.

MR. LANCASTER: It's not that much earlier, it is appropriate. Fifteen minutes.

--- Break

MR. LANCASTER: Please be seated.

MR. MCQUAID: Mr. Chairman, Dr. Kingham at the break I was looking for a reference. I would like to refer you to volume 174 page 43255 going over

to the top of 43256. The question at line 14:

"Q. Then, also if we carry it further, given your hypothesis of upward flow in certain portions of the site, again does this not also suggest that it is not unreasonable to assume that the shadow effect won't affect the successful operation of the hydraulic trap.

A. With evidence of a reasonably permeable lower till and the evidence of upward gradients at some locations, it would certainly give a mechanism by which the effect, or the shadowing effect would be minimized that is correct.

Given the information we have at the present time, it is not possible to quantify what that effect would be. It is quite conceivable that the shadow effect might not result in a significant decline in the water level beneath the site, but I have recommended that because of the possibility that it may occur that it should be monitored very carefully."

Now, I ask the Board to note, we are dealing here, in the first one that I dealt with that is the geotechnical concern, at page 42121 of volume 169 line 4 to 6 and he felt it was appropriate to point out his concerns on this particular point. Here, because of the possibility that may occur it should be monitored. I just ask the Board to bear that in mind that we have the natural mechanisms we have just been discussing before the break of upward flow from the bedrock or lateral flow through the till. I would also refer you on this aspect of the third mechanism or means by which the shadow effect could be alleviated or overcome. Paragraph 16 of H-936, the Witness Statement:

> "In the event that drought or reduced recharge due to the landfill result in significant reductions in the groundwater level in the UGU, rather than purging contaminated groundwater from the UGU, it may be possible to maintain the hydraulic trap by recharging the UGU by using a series of injection wells. Water could be obtained from piped Municipal supply or from bedrock or basal overburden zones to surcharge the UGU to maintain a

hydraulic head above that of the leachate in the landfill"

So, the third means is by, as I have noted earlier in reference to the evidence, by recharging or charging the water to the UGU using these injection wells. I just ask you to notice, as well, he goes on to express a series of concerns about doing that. My submission is, as we go into discussion of the first hypothesis in the reverse order I am doing, that Mr. Feenstra in his reply statement was increasingly, in my submission, becoming overly cautious, overly academic about concerns, any thought, possibilities, concerns, et cetera that were coming to his mind.

Let me turn now to the fractures in the, or fracture hypothesis. Now, the evidence was, and in both his evidence and in his witness statement I think the expression was used that there was a reasonable possibility that the fractures extended through the unweathered upper till at Site D. I think he noted in his evidence and I think it is referred to in paragraph 3 that that had not been confirmed or even suggested by the field data available. I will just pick that up. Paragraph 3:

"The presence of fractures through the unweathered Upper Till has not been

confirmed or even suggested by the field data at Site D ..."

That is the beginning portion of his sentence. It would appear to contradict the lack of tritium in the THCL tritium nest and the lack of tritium in the UGU and the lower granular unit pumping test discharge water. Mr. Feenstra in his evidence, in the reply statement with respect to the absence of tritium in the granular units suggests that this observation could be explained by the mixing of water in these granular units. That is some of the water could be derived from the upward flow from the bedrock. He made reference, expanded on that in paragraph 15 of his witness statement where he referred to Dr. Charlesworth and indicated there were upper gradients from the bedrock into the lower granular unit and the upper granular unit in some areas of Site D.

Mr. Feenstra, in his evidence, indicated he really didn't have sufficient data to distinguish between the hydraulic head in the granular units. It is my submission that all the hydrogeologists at this hearing have indicated that downward flow dominates across the upper till to the upper granular unit. It would be my submission that this would suggest that much of the water in the upper granular unit is derived

from above. The absence, in my submission, of tritium in the upper granular unit therefore is a strong indication or suggestion that the fracture hypothesis cannot be supported. Mr. Feenstra indicated that the possibility of fractures at Site D first occurred to him during the cross-examination of Mr. Petrie by Mr. Estrin where reference was made to Mr. Petrie's work on the Maryhill Till in Waterloo. I just ask the Board to note, I think there are a number of references but there are certainly two. Volume 124 and volume 133. There were references by Mr. Petrie to caution regarding the interpretation of the pumping test results that were undertaken in that Maryhill Till. Then at volume 124 page 29962 at line 9 he was asked by Mr. Estrin:

> "Are you now saying you don't place greater reliance on pumping tests than the other tests?
>
> A. I believe pumping tests will produce some data which reflect a stressed physical condition in the aquitard and I do not know how to translate that to an in situ hydraulic conductivity. I suggest that point has not been researched in depth and there

might be a great variety of opinions from various researchers."

Then Dr. Kingham you asked him to return to this discussion in volume 133 at page 32096, 32096. I am sorry that is where the discussion begins, going over to page 32102 I think we pick up the summary and line 6 there is discussion about the use of numbers and at line 11:

"The mathematics are there to use, but there is some large measure of uncertainty in what the numbers means, and my response to a question in that respect was that I feel it is more still within the domain of research ... "

Then he goes on to indicate changes that might occur and responses in aquifers and so on and then that was continued over to page 32103 where it was summarized, Dr. Kingham by you:

"... still close to the domain of research in terms of the interpretation of results of such a test ..."

Now, there were other references as well I believe during the cross-examination of Mr. Estrin.

Mr. Feenstra also made reference, as the Board will recall, to the Vandalia Till in Illinois.

However, I think when you look through the evidence there was not a great deal of weight given to that particular aspect of the matter.

The main support for the fracture hypothesis was the research done by Mr. Ruland as indicated in paragraph one of Mr. Feenstra's witness statement where he refers to that particular paper and indicates that the presence of tritium indicates fractures might extend below the zone of weathering in the Sarnia Till. In response to a series of questions from Ms. Vigod, Mr. Feenstra indicated in volume 175 at page 43536, there is an exchange on these pages going over to the next page about what really Mr. Feenstra had done, as to how the drilling had been done, what techniques were used to instal the piezometers, whether there had been examination of drill logs in each of the piezometers sampled by Mr. Ruland. At page 43542 Ms. Vigod explored with Mr. Feenstra the fact that Ms. Hewetson's thesis, another researcher thesis document had also been reviewed by Dr. Cherry who had supervised that work also. The point really I think that comes from the use of Mr. Ruland's thesis, student thesis, developing a hypothesis based on that work is in the proceeding such as we have here. There has not been any first or primary investigation of the work

that has been undertaken by the student, nor has there been any confirmatory sampling undertaken at the site to confirm the results reported by the student. In volume 175 at page 43662 Dr. Kingham asked Mr. Feenstra a question regarding the existence of contaminants migrating laterally from liquid waste lagoons in the Sarnia area. At line, I think lines 12 to 19 I think would just confirm that he was really not aware of that, he really hadn't visited the sites:

> "I'm not familiar with the actual waste disposal units at the various plant sites".

In my submission the lines of evidence advanced by Mr. Feenstra in support of the hypothesis are weak and tenuous. The field data, that is the absence of tritium in the upper granular unit suggests that more probably the overlying till is unfractured and of low permeability. I am going to go to -- the Ruland work that I was just mentioning consisted of one round of tritium sampling taken from piezometers installed by another student. Mr. Feenstra had not seen the installation of those wells nor the geologic record of that drilling. The wells have not, have yet to be sampled a second time to confirm the initial tritium data and two, the validity of extrapolating results

from Sarnia to the Site D area are very much in question. I remind the Board that in, yesterday at the outset when we were reviewing some of the evidence of Mr. Sobanski and Trow I read to the Board a passage in which he indicated that one, he was familiar with the situation in Sarnia, he had actually been retained by Tricil and he also indicated that there was a difference in the clays between the two, between Sarnia and Site F -- I'm sorry, Site D. That portion, as you may recall, was volume 29 where he said the Sarnia clays are different. At page 6220 and at line 20 he says:

"A. Not entirely. The Sarnia clays are different than here."

And he comments on desiccation and so on. He was involved as a consultant at Tricil as I mentioned and that is referred to at page 6223 and he indicated his familiarity, he was as a consultant familiar with the situation.

Now, in addition, at this point I would just like to make these submissions to the Board. There is no site-specific data and indeed the tritium data appears, in my submission, to the contrary. I ask the Board to take that into account.

Secondly, the hypothesis is based on

unconfirmed, unverified double-checked work performed by a student. Third, in his reply statement, as we have gone through the three hypotheses, it is my submission that Mr. Feenstra is exercising an overly amount of academic caution. He is into concerns and possibilities and that these are really not of assistance to the Board. I think it is fourthly, but I am not sure, this hypothesis of fracturing in the unweathered upper till was not supported by Trow. Mr. Feenstra admitted that. Mr. Sobanski disagrees with him on this particular aspect of the matter. That is found in volume, it is page 43301. Volume 174 page 43301 at line 9 to 16:

> "... hav(e) you discussed this Ruland thesis or hypothesis with Trow, Mr. Sobanski.
>
> A. Yes I have.
>
> Q. Does he agree or disagree with you?
>
> A. I would believe he disagrees with me based on my most recent conversation"

We did not hear from Trow anything further than that.

In addition, fifthly, I submit that the Board is entitled to look at the situation with respect to the Feenstra hypothesis given the fact that there is

limited evidence on the record but the fact that a test pit was undertaken by the Town of Milton in April of 1988 under the direction of Dr. Charlesworth. I would like to just refer briefly to some of the events. They are summarized in volume 170. That was the date we had the argument of the motion, volume 170, August 30th. I am just summarizing. It is summarized, let me put it that way, some of the events -- have I got it wrong? -- I'm sorry. Volume 176, just to get the history and this is where I summarize some of the events that were taking place chronologically page 43781. At line 5:

> "Mr. Leitch has indicated the test pit was sunk on April 6th and April 7th of this year."

And then at this point I was referring to some of the events that took place after that, line 7:

> "In April, April 11th to 21st, Mr. Estrin cross-examined Mr. Petrie and Mr. Crutcher. During the cross-examination of Mr. Petrie specifically..."

and then I quote some references:

> " ... on April 12th, 1988, at page 29416. There were discussions about test pits at Waterloo, in the Region of

Waterloo site.

At page 29419, there was reference to vertical fracturing."

And this was the question of Mr. Estrin:

"'I suggest to you, you can't reliably determine the extent of vertical fracturing or root holes fissuring from a number of vertical boreholes; would that be fair.

A. That would be fair.'"

Going over to the next reference as we see it on page 43782 Mr. Petrie said:

"'I have not been provided with evidence of fracturing at Site D in any way, shape or form.'"

Then there was reference in the middle of page 43782, the reference there is:

"'As far as I am aware there are no test pits at Site D.'"

Then I went on to comment that Mr. Bowen was in the witness box on August 9th, the reply evidence of Dr. Rowe, Mr. Gray was put in August 22nd and there was no cross-examination of Mr. Feenstra on any results of a test pit. There was reference that there had been discussion, as we see at the bottom of page 43782 over

to 783, there had been some discussion of parts of Mr. Feenstra's hypothesis with Dr. Rowe and the point of really all of those references that I am bringing to the Board is that in my submission you have a situation in which a test pit was undertaken by the Town of Milton under the direction of Dr. Charlesworth and no evidence was forthcoming from April down to the point that the motion was brought and of course at that point the request was to put evidence in through, not through Dr. Charlesworth but through another witness. I had objected to the fact that that was one of the aspects, that was one of the aspects I was objecting to. I ask the Board to bear in mind that obviously that pit was dug to find out what frailties or anomalies or whatever you want to call it were in Site D. In fact Dr. Charlesworth prior to that had made a great deal about uncertainties resulting from the absence of information. That test pit was done after that evidence was in and we did not hear any positive evidence in reply, in Milton's reply, nor in cross-examination about the use of that evidence. It is my submission that there is an inference, and it is overwhelming, that the Town of Milton really did not share the view of Mr. Feenstra that fracturing was a problem. If it had shared that view the evidence would

have been produced before the attempt to bring it in through Dr. Isles. That was introduced in such a way in my submission that neither Dr. Rowe or Dr. Charlesworth could be asked about it. If there had been any results of hydrogeological significance, it is my submission that Dr. Charlesworth would have been produced and he would have testified to any concerns or uncertainties if any test pits had been hydrogeologically significant. The same is true for Dr. Rowe.

Dr. Charlesworth said in his report he didn't have enough information about Site D to finally come, in my submission, to formulate an opinion. The evidence is in fact that they dug a test pit and obtained more information. We only know of the one test pit that has been referred to. So, in my submission, bearing in mind your assessment when you are looking at Mr. Feenstra's hypothesis I ask you to take into account the inferences I have indicated as the fifth reason or fifth item that in my submission the Feenstra hypothesis, by the actions of the Town of Milton, really the Feenstra hypothesis has not been supported.

Now, I would also ask you when you are considering the hypothesis to consider one other matter

which I think is of significance and it comes from the submissions that were made by Mr. Hodgson himself. It amounts to this, that when the evidence of, sorry when submissions were made by the Region you will recall that there were the three means that Mr. Feenstra had said you could remedy if there was fracturing in the unweathered upper till. The first was monitoring and some purge well arrangement. The second was piped water and the third was a liner. Yet, when Mr. Hodgson made his submissions to the Board with respect to that matter he indicated that the Region was not in agreement, effectively, with Mr. Feenstra on this aspect of the matter and that the Board should not accept the second or third contingencies. Now, my submission to you is that based on that that in a sense the Region itself is, at best, giving a limited acceptance of their own witness's concern or hypothesis. It would be my submission that the presumption is that through the corporate assessment that goes on with a solicitor such as Mr. Hodgson, that the Region from internal sources or sources such as Trow and so on, that there is an indication to this Board that the Feenstra hypothesis should only be accepted to a certain extent, that first extent of monitoring to the point of the first contingency.

For all those reasons that I have submitted to the Board, it is my submission, that what Mr. Feenstra was really doing was at the end coming to the Board with a series of concerns, possibilities, worries, however you want to characterize them and putting them to the Board. It is also my submission that it would be really, if the Board were to decide on the basis of this sort of evidence which we have been describing and which we have heard, that the Board itself and parties should not be saddled with evidence of this nature in reply. It really is not helpful to the Board or the parties, this is day 169 or 170 -- the parties devoted the time and energy. It really means that the parties can come in with concerns or worries, create hypotheses or possibilities in reply after the positions of the other parties have been established. What it really comes down to is that for that reason and for the reasons I have indicated it is my submission that Mr. Feenstra was caught up, in a sense, in the Region's case, was concerned about the worries or everything that he could think of to be of assistance but he went beyond the point of being of assistance to the Board from an engineering point and really was into the domain of worry and academic research, in my submission.

M-962

Witness Statement of Dr. N. Eyles/Interrogatory and Interrogatory Response

M-962

In the Matter of the Halton Region Landfill Undertaking

WITNESS STATEMENT
OF NICHOLAS EYLES, Ph.D
Associate Professor of Geology
University of Toronto

September 22, 1988

Fractures Observed in a Test Pit, Proposed Site D, Milton

In April 1988, one test pit was dug on the lands of the proposed Site D, Milton. The test pit was located beside a fence line in the northwestern area of the site, approximately 160m in from First Line and 275m from the northerly site boundary.

The test pit was excavated through the glacial till to a maximum depth of approximately 8.2m. The main trench, oriented northeast-southwest, was, at the base, 1.5m wide and 6 to 7 m long. A short side trench was dug at a right angle on the southern side of the main trench.

The stratigraphy observed in the trench agreed with the general descriptions in the THCL Site D Hydrogeology Report (Exhibit H39). From surface, the overburden was:

0 - 0.6m	Topsoil, sand and silt (Peel Ponding)
0.6 - 3.5m	Red-brown clayey silt till; weathered, heavily fractured;
3.5 - 5.1m	Red-brown clayey silt till; occasional fractures; groundwater seeping from below approx. 4.5m on south side of pit from a silty sandy gravel "lens"

color phase of the till;

5.1 - 7m — Grey clay till; occasional fractures (described below)

7 - 8.2m — Red-brown sandy clayey silt till.

8.2m — Base of Test Pit.

Several naturally occurring fractures were observed in the red-brown clayey silt till and grey clay till below the heavily fractured upper 3 to 4m of the test pit. One major fracture was observed in the northern wall of the test pit and was marked by some oxidation (brown colouration) on the fracture face where it penetrated the grey till. The fracture extended through the grey clay till into the lower red-brown till at about 7m depth. The fracture appeared to be trending north-northeast, roughly sub-parallel to the northern test pit wall and could be traced across the trench to the southwest face of the pit.

Other fractures were observed on the southern side of the test pit, about 3 - 4m away from the major fracture. These extended from the upper red-brown till into the grey till and appeared to terminate before reaching the base of the grey till. The trend of these fractures appears to be north-northwesterly, intersecting the trend of the previous fracture.

Due to the nature of the exposure (i.e. the geometry of the test pit), it was not possible to trace a particular fracture from the

ground surface to depth.

On the basis of this test pit, it appears that at Site D there are fractures extending from the weathered zone through the grey clay till (upper till) and that some of these extend into the red-brown sandy clayey silt till (lower till). On the basis of the one test pit, it is not possible to determine the frequency, spacing, nor ultimate depth penetration of such fracturing.

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N.G. Davis
A.K. Clute
V.J. Murphy
G.H. McPhail
C.L. Milne
C.G. Israel
D.R. Wingfield

M.S. Archibald, Q.C.
A.S. Waklm, Q.C.
W.T.R. Wilson
G.R. Baker, Q.C.
R.R. Wozeniiek
R.S. Sleightholm
R.B. Warren
J.S. Prypasniak
G.M. Caplan
L.A. Borsook
L.M. Duffy
J.N. Tascona
M. Protich
S. R. Douglas
J.B.A. Wilkinson
J.L. Pandell
R.D. Harkness

J.J. Carthy, Q.C.
M.J. McQuaid, Q.C.
B. Finlay, Q.C.
W.J. McNaughton
B.W. Tinsley
P.M. Perell
J.G. Cowan
C.J. Taskas
J.M. Buhlman
A.K. Shaffer
D.S. Tarshis
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September 26, 1988

VIA FAX

Mr. F.E. Leitch, Q.C.,
O'Connor, Leitch, Hays, Gangbar
& Sheridan,
Barristers, Solicitors, Notaries,
Suite 300, Hopedale Mall,
1515 Rebecca Street,
Oakville, Ontario,
L6L 5G8.

Dear Mr. Leitch,

Re: Halton Landfill Hearing

I received a copy of your letter dated September 22, 1988 to Osler Hoskin & Harcourt. It comes as a surprise!

If you or any of the other counsel wish to use this information, it seems to me that you will have to bring a motion to re-open the evidence.

In order for the City of Burlington to take a position on such motion, we would ask that you let us have the following information by way of interrogatories. Such requests are made completely without prejudice to our position with respect to admissibility but we believe we need to have more information before we are in a position to take a position on your motion. Could you supply the following information.

....2/.

1. A drawing showing exactly where the pit was and its orientation and describing the dimensions referred to in Professor Eyles' statement.

2. Who conducted the test, who dug the pit? What machinery was used? What additional test equipment was on site at the same time.

3. Information why this location was chosen? Who selected the location?

4. Information on what the purpose of the test pit was? Was this part of an overall test programme? Please provide information on the test programme. Were other test pits considered as part of the programme?

5. Who was in attendance and directed the test programme? Please produce all correspondence, memoranda and documents of any nature indicating what instructions were given and what Prof. Eyles' retainer was in connection with this programme. Also please produce whatever correspondence, reports, memoranda or documents of any nature reporting on the result of any kind whatsoever, leading up to the witness statement dated September 22nd, 1988. Also, please produce any other photographs in addition to the one produced.

6. How long was the test pit open? Were any other inspections or tests of any kind whatsoever undertaken at the same time? Were any pumping test of any nature taken in connection therewith? If so, please produce the results.

7. Also, please let us know why this information was not brought forward earlier or could not have been brought forward earlier as part of the evidence either through cross-examination or in Milton's reply. The issue was raised in cross-examination of Mr. Petrie by Mr. Estrin but no specifics were presented for Mr. Petrie's comment nor was any reply evidence sought to be adduced.

Following receipt of the above information, we will be in a position to respond to the suggestion outlined in your letter and by you in the telephone discussion this morning.

In addition, such answers would be consistent with Ms. Cronk's statement that "all relevant evidence is before the Board to assist it in reaching its decision in this matter and to avoid unfairness to any party."

....3/.

We look forward to receiving the response to our requests before any motion is argued before the Board.

Yours very truly,

WEIR & FOULDS

M.J. McQuaid

MJM/wh.

c.c. Ms. E. Cronk

O'CONNOR, LEITCH, HAYS, GANGBAR & SHERIDAN
BARRISTERS, SOLICITORS, NOTARIES

TERRANCE P. O'CONNOR, Q.C.
FREDERICK E. LEITCH, Q.C.
THOMAS C. HAYS
LARRY S. GANGBAR
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SUITE 300 - HOPEDALE MALL
1515 REBECCA STREET
OAKVILLE, ONTARIO
CANADA L6L 5G8

September 28, 1988.

Weir & Foulds
Barristers & Solicitors
1600 Exchange Tower
2 First Canadian Place
P.O. Box 480
Toronto, Ontario
M5X 1J5

ATTENTION: M. J. McQuaid, Q.C.

Dear Mr. McQuaid:

Re: Halton Landfill Hearing

You requested information by way of interrogatories in your letter of September 26, received by us by FAX at 3:17 p.m. September 26, 1988.

I will deal with your numbered paragraphs, Page 2, in the same sequence as follows:

1. I am enclosing a copy of a freehand document entitled "Plan sketch of test pit, Site "D"". The sketch is not to scale but shows various dimensions and the approximate location of the test pit in relation to First Line and certain physical features of Site "D".

2. The test pit was under the supervision of David Charlesworth. The pit was dug using a backhoe. No additional test equipment was on site with the exception of hand tools.

3. Permission was obtained from Mr. and Mrs. Martin, the owners of the land. The location was chosen for its ease of access from First Line. David Charlesworth selected the location.

4. The purpose of the test pit was to view the subsurface conditions in the fill area of proposed Site "D". The pit was not part of an overall test program but was a discrete

stand alone test. No other test pits were considered as part of any program.

5. Over a two day period various persons were in attendance including David Charlesworth, Janet Haynes and Dr. Nicholas Eyles. David Charlesworth directed the test program. Instructions in respect of the test pit were all oral. Professor Eyles was not retained by the Town of Milton. He was in attendance at the invitation of Dr. Charlesworth. Dr. Charlesworth and Professor Eyles were working together for the Region of Peel in respect of its search for a new landfill and the investigations in Peel dealt with Halton Till. There is no correspondence, there are no reports, memoranda or documents reporting on the result of any kind whatsoever save and except the plan sketch which we have included and the attached field notes dated April 7, 1988 and entitled "Memo to File re test pit Site "D"". There are some other photographs of the pit which we will produce to you prior to the commencement of the motion.

6. The test pit excavation commenced at 11:50 a.m., Wednesday, April 6, 1988 and was fully open at 5:00 p.m. on Wednesday, April 6, 1988. No other inspections or tests of any kind whatsoever were undertaken at the same time. No pumping test of any nature was taken in connection with the test pit and accordingly, there are no pumping test results. There were no other investigations of any kind conducted by the Town of Milton. The test pit was closed commencing 3:30 p.m. Thursday, April 7, 1988.

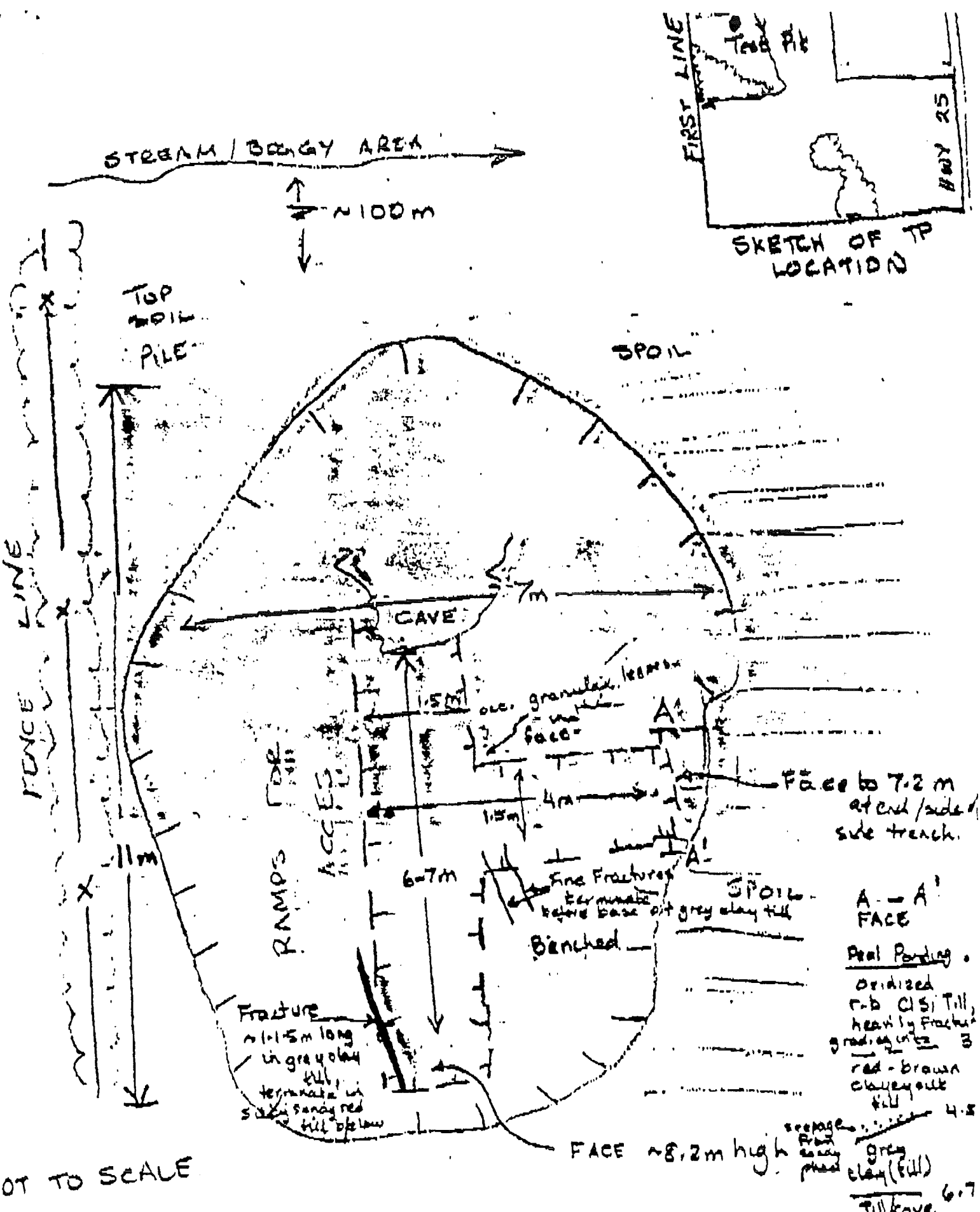
7. This is not an appropriate interrogatory. It is a matter for submissions in respect of the motion and we will make our submissions on the motion.

Yours very truly,

FREDERICK E. LEITCH, Q.C.
FEL/jh
Enclosures.t
c.c. H. G. Hodgson
E. A. Cronk
David Estrin
Stephen S. Garrod
John Tidball
T. Vigod

Post Script:

At the time of writing this letter, Dr. Charlesworth is in England. My answers to the interrogatories are a result of previous conversations with him.



PLAN SKETCH OF TEST-PIT, SITE D.

MEMO TO FILE: April 7/88

Re: Test Pit Site D

Schedule

Wed. April 6/88 - clear, cool

Arr. 11:00am at Martin Property , First line

Backhoe Arrive 11:40am
on site and start digging 11:50am
11:50 - 12:00am backhoe operate
12:00 - 12:30am lunch
12:30 - 2:30 pm backhoe operate
2:30 - 4:30pm " broken down
4:30 - 5:00pm deepen excavation

5:00 - 6:00pm examine excavation/photograph

Thurs. April 7/88

7:00 - 12:30am backhoe on standby
12:30 - 3:30pm examine hole in detail/backhoe deepen & widen
3:30 - 5:00pm test pit infilled/ topsoil replaced

Test Pit
located along fence row(south side), approx. 150m from First Line, just west of stream; on Martin property, central part, north quadrant of Site D

0 -0.6m -Topsoil(sandy; Peel ponding)

0.6 - 3/3.5 m -red-brown clayey silt till; oxidized;heavily weathered;fractured; various precipitations; evidence of gleying,etc. suggests active water table zone

3/3.5 - 4.5 /5.1m - red-brown clayey silt till;occasional fractures ; some cobbles

4.5 -5.1m - on south side silty sandy gravel phase; showed some seepage from this zone; irregular form-(lens-like); appear to run most of the length of the excavation

5.1+/- m - 6.7/7m - grey clay till; occasional fractures; some showing brown to grey-brown colouration along fracture length; one fracture go through grey till and appear

to terminate in lower red till; this fracture definitely show brown colouration; other fractures not marked by discolouration;

6.7/7 - 8.2m red-brown sandy clayey silt till

8.2m end of test pit

Fractures
- upper 3.5-4m heavily fractured; oxidized

- below this appear that several fractures do extend; observed one fracture trending roughly north that extended down to the lower red-brown till at approx. 7 m depth; could not trace it further; observed several other fine fractures(closed prior to excavation) extending from upper red till into grey till and appearing to terminate before reaching the base of the grey till; these were not a single specific fracture that could be traced from surface but fractures that apparently extended down from the upper heavily fractured zone;

orientation - larger fracture roughly trend north; second set of fractures intersect at acute angle roughly trending north-northwest;

See also attatched sketch

PHOTOGRAPHS TAKEN AT A TEST PIT, PROPOSED SITE D, MILTON, APRIL 1988

1. Dr. D. Charlesworth in base of test pit, at main fracture

2. Close-up of (1)

3. Base of pit, at end face of main trench

4. Minor seepage from sandier lens in till

5. Close-up of main fracture

6. - ditto -

7. - ditto -

8. - ditto -

9. Dr. N. Eyles and Dr. D. Charlesworth examine pit

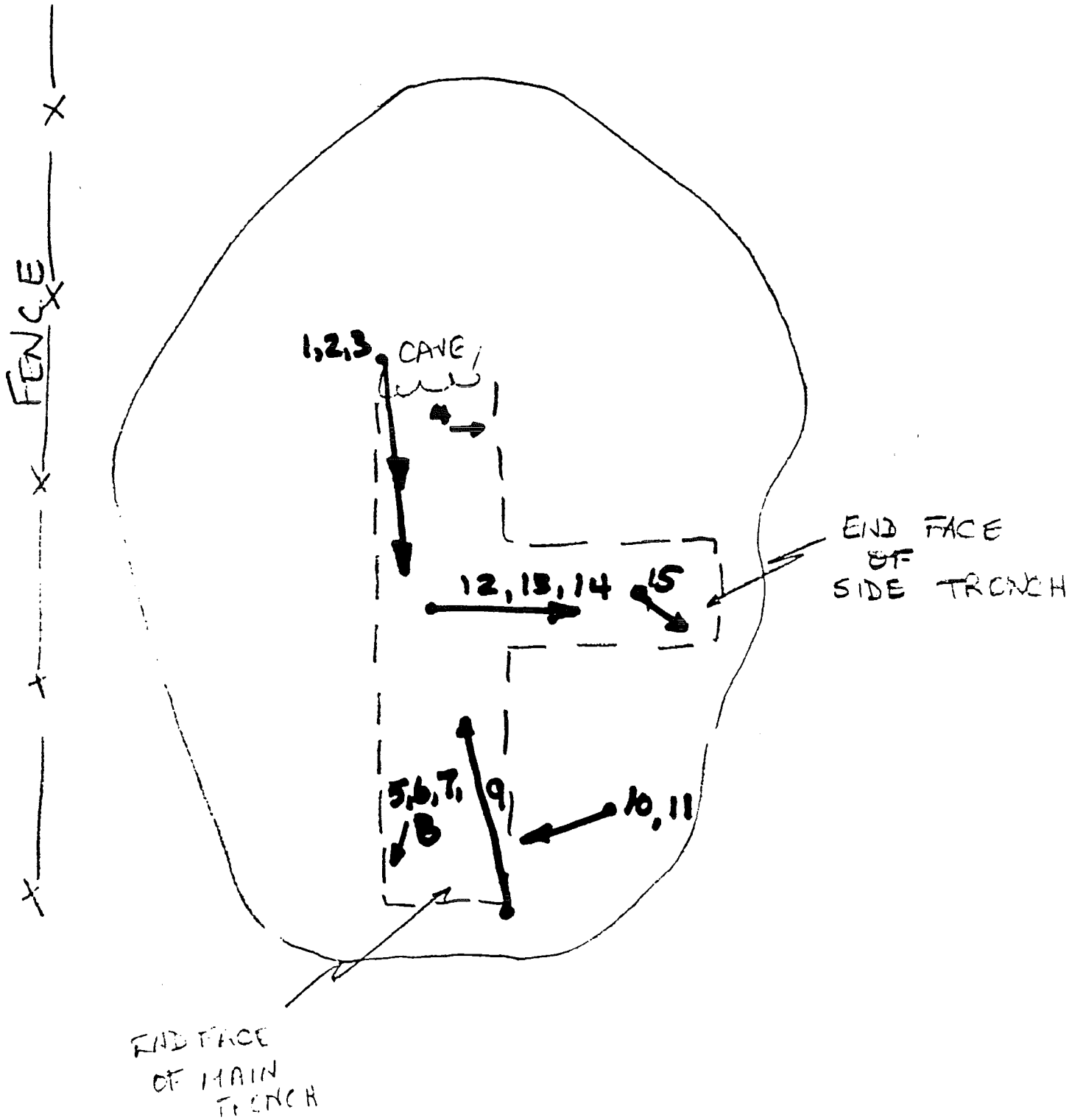
10. Dr. D. Charlesworth in base of pit on Day 2; some cave in base

11. - ditto -

12,13,14. Three overlaping photos covering top to base of end face of side trench

15. Seepage from base of red-brown till

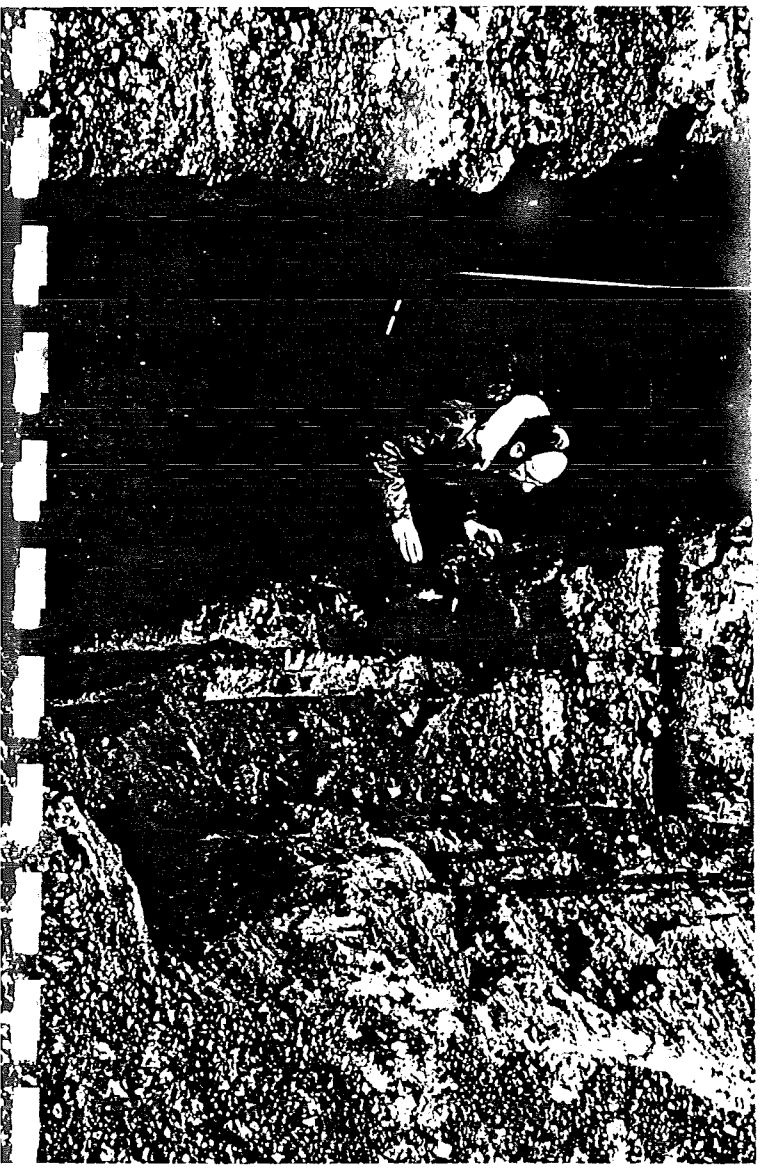
Orginal photos in exhibit file.



SKETCH SHOWING PHOTOGRAPH LOCATIONS

Photos with Instructions
Statements

M-962

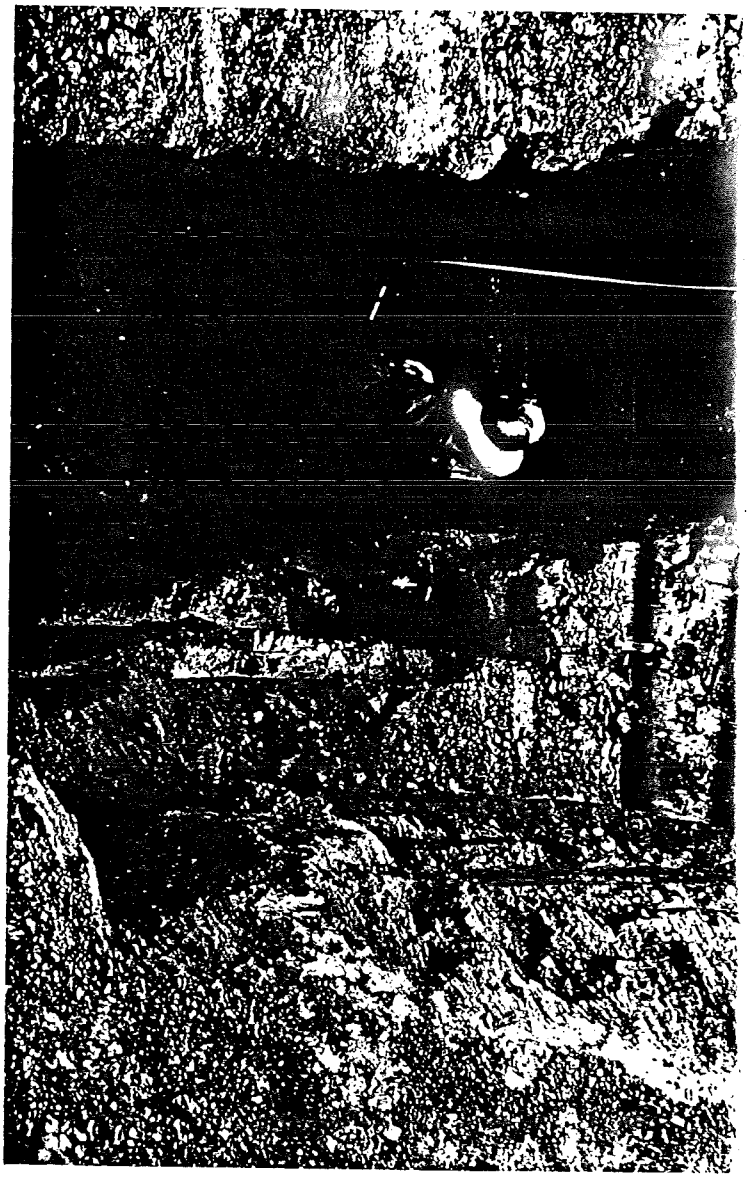


2

1

Milton fracturing

4



3

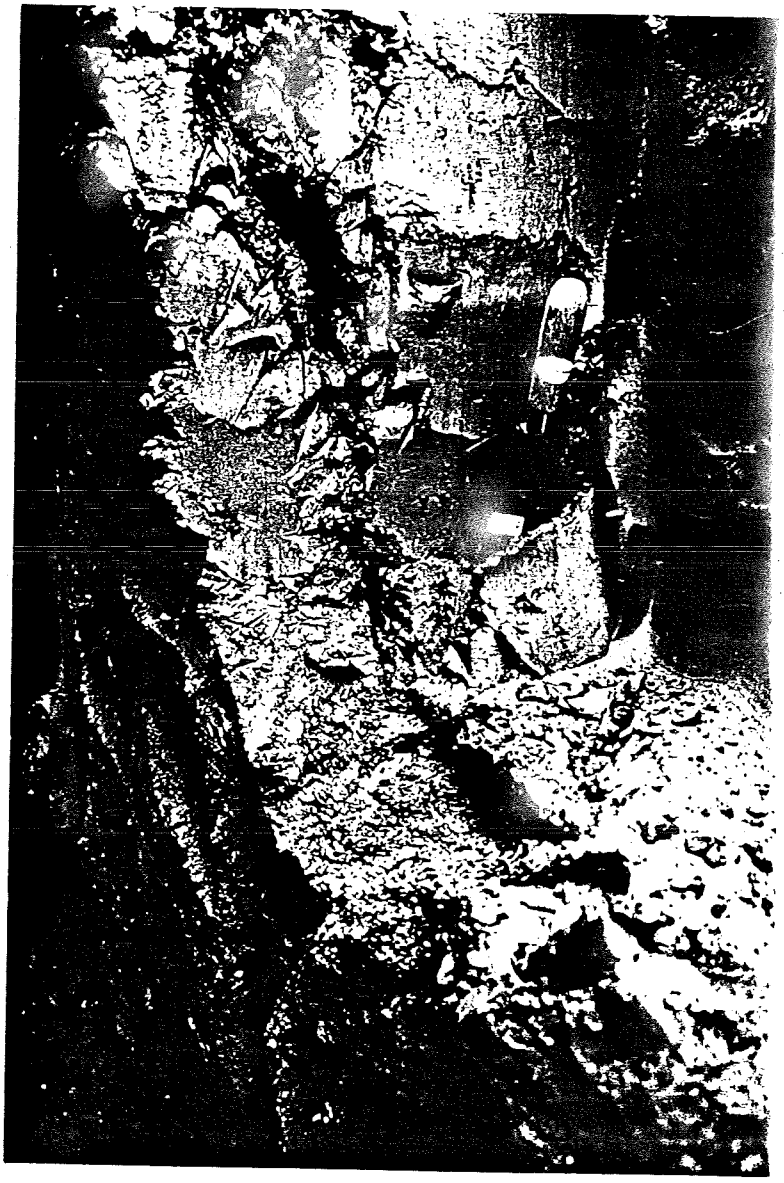
Milton Fracturing

6

6

Milton fracturing

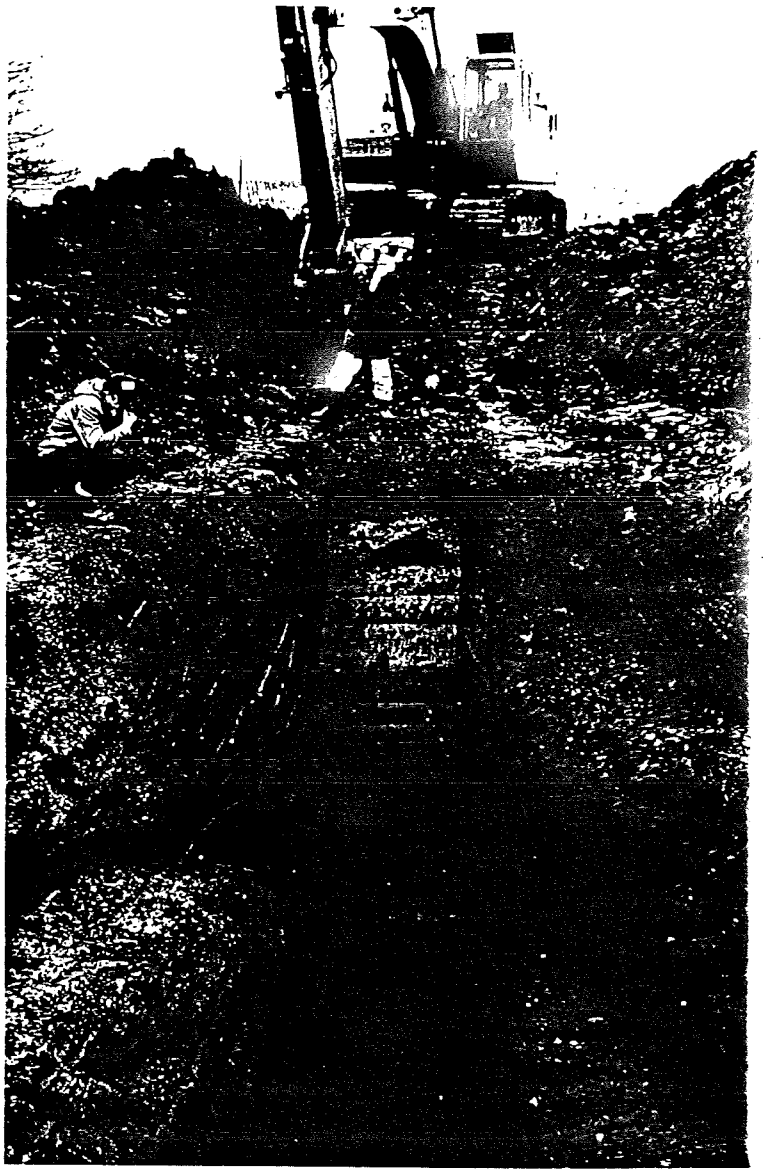
8



7

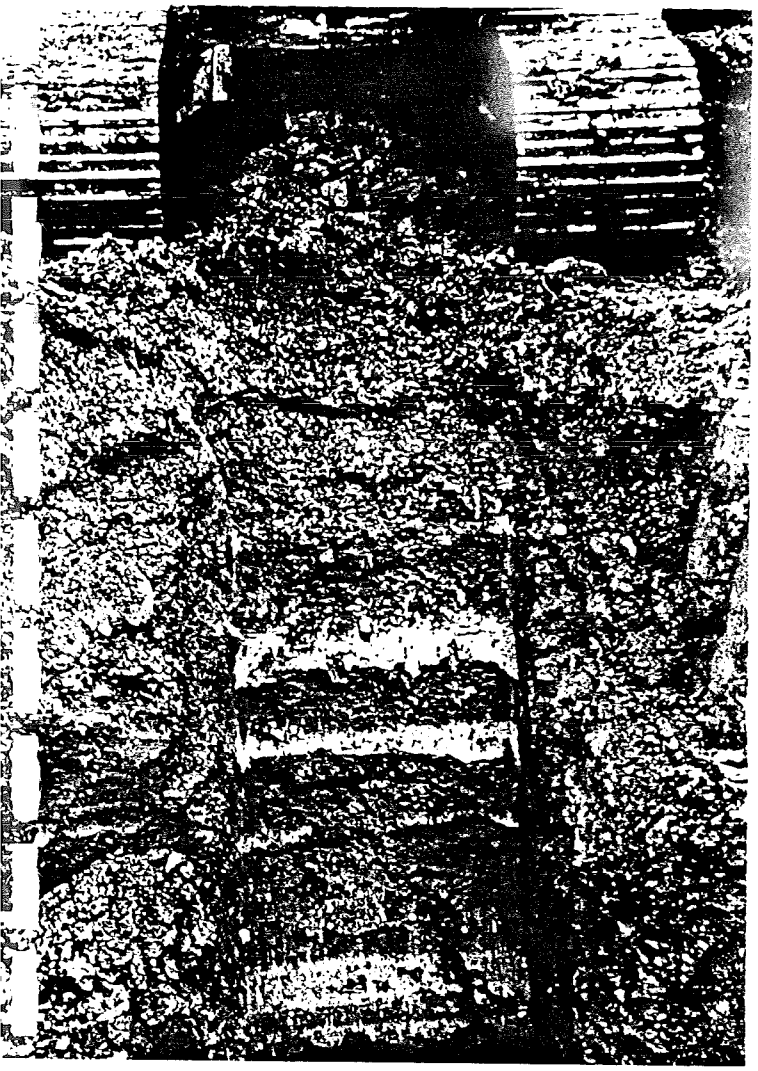
Multistage fracturing

10



9

Milton Fracturing



12

11

Multiple fracturing

13

14

Mullan Fracturing

Milton Fracking 15

Photograph of the Major Fracture

in Northern Wall of Test Pit

Taken at a Depth of 6-7 Metres

M-438

Review of Hydrogeological Report on Site D - Milton, Proposed Landfill Region of Halton

Report to

David Estrin, Barristers and Solicitors for the Town of Milton

October 1987
43805

Geocon
Lavalin

4.3 Upper Till

The Upper Till deposit, in which the landfill is proposed to be founded, is somewhat more variable than Trow seem to imply. In discussing values for hydraulic conductivity they state that the unit is devoid of features such as sand layers whereas an examination of the borehole logs, as discussed below in Section 5.3.2, shows this not to be the case.

An examination of the log for borehole HC1-85 (Vol. 2, ref. 1), and Trow's cross-section E-E, (Vol. 1, ref. 1) indicates that the lower two metres or so of the Upper Till at that location are actually silt and sand, with only traces of clay, rather than the clayey silt till that Trow describe elsewhere.

Under cross-examination by Mr. Estrin, Trow suggested that this could either mean that there was a zone of increased silt and sand content within the Upper Till, or alternatively that the contact between the Upper and Lower Tills should have been drawn "a couple of metres higher". Either way this suggests a further degree of uncertainty with regard to the stratigraphy.

Occasionally the Upper Till appears to thin slightly such as at GL 84-1 or MB OW-4. In the latter borehole the base of the upper clayey silt to silty clay till is at approximately 5.05 m depth (176.76 m elevation) where it overlies 2.27 m of a sandy silt till with numerous sand seams. In this area the base elevation of the landfill cell is at approximately 179.3 m giving only 2.54 m separation between the base of the landfill and the Lower Till.

4.4 Silt Layer

In the case of the unit described by Trow as a "thin bed of silt", Trow did not prepare a plan view of its extent but, from our Figure 7, it can be seen that the most conservative approach (in terms of assessing potential paths for leachate migration) could have it underlying virtually all of the site.

8. CONCLUSIONS

The key conclusions derived from this review of the hydrogeological data for the proposed Site D in Milton are set out below:

- Trow's basic assumption that the vertical gradients are downward into the shale bedrock and that the rock thus functions as an underdrain to the system is largely incorrect. Where adequate instrumentation exists the water levels indicate that, at most locations, the gradient is upwards from the rock. Thus Trow's water balance and the basic concept for their model at Site D appear to be based on an incorrect analysis of the groundwater regime.

- Trow's value of 10^{-6} cm/sec for the hydraulic conductivity of the weathered Upper Till is not as conservative as they wish to imply. It can be considered to be a reasonable value but does not provide "a margin of safety in the impact assessment calculations". Further, no confidence can be placed on the use of the tritium profiles to calculate or corroborate the hydraulic conductivity of this unit. In fact the hydrographs suggest that the groundwater regime in the Upper Till may be reasonably active.

- Trow have not been conservative in assigning a value of 8.1×10^{-8} cm/sec for the hydraulic conductivity of the unweathered Upper Till, as evidenced by the fact that the geometric mean of the relevant Trow data is actually 2.4×10^{-7} cm/sec.

- There is considerable uncertainty with regard to the lateral extent of the Upper Granular Unit and also some uncertainty with regard to groundwater flow directions within that unit.

- There is uncertainty with regard to the hydrogeological significance of the Lower Granular Unit, in view of the fact that flow appears to be upwards from the bedrock to that unit. Based on the evidence presented

lity groundwater at Site F, and lack of residents who are dependent on the resource, combined with the acceptable performance of the existing landfills at that location, make Site F a preferred location for the proposed landfill.

based solely on piezometer response and triaxial testing results would be overly optimistic'

I would suggest that would be a very apt statement?

A. I also note you would find statements like that in Dr. Cherry's textbook and I am not the first one to make those statements and I would be most surprised if I were.

Q. You agree we could do that and apply that to Site D?

A. Those are your words. I have not been provided with evidence of fracturing at Site D in any way, shape or form. Obviously if evidence were provided by yourself or the proponent, one would have to consider that fracturing with respect to assessing Site suitability, but I am only going on the data that has been provided to me.

Q. Let's read your next sentence on page 36:

"The Maryhill Till was not previously recognized as a fractured medium."

You are telling us at Site 2 the unweathered upper till has not been recognized to this point in time as a fractured medium?

A. That is my understanding of it.

that all of the investigators, including Trow, Conestoga-Rovers, and Dr. Charlesworth, are in agreement with what I would call the general stratigraphic characterization of the site. By that I mean they identify the same zones, the same strata within the site and that the concern of the discussion has only arisen concerning perhaps the extent of those strata or to some degree their hydraulic properties.

The discussions about extent and hydraulic properties have not been nearly as extensive nor nearly as variable let us say as those same discussions were at Site F.

Just in summary, the stratigraphy that is presented for Site D consists of weathered upper till and following along on page 10 of my report at this time, followed by an unweathered upper till, a lower till, an upper and lower granular unit, shale bedrock and a thin bed of silt. I think all parties are in agreement that those units are present at the site and can be characterized in that way.

It is my feeling that disagreement occurs as a result of again the lithology of Site D. The significant strata at Site D consist of soil or overburden materials and those sorts of materials can be readily identified on a visual basis. It is very

another graduate student for the purposes of examining the geochemical nature of the clay deposits in the Lambton area.

Mr. Ruland referred to that data in his work, although he may have referenced it a little more clearly.

Q. I am not sure I understand Table 2, where does it say that Mr. Ruland put in continuous core?

A. That is what I tried to explain. Mr. Ruland himself did not put in continuous cores. Mr. Ruland in this thesis in Table 2, refers to the maximum depth of fracturing found in core samples and those core samples were taken by another graduate student at the University of Waterloo, doing work, investigating the geochemical nature of the clay deposits.

Q. Who was that student?

A. I believe that was Joan Rodvang.

Q. Where does it say cores were taken on this table?

A. The bottom line, cores from the Esso site, the Union Carbide site, RP is Rural Polysar, and CIL.

Q. All right, I understand you have

not seen any cores.

A. I have not personally examined these cores, no.

Q. Nor is there any description in this report as to core logs.

A. There are no specific core logs, I recall. Just give me a moment. I can't recall whether Mr. Ruland describes them in the text of his project or not. I will just check.

Page number 1, in the middle of the second paragraph, it would be the second sentence:

"Rodvang, 1987, observed fractures in drill cores as deep as 9.3 metres."

Referring back to page 30, would be the maximum depth of fractures indicated at the Union Carbide site. The reference to Rodvang, 1987, is Ms Rodvang's masters thesis.

Q. All right.

Can you tell us what type of cores were undertaken at these sites?

A. I believe in some cases they were Shelby-tube samples and in other cases, they were continuous cores taken with CLE, which is central lining equipment, a five-foot long core barrel. I could determine that for you if you like.

Q. Certainly, there is nothing in Mr. Ruland's report on this?

A. No, there is not.

Q. Do I understand that prior to your giving evidence, you had not examined these core logs, any core log information, including the Rodvang thesis, to see if there were core logs in any detail reported in that thesis?

A. That is correct.

Q. So, what is the basis then for your comment on page 42080 that there was continuous core sampling?

A. The basis for that was the report on page 1 of the Ruland project referencing the work done by Rodvang in 1987.

Q. That is all?

A. That is correct.

Q. Now, do you know whether Mr. Ruland installed the Shelby-tubes that he is discussing in his project thesis?

A. Whether he was personally involved in all of them? I can't say.

Q. Do you know if he was involved in any of them?

A. I believe he was, yes.

Q. The reason I ask these questions, Mr. Feenstra, among others, which I will be getting to, you recall when you examined the Hewetson thesis, you went back to, I think it was Dr. Pankow, and you asked for as much of the basic data that you could get hold of in order to investigate the Hewetson thesis, whether tritium had got into the wells and so on.

A. That is correct. I wouldn't consider what I requested as basic data. It was data which considered, which included much of the data that Ms Hewetson reported.

It also had information on some other chemical parameters which were considered by Dr. Pankow at the time as being either extraneous contaminants due to the sampling methodology, or naturally occurring compounds. It was really that additional information that wasn't reported initially that I requested.

Q. You were looking for additional background data in any event.

A. Additional results to those reported initially, yes.

Q. In this case, am I correct that you have not really gone back and looked for additional background data on the core logs that are referred to?

Certainly not in Table 2.

A. I don't think they are exactly comparable.

Q. That really wasn't my question.

MR. HODGSON: I think the witness is answering whatever question he understood.

THE WITNESS: I think in the case of the data from the Bayview chemical monitoring, I was informed there was additional data available which was not reported and I requested to see it.

In this particular case, I have examined Mr. Ruland's project, the information from the test pits were synthesized in a written description in the text and in several figures showing fracture frequency and a variation of fracture frequency with depth.

I did not personally ask to examine the borehole logs or test pit logs. In fact, following your request, Mr. McQuaid, a few weeks ago, I spoke to Mr. Ruland and there are not test pit logs per se.

Mr. Ruland's observations and measurements of the test pits were integrated into the figures which I have noted in his report, his written descriptions in the text and this conceptual diagram showing a typical test pit cross-section as shown on page 32, I believe, of his project.

Q. Mr. Feenstra, you are, of course, aware that by bringing this hypothesis forward, it has important practical effects on what might be argued, or what might be recommended to the Board.

A. I recognize that and I also recognize its importance in terms of the potential impact on the groundwater resources around Site D if we don't acknowledge that there are fractures in the unweathered upper till when, in fact, there are.

Q. The point, however, is this: Are you on the list of Dr. Cherry to analyse or look at many project theses during the period of a year?

A. Yes, I am privileged enough to be able to do that, yes.

Q. How many would you look at a year, five to ten?

A. In that range.

Q. You would agree with me that a project thesis, the objective of a project thesis, is to get the degree, somewhat different from the purpose of a hydrogeological report that is being submitted to this Joint Board.

A. It is quite a different purpose, that is correct. To some degree, I think that is one of the reasons why, although it might seem like a

deficiency that there weren't test pit logs prepared for all of Mr. Ruland's test pits, but just for the reason you just described, there is a difference between a standard hydrogeological investigation one would conduct in terms of the siting of a landfill and a research project.

Q. The impact of the hypothesis that is put forward, of course, we have discussed it at this particular -- at Site D -- but would you agree with me that it also has impact generally for landfill sites that may have been placed on tills throughout the rest of southern Ontario?

A. I think it is likely to be an effect that should generally be considered. In general, I would think that it is not likely to be a significant occurrence. The example at Site D, I believe, is reasonably unique in the fact that we have, with the proposed landfill design, a fairly thin unit underlying the landfill of between three and four metres of what was considered to be unweathered, unfractured till overlying a thin, granular unit, in which there is very little potential for dilution to clean water or a cross-flow beneath the site.

We have got potential receptors or private wells that would be potentially impacted by

off-site migration relatively close to the site boundaries. I think those are fairly unique conditions.

If one took a hypothetical Site D, where the granular units were at a depth of 15 metres, rather than eight metres, given that we would expect the depth of fracturing or the frequency of fracturing to diminish with increasing depth, I think we have a much more difficult time imagining fractures extending to granular units at that depth.

Q. I am sorry?

A. May I continue?

Q. Yes.

A. In terms of lateral flow away from the landfill site you are dealing with distances that are much greater than just the three or four metres we are talking about from the bottom of the landfill to the granular units.

At Site D, the lateral distance of flow would be 100 metres to the site boundary. Over a distance of 100 metres, matrix diffusion will be a very important process and will minimize any impacts on off-site ...

So, just the fact that there might be fracturing extending to depths of eight or possibly ten

metres, I don't think necessarily has implications at a great many sites.

Q. Have you studied to determine how many sites may have three to four or five metres of till below?

A. I haven't obviously done a systematic study of the Province of Ontario to determine how many sites that includes. I am sure it includes some.

Q. Yes.

A. But there are a great many sites where the conditions are different in terms of the aquifer or granular zone that might be impacted and the distance to any receptors in terms of distance from the site boundary.

Q. We heard evidence earlier from Mr. Hughes, and we could refer to the position statement of the Ministry. They, in their guideline, in the exhibit referred to preference for sites in environments where they used the words:

"... a high degree of natural protection, e.g. thick clay deposits."

A. Yes.

Q. Now, if this fracturing is more prevalent that general statement would have to be very

much qualified, wouldn't it?

A. The qualification would particularly have to be put on thick clay deposits and what that actually represents.

Q. I guess you are saying it has to be 15 metres now before you would not bring it forward to a hearing.

A. I would certainly acknowledge that at this time we don't know what the depth of fracturing is. Based on the work in Lambton County, it seems to be quite variable. In some areas it is restricted to five or six metres and in other areas, it seems to be deeper than that, as much as ten metres.

At the present time, as I discussed earlier this week, we don't precisely know what the mechanism for formation of these fractures is and I think until we get a better understanding of why these fractures should exist, we can't really go to a site and ahead of time estimate or evaluate what we would expect to find in terms of depth of fracture.

Q. That is what I thought. To me it seemed that the Ruland thesis, if it applies, as have just described, has almost a revolutionary i on what has been traditionally thought of as appropriate till deposits.

A. I think you could describe it as that, and I believe the publication of these results in a refereed forum will emphasize precisely that point.

One other comment I might like to make with respect to fracturing in clay deposits, it has certainly been my experience, when I describe to you why I didn't think fracturing in itself was generally important to all sites, I was mainly considering municipal waste disposal sites. That is where there is escape of contaminants from the landfill. It is in the form of contaminants or chemicals dissolved in the water and moving with the leachate and the groundwater out of the site.

In this situation where the cracks, the fractures, are fairly widely spaced and the actual volume of contaminated water making it to an aquifer or granular unit, is relatively small. It is quite possible in some situations it doesn't make any difference. In other words, there is no significant impact. I am sure that -- maybe people don't recall, but certainly if one looks at my CV, I have done a lot of work related to organic chemicals in the past and it has certainly been my experience that there have been many cases where we have had a clay unit that we would have expected to impede the migration of a pure

chemical phase which hasn't. The only mechanism we could attribute to that is fracturing in those units.

If I may make one editorial comment, it makes a big difference in terms of impact on other underlying granular units where you have got 100 litres per year of leachate with dissolved constituents in it moving into an aquifer or 100 litres a year of a pure base chemical. I think in some particular sites, particularly related to chemical spills, we have a much different insight into the behaviour of clay barriers than you would have from looking at other sites like landfills.

Q. All right. Well, maybe you have to discuss the chemical waste sites in your experience, but let us just concentrate for a moment on municipal landfills. Are you aware, in your experience, of any sites in southern Ontario on clay where monitoring has indicated that this deep fracturing is a problem?

A. I am not aware of any such sites. Based on the findings previously reported in the D'Astous et al paper, Exhibit H-88, and the difficulty with smearing around a borehole installed with the hollow stem auger, which is the conventional method which is used in Ontario for the installation of monitoring wells, it is quite conceivable that much of

the monitoring that has gone on in the past may not really reflect actual conditions. I really hate to say that, but that is a possibility.

Q. So, you are saying there could be leakage, contaminant leakage occurring, but the monitoring is not picking it up because of smearing?

A. That is true, yes.

Q. This is even more serious than I might have thought. You are saying the monitoring may be suspect.

A. That is a serious consideration, but, as I described earlier, for there to actually be an impact on a groundwater resource due to fracturing, because we are talking about fractures, but you have to remember that we are looking at small volumes of flow.

In the deeper fractured zones if the bulk hydraulic conductivity is 10^{-7} or 10^{-6}, you are still getting a very small volume flow of contaminated water to whatever receptor you are looking at. At Site D that is important. At other sites, it probably isn't as important if there are other mechanisms for attenuating the leachate or diluting the leachate as it enters the aquifer.

In the United States, the criteria for a clay liner is 10^{-7} centimetres per second hydraulic

conductivity. We are talking about a hydraulic conductivity or a leakage rate of that same magnitude in this particular case.

Q. Not with fractures.

A. But not with fractures. The flow rate, the impact is going to be the same. What the fractures do is, they get you the contaminants there faster and that is the only difference.

Q. Let me ask you, hav you discussed this Ruland thesis or hypothesis with Trow, Mr. Sobanski?

A. Yes, I have.

Q. Does he agree or disagree with you?

A. I would believe he disagrees with me based on my most recent conversation.

Q. Are there any physical evidence that we have been discussing upon which he relays to you why deep fracturing is not a problem?

A. No. Mr. Sobanski did not present to my any physical evidence to support that opinion.

Q. Would I understand that you put the Ruland hypothesis to him, you explained it to him, the results of this project thesis?

A. Yes. Mr. Sobanski had an opportunity to review my witness statement.

Q. Just let me ask you, are you aware of the implications that this might have in Lambton County at the Sarnia sites, the sites around Sarnia that were investigated by Mr. Ruland? Has this resulted in any stop of landfilling?

A. No, it certainly has not.

Q. Hazardous wastes?

A. As an example of what I described 15 minutes ago, at the Sarnia location we have got a very thick deposit of clay. There are no granular units. The nearest aquifer is at a depth of 40 to 45 metres. Even if there is downward movement through this weathered zone in Lambton County, it is not significant. In terms of lateral migration through a very weakly fractured clay, there again it is not likely to be significant.

Q. The fact that it is a hazardous site, the Tricil site, it doesn't make any difference in your mind, this is not something of significance then?

A. In terms of the Tricil site itself, no, I don't suspect that it is significant there. I haven't done a detailed evaluation of it.

I haven't reviewed any reports on Tricil for three or four years.

In that case, the waste is being buried below a depth of five, I would be guessing, somewhere between five and ten metres.

MR. McQUAID: Mr. Chairman, I wonder if I could ask for our morning break at this point.

MR. LANCASTER: All right, it is quite appropriate, 15 minutes.

--- Recess

MR. LANCASTER: Thank you, please be seated.

MR. McQUAID: Q. Mr. Feenstra, a few minutes before we adjourned, you made reference to the fact that publication of the hypothesis in a refereed forum will emphasize the importance, I guess, of the thesis or the hypothesis.

A. Yes.

Q. So, you are assuming, I presume, that this, in fact, will be approved by some publication or forum.

A. I am making that assumption, yes.

Q. Perhaps you could be more specific. On what basis do you make that assumption?

A. I believe, based on the validity

of the research and its importance and its implications on a great many aspects of how we look at clays and fractured clays.

Q. Is there something coming out in the next couple of weeks that you can tell us about?

A. There is certainly not a timetable for the final preparation of that paper yet, no.

Q. All right, let me ask you about the Ruland Report.

First of all, in looking at it, am I correct that Mr. Ruland only took one set of tritium data?

A. I believe that is correct.

Q. Do you know whether that is the case or not?

A. Would you like me to check?

Q. You are saying by recollection you believe that is correct?

A. Yes.

Q. All right, I think you should check it.

A. I think I should be able to determine that from the information in the appendices. Yes, I believe that is correct.

Q. Am I correct that in the report we do not find any discussion of the well installations?

A. I can check that if you wish.

Q. Let me be more specific. Any specific discussion about quality control on the well installations to ensure there wouldn't be water seeping down into the boreholes.

A. The actual well installation procedure is described in D'Astous et al, H-988, with respect to the Shelby-hole type piezometers. It is not described specifically.

Q. What I guess I am getting at is, is there any way of knowing whether any water would have seeped into these boreholes in the same way as others that we have been discussing throughout the proceedings?

A. In general, it has certainly been my experience in Lambton County area and the Essex County area that the holes are dry during drilling and installation. There is very little, virtually no flow of water into the open hole during the augering process. So, there is certainly no obvious evidence of water that may contain tritium in the upper zones percolating down into the lower zones.

Q. What about rain?

A. Rain is a possibility if it was raining during the installations.

Q. We don't know that one way or another. What I guess I am getting at is how do you establish the quality control of the well installation in a paper such as this.

A. A variety of techniques can be used. One has to take care during an installation of the wells to make sure there isn't any foreign water introduced either in terms of seepage of water from shallower zones into the borehole, or as you say, rainwater or surface water runoff into the borehole or drilling water.

One has to take those precautions during installation. To some degree, the results also, the confirmation or support of results such as tritium can also be evaluated by looking at other information that might be available such as at Site F. To get some indication of our confidence or our reliability of the tritium data, one can compare them to the chloride concentrations and note whether there are consistencies or inconsistencies with respect to the nature of the flow system, the groundwater flow system as interpreted.

Likewise, in the work by Mr. Ruland, I think it would have been difficult to imagine why there was tritium in the deeper piezometers if one hadn't observed water level fluctuations in the similar group of piezometers that occurred in concert with the water level fluctuations in the overlying weathered till.

So, to some degree it is difficult to evaluate the precision or the accuracy of a particular piece of data on its own.

Q. Yes, okay.

You have answered with the exception, I guess, of the water level fluctuations. I think your answer was fairly general. What it really comes down to is, you can't specifically, in this case, assure yourself about the well installations, first of all, can you?

A. I don't have written documentation of precisely how each and every individual well was installed, no. To some degree, one has to, in this particular case, rely on the abilities of the researchers to perform those tasks properly.

Q. That includes their experience?

A. That is correct.

Q. I take it they are really not

experienced in terms of drilling wells. They rely on some well driller.

A. I can't recall precisely which drilling company was employed to install these particular nests of piezometers. It may have been the University drilling rig. It may have been an outside contractor. I think one thing to recognize with respect to evaluating the installation of these particular types of piezometers is that the technique and methodology was specifically developed at the University of Waterloo. It is not a technique that one might say they adopted from elsewhere having not experienced it before or understanding the rationale for why it is done in a certain way.

Q. So, based on that, you are assuming it has been installed correctly, is, I guess, what you are saying?

A. That is an assumption we have to make, yes.

Q. You can't say whether it was installed by the University drilling rig, that team or by some outside consultant or company?

A. I can't say, no.

Q. Wouldn't that be of some use though when you are making a revolutionary hypothesis,

or espousing your revolutionary hypothesis?

A. Which drilling company was used?

Q. The quality control.

A. The quality control is always a concern. To some degree, I think you have to recognize that the documentation for this type of work isn't the same as one might see for a hydrogeological investigation which was intended to go to some type of hearing or litigation.

On the other hand, I think you also have to recognize that the people doing the work, in general, are going to be very conscientious. They are, basically, doing work to satisfy a very specific personal goal from their point of view.

I think, in general, one could -- there are always questions, there may always be doubts essentially when precise documentation isn't provided. I think, given the individuals that I have come in contact with at Waterloo, and certainly the University of Waterloo's reputation, I don't think there is any basis to assume, necessarily, that things were done improperly.

Q. Would you agree with me that it would have been preferable to have had more than one sample of tritium?

with Mr. McQuaid, Mr. Ruland did not himself do any of the piezometer installations or log any of the boreholes or do any soil investigation; is that your understanding?

A. That was not my understanding, no. Mr. Ruland, go through the list again?

Q. I am really focusing on piezometer installation with the logging, the initial logging of those installations?

A. Of the boreholes?

Q. Yes, the boreholes.

A. I understand that the piezometer installations and the boreholes associated with those installations were not logged in a particular degree of detail. The core logs which are referred to in Mr. Ruland's thesis were a different series of borings.

Q. We are focusing -- there is two points -- one, the degree of logging which you are saying was not extensive and I think you make mention of the fact that that is not necessarily the practice of students to do that. Is that fair?

A. No, I am saying there were two series of investigations, two series of putting in boreholes. The one to put in the piezometer nests and another series for the purpose of actually looking at

the core and collecting samples of clay for chemical characterization.

Q. Who did the first series then if we could focus on that?

A. As I indicated to Mr. McQuaid, I am not precisely sure who did all of them but Mr. Ruland, I believe, was involved in the installation of at least a portion of those piezometers.

Q. We don't know what portion or what holes?

A. No, at this stage, no, but I can certainly find out for you if you wish to know.

Q. I think I may want to follow up on that. The second series you said was looking at the cores?

A. That is correct.

Q. In that respect Mr. Ruland did some of that?

A. No, the core samples that Mr. Ruland refers to in Table 2 on page 30 of attachment 1.

Q. I am sorry, page?

A. Page 30, were installed at the various sites for the purpose, I understand, of examining the clay and collecting samples for

geochemical studies of the clay. As I indicated to Mr. McQuaid, that work was conducted by Ms. Rodvang in 1987.

Q. I think that's what my understanding was, that he relied on, I think there is a clear reference in his paper to the earlier work done by Ms. Rodvang?

A. That is correct.

Q. Ms. Rodvang's project was involved in an investigation, I think you said, into the geochemistry of the weathered zone?

A. That is correct.

Q. You did not review the Rodvang thesis prior to filing your witness statement or giving testimony before the Board?

A. No, I did not.

Q. My understanding is this thesis was supplied to you either earlier this week or last week by the City of Burlington experts?

A. Last week.

Q. I think -- I am just asking to clarify this situation of the borehole logs. Do you have a copy of that thesis?

A. I have a copy here.

Q. Could you just turn to page 7, it

Q. Again that wasn't, because that really wasn't related to his particular focus, that may be one explanation why he didn't?

A. That is correct, yes.

Q. You would agree though that it is important to understand the depositional history of the till that you are looking at, certainly in relation to both your fracture theory and in relation to certainly various aspects of comparison between tills?

A. Certainly in terms of the development of fracturing. The age of the deposit, well actually to some degree it depends largely on what one's hypothesis is for the mechanism that caused the development of these types of fractures. Certainly the depositional environment, the age, the length of weathering at the ground surface, the climate during the period in which the surface of the deposits were exposed; yes, these are all factors you need to consider.

Q. In fairness, I believe in the first paragraph in your witness statement, you make a reference to the fact that, for example, the Vandalia till is over 225,000 years old compared to the Halton till which is less than 50,000 years and as you stated, likely not comparable in the nature of organic

fractures.

A. It would certainly be my expectation giving my limited understanding of pleistocene history in the Illinois area, that the Vandalia till would have been subjected to a much longer period of weathering for those portions exposed than the tills exposed at the surface in Southwestern Ontario, South Central and Southwestern Ontario. Consequently in that particular interest the depth of weathering and depth of fractures and those types of features might be quite different. The depth below the original ground surface.

Q. Again, also in relation to whether there are fractures or not, certainly the depositional history is a factor that should be taken into account?

A. I am not clear what you mean by depositional history, in terms of formation of fractures in clay materials, particularly if the fractures in fracturing -- excuse me -- the fracturing is due to climatic fracturing, the drying and desiccation of the upper part of the clay, perhaps the development of deeply rooted trees on the strata, I am not sure that the actual depositional history of the material itself has that great a bearing on it. In other words, the difference between a lacustrian clay

and a clay glacial till may not be significant.

Q. Let me pursue this a little bit further and I think there is a reference in the Ruland paper that Sarnia is in the geographic area of the St. Clair clay plain. Would it be fair to say that the tills that are found in this area are rather unique in that they are believed to have been deposited in a lacustrian environment. In other words, put down in water?

A. That is one of the theories, yes.

Q. In contrast, the Halton till is what is called a lodgement till which was deposited in front of the advancing glaciers and were deposited in a different manner?

A. That is also correct.

Q. Again I would like to refer you back to the Exhibit 254 -- N-254 the Quigley and somebody with an unpronounceable names paper, on till geology, mineralogy and geotechnical behaviour?

A. Yes. I have that exhibit, N-254.

Q. Mr. Feenstra, I would ask you to turn to page 337 of that document?

A. Yes.

Q. And we see Figure 1 there?

A. Yes.

in other words, there is less clay content and less opportunity for fracturing?

A. To a certain degree it depends on the actual proportion of clay present. Certainly in the sandy, silty sands, sandy silt till that I observed in cores at Site D, just from my visual observation it would seem to me that if that material was dried, it would not lead to significant cracking. In other words, when the sample of material from the lower till dried out they just crumbled. However, the samples of the upper till which were dried out and these were cores that were taken three years ago when I saw them, were very distinctly cracked and very, very hard.

Q. Mr. Feenstra, in general, wouldn't you agree that the mechanical properties of these two tills are important and this is something you really didn't examine in any detail?

A. The mechanical properties would certainly be important if the mechanism for the fracture formation is fracturing due to stress relief with respect to glacial rebound, glacial uplift ... With respect to the formation of cracks due to weathering and desiccation from deeply rooted trees, I am not sure that the physical properties, the geotechnical properties would have much bearing.

Q. Really, is this getting, I think you would assess these various possibilities for explaining fractures in stress relief, but wouldn't you agree that the effect of these would depend on the properties of the till, certainly to some degree?

A. Well, as I indicated, it will certainly depend on the clay content. Basically if the clay content isn't sufficiently high or the clay silt content isn't sufficiently high when desiccation and drying occurs, the material will crumble instead of crack. The actual geotechnical properties in terms of shear strength and plasticity, I am not altogether sure that those would have much bearing at all with respect to drying and desiccation.

Q. Wouldn't it be related as to the time or the method by which these fractures might occur?

A. I am not quite sure what you mean by time.

Q. Perhaps it would require more desiccation to have these cracks occur given the different properties of these materials?

A. That may certainly be. The clay content in particular and to some degree the strength of the material might certainly have a bearing on, for

example, how deep the tree roots would actually be able to penetrate.

Q. If we are talking about the same sort of climatic region there may be differences as to how far the depth of these fractures, depending on some of these characteristics we have been talking about?

A. They certainly may have some bearing, that is correct. Certainly, once you start getting very deep into the clay like down in the vicinity of 8 or 9 or 10 or deeper metres, and the actual, I guess the long-term, the ability of the clay and the ability of the fractures to stay open in the long-term may in fact be due to, may to some extent be controlled by the geotechnical properties per se. Especially in terms of the horizontal and vertical stresses which exist in different directions and at different localities.

Q. If you just look back at the Quigley paper, Exhibit N-254 on page 337, again he is -- that he describes the Sarnia till as constituting an unusual deposit. Do you see that on page 337?

A. What paragraph is that?

Q. The second paragraph he says: "Since most tills are understood by engineers to have been heavily pre-

consolidated by ice loads, for example, the Halton till, the Sarnia tills constitute an unusual deposit."

I take it from that because they weren't deposited in that fashion that they again were maybe -- as he says, unusual?

A. I think they are certainly unusual from a geotechnical viewpoint, that is correct. Another aspect which will enter into -- the whole question of whether the fractures will remain open at a specific depth, in other words, there is a possibility that fractures may have formed in the geological past through desiccation and different climatic factors. But, at the present time, the stress conditions in the subsurface are such that those cracks although we see visual evidence of alteration and movement in the past, those cracks are indeed open at the present time. I think that is going to depend to a large extent on basically the strength of the materials and the in-situ stresses involved.

It is on that basis that I wanted to, or as I described in my witness statement, that although the formation of fractures in for example, the Maryhill till, may be quite different than has occurred on the surface at Halton or in the Lambton area. Likewise,

the formation and the mechanisms that caused the formation of the fractures in the Vandalia till might be quite different. I think it is quite significant that there is still evidence of hydraulically open fractures at significant depths from 10 to 18 metres below the present ground surface.

Q. You are talking about the Vandalia?

A. The Vandalia till and the Maryhill till. So, in those particular cases one could argue that the deeper you go the less likely it is to find open fractures, because as you go down the stresses are likely to co-act to try and close the fractures...

Q. Can you help us...because the Halton till has been heavily consolidated that there is a greater horizontal stress?

A. I am not sure that I can relate those two specifically, not speaking as a geotechnical engineer. There are other considerations such as the actual, the nature of the clay itself. The clay at Sarnia is relatively stiff but not hard. Likewise, the clays at the OWMC site where we have been down and looking at them are very soft. Conceptually it would be difficult to imagine that a fracture or a plane through this material could be open because the material is indeed so soft. In other words, when there

complexity. That would be a problem anywhere where the real world has not yet succumbed to modeling.

THE WITNESS: I like that expression.

DR. KINGHAM: Let us think about where the fractures have been observed in Lambton County and in particular where they are in an area with a large number of hazardous waste disposal sites containing, among other things, liquid hazardous waste. Is that right? Do I understand those sites, there are lagoons and so on in that vicinity; are they? You have been there, first of all?

THE WITNESS: I haven't visited all the sites, no. In terms of various waste disposal facilities at the plant sites themselves, most of Mr. Ruland's work was done actually in conjunction with the Lambton Industrial Society and its member companies. I am not familiar with the actual waste disposal units at the various plant sites. I am sure there are lagoons at a variety of the sites.

DR. KINGHAM: You can't give us evidence of whether there actually are and whether as a consequence one would expect the groundwater laterally from those lagoons to be showing evidence of contaminants because the strikes are not in fact parallel, fractured but not in fact parallel?

additional benefit to the addition of a liner, consequently, it is my opinion that a liner is not required at Site F.

CONCLUSIONS

50. It is my opinion that Site F is suitable for landfilling. There should be no significant impact on the groundwater or surface water environments due to landfilling at Site F. In the event that subsurface conditions differ from my interpretation of the site and these conditions allow the migration of groundwater contaminants off-site, no water supply wells would be threatened and the would be ample time for implementation of contingencies if they were required.

51. It is my opinion that Site D can be made suitable for landfilling. For conditions when the hydraulic trap is functioning, there will be no leakage of leachate from the landfill. In the event of failure of the hydraulic trap, leachate will escape the landfill and could result in contamination of the private wells believed to draw water from the granular units underlying the landfill. If the unweathered upper till is unfractured, travel times for contaminants to reach the private wells will likely be many years. Either failure of the hydraulic trap or migration of contaminants would be detected by monitoring before the occurrence of contamination at the private wells. Within this timeframe, contingencies such as the pumping of leachate from the landfill to re-establish the hydraulic trap or the purging of contaminated groundwater from the granular units could be readily implemented.

52. If the unweathered upper till is fractured, travel times for contaminants from the landfill to the private wells may be less than a year. In this event, it is unlikely that a typical landfill monitoring program could identify the failure of the hydraulic trap and permit timely implementation of appropriate contingencies before the private wells might be contaminated. It is my opinion that it is a reasonable possibility that fractures exist in the unweathered upper till. Given the threat to the private wells, it is my opinion that this possible eventuality should be avoided by alternatives such as design, installation and testing of the purge well system prior to landfilling, the connection of the residences to piped municipal water supply, or construction of a liner of re-compacted native clay silt till on the base on the landfill.

53. The existence of fractures in the unweathered upper till and possible rapid contamination of the UGU also magnifies the importance of even short-term (seasonal) failures of the

at all to that on page 81 of the final report of your Site F report.

MR. PETRIE: A. That is correct.

Q. I suggest again to you that was removed because it is not accurate because, in fact, Unit 3 does have good attributes for waste disposal; isn't that the case?

A. I do not agree that Unit 3 exists as defined. Taking that, where the rock is fractured, it will have attributes for attenuation capacities. The question in my mind is, where is the water or leachate moving through the rock. Within the fractures, the attenuation is less. The higher velocities in the fractures, the attenuation capacity is still less. The rock moving through the matrix, I beg your pardon, the leachate moving through the matrix and not the fractures, yes, it has attenuation capacity.

Q. Please answer my question.

I suggested to you that the second paragraph in Version 2 does not appear in your final report because it is inaccurate because, in fact, Unit 3, has "relatively good attributes for waste disposal" isn't that true?

A. It is not entirely inaccurate.

When you are dealing with fractured rock, you have a two-phase attenuation capacity. Within the matrix you have a much better attenuation capacity than within the fractures.

So, the unfractured portions of the site will have a greater capacity to attenuate than the fractured portions. However, the leachate movement is more likely to be confined to the fractures rather than the matrix.

Q. To the extent that Unit 3 is less fractured than other zones at Site F, can we agree, first, that that unit would have good attributes for waste disposal?

A. Again, one would have to be able to define the unit, agree that the unit exists as defined and I cannot do that. Unfractured rock, or I beg your pardon, the less fractured rock at the site will have better capacity for attenuation than the fractured rock.

Q. To the extent that Unit 3, as interpreted by Trow, has less fracturing than other areas of the rock at Site F, I suggest to you, sir, is it would be an area with good attributes for waste disposal, isn't that so?

A. If the leachate migration was

which I suggested here of hydraulic conductivity and fracture spacing, that after a period of one year, the concentrations of contaminants exiting a landfill under failure conditions would be arriving at the base of the fractured unweathered upper till at concentrations or at significant concentrations with respect to the input concentrations. In periods of less than a year, contaminants will be able to find their way through cracks of this nature very readily.

One should note that very readily it is still much reduced by matrix diffusion from what you would have calculated based on the actual velocity of water through those cracks, but in the context of assessing a landfill at Site D, matrix diffusion does not give you sufficient attenuation to reduce the travel times through a fractured unweathered upper till.

There is one other aspect of the presence of fractures, possible presence of fractures in the unweathered upper till which I feel needs to be addressed, and that is the possibility of heaving and some stress relief during the excavation and construction of the landfill itself. Right now I am going to present some concepts that are largely in the domain of geotechnical engineering and as a

geologist/hydrogeologist, I am quite aware of the processes, but I am not capable of doing a detailed evaluation of their significance at Site D. However, I felt it was appropriate at this time to point out my concerns on this particular point.

Given the assumption that fractures extend downward through the upper till and so that fractures exactly exist in the upper till, the nature of the fractures, that is the aperture, and because their aperture relates to hydraulic conductivity, the hydraulic conductivity of these fractures is controlled largely by the horizontal stresses and the vertical stresses acting in the subsurface. When the upper four metres of upper till are removed, you will basically change the stress conditions in the upper till underlying the landfill. You have removed some of the overburden, reduced the vertical stress and the horizontal stresses are going to act to try and move the till around and to compensate for the removal of the overlying material. A very common observation in many excavations is heaving in the base of the excavation caused by stress relief and in some cases groundwater pressures from below. If there are indeed fractures through the lower part of the upper till, on excavation of the 4 metres of upper till for the

completed before we went to get instructions on our situation. In other words, they had effectively closed their case as to the position that they were taking with respect to Mr. Feenstra's evidence.

I would also like to ask the Board to consider in the exercise of their discretion in this matter and of the submissions as to what the results really will accomplish. If you receive the evidence of a geologist at this point on what I submit, this is an alternative argument in a sense, I suppose. You receive the bare evidence of a geologist at this point and not the evidence of a hydrogeologist, it is sitting there as bare evidence.

It does not have the context of hydrogeology in which reference to fractures has been made. Only a hydrogeologist can question or speak to the significance of features that would be observed such as the transmissive nature of a fracture, weathering, precipitates, infill, significance hydrogeologically. Dr. Charlesworth or Dr. Rowe is not being presented, as I understand it, to comment on this evidence.

I submit the inference is that these features, or whatever it is, the hydrogeological features were not considered significant with respect

to hydrogeological suitability and this is an attempt through another outside witness to somehow presumably advance the hypothesis.

The Board has already indicated in its statement, the situation with respect to -- I would submit -- data that is not going to lead to a resolution, as it were, scientifically, of the hypothesis, but merely just, I suppose, put us all in a position where we are arguing the pros and cons of a hypothesis newly presented.

In other words, I am submitting that the motion, the material should have been presented if it is of any significance, of course it would have been presented earlier but surely at this stage it would have been presented by an experienced hydrogeologist so the Board would have the context and the parties would have the opportunity to consider whether they are going to ask for rejoinder. In other words, we have to submit hydrogeological evidence or a quaternary geologist.

So, I am saying, in essence, I think Mr. Chairman, that the evidence is devoid of the hydrogeological context that would assist the Board and I ask you to consider that when you are examining the witness statement.

---- Upon resuming at 2:35 p.m.

MR. LANCASTER: Thank you, please be seated.

It has been suggested a number of times throughout this hearing that the purpose of the Environmental Assessment Act is to ensure that the Board hearing an application has all the information necessary to make its decision on behalf of all parties concerned.

Mr. Garrod re-emphasized that purpose this morning when he suggested that this forum should not be a dispute between parties. In this case, between municipalities and Halton. In gathering this information we understand that the Regional Municipality of Halton has acted in the spirit of the Act and in particular with respect to hydrogeology, they allowed for observations and participation by the other parties to the hearing. This helped the Board to have a clear understanding of the evidence brought before us.

The Board now understands that additional hydrogeological studies were undertaken on April 6th and 7th of this year. With the exception of the Milton parties, other parties were not informed of the test and this result and were not invited to

participate in it. Within 30 hours the T-shaped hole, more than eight metres deep had been dug, examined and filled in again. In subsequent days, particularly on April 12th, 1988, counsel for the party on whose behalf the test pit had been dug was cross-examining a witness on the hypothetical existence of fractures in clay tills across southern Ontario. The witness stated that he had no evidence to support such a hypothesis, but that "If evidence were provided by yourself or the proponent, one would have to consider that fracturing with respect to assessing site suitability."

It was not suggested to the Board at that time or at any time since then that such evidence was available. When the expert witness for the proponent, Mr. Feenstra, proposed an hypothesis about fracturing in such tills, he also stated that he had no data to support such a hypothesis in the vicinity of Site D. Again, it was not suggested to the Board that such data might exist. When cross-examined about his hypothesis by counsel for the City of Burlington about the extent of the testing necessary to prove his hypothesis, Mr. Feenstra gave evidence that conclusive evidence could not be assured with even five test pits.

Additional tests of a different kind would be needed to clearly support or refute that

hypothesis.

Now the Board has been asked to consider a motion to admit additional evidence, evidence that was known to the party since on or about April 7th of this year, evidence that was collected in the absence of experts for the other parties, evidence that has not been alluded to in the months since it was gathered, evidence for which the hydrogeologist in charge is not present to testify.

The witness statement of Dr. Eyles confirms the general hydrostratigraphy in the area, it describes some fractures and concludes that a single test pit is inadequate to define the frequency, spacing and ultimate depth of the penetration of such fractures. The first observation is not at issue and the second is itself qualified by the inadequacy of the data base. This confirms the evidence of the proponent of the hypothesis, Mr. Feenstra, about the insignificance of a single test pit result.

As previously, throughout this hearing, the Board has considered whether the admission of evidence would materially assist in its deliberations. We are mindful of precedents brought to our attention by Ms Cronk that suggest that such evidence could be admitted although our acceptance of this approach is

tempered by the suggestion in Sopinka and Lederman, and I quote:

> "... the evidence must be newly discovered evidence which reasonable diligence could not have discovered during the trial, ..."

We are mindful as well of Ms Vigod's reference to cases where such evidence has not been admitted.

Taking all these factors into account and especially the discretion allowed us under the legislation, we conclude that the evidence proposed to be introduced by Dr. Eyles should not be admitted because it will not clearly assist us in arriving at our decision. We rule against the motion to have such evidence introduced at this late date.

The Board will adjourn this hearing until Tuesday, October 11th, at 9:30 a.m.

MR. LEITCH: Mr. Chairman, with respect to the witness statements which were handed forward and which you have had an opportunity to look at before your ruling, could you mark those for identification purposes, not as exhibits, but rather for identification for the public record which is being created here.

E-928

BEFORE THE JOINT BOARD

IN THE MATTER OF The Regional Municipality of Halton's Landfill Environmental Assessment

WITNESS STATEMENT

OF

GEORGE M. HUGHES

Supervisor

Landfill Disposal Technology Unit

Waste Management Branch

Ministry of the Environment

June , 1988

Witness Statement of George M. Huges

I. Qualifications

1. My Curriculum Vitae is attached as Appendix "A" to this Witness Statement.

II. Involvement With Halton Landfill E.A.

2. With the exception of brief discussions pertaining to the interpretation of Ministry policy and guidelines and occasional technical advice, I have had no involvement with the Halton Landfill Environmental Assessment. I have not reviewed any of the documents in evidence before the Joint Board.

3. I am not sufficiently knowledgeable about either Sites D or F to comment on their hydrogeologic suitability for sanitary landfilling. I am in a position to explain two Ministry policies which are applicable to the consideration of the hydrogeologic suitability of the two sites.

III. Reasonable Use Policy

4. Ministry Policy 15 - 08, the "Incorporation of the

Reasonable Use Concept into MOE Groundwater Management Activities", is before the Joint Board as Exhibit E - 154.

5. Policy 15 - 08 explains and clarifies a statement in Policy 15 - 01, "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment", which is also found at page 27 of the Ministry's "Blue Book". The statement is as follows:

> "Degradation of ground water quality will be controlled to protect both existing and potential, reasonable uses of water on adjacent property."

6. Included with Exhibit E - 154 is a guideline document that is referred to in Policy 15 - 08. The guideline document describes the methods the Ministry uses to,

> a) define the reasonable uses of ground water, and
>
> b) determine the levels to which ground water degradation will be controlled to achieve protection of those reasonable uses.

10. The basic approach to the determination of what level of degradation is acceptable is set out at page 16 of the guideline document as follows:

> "Quality cannot be degraded by an amount in excess of 50% of the difference between background and the quality criteria for any designated reasonable use except drinking water. In the case of drinking water, the quality must not be degraded by an amount in excess of 50% of the difference between background and the Provincial Drinking Water Objectives for non-health related parameters and in excess of 25% of the difference between background and the Provincial Drinking Water Objectives for health-related parameters. Background is considered to be quality of the ground water prior to any man made contamination."

It is the policy of the Ministry of the Environment that such increases in levels of contamination at the site boundary will have no more than a negligible impact on the use of ground water on property adjacent to a landfill site.

11. Provincial objectives for drinking water are set out in the Ministry publication Ontario Drinking Water Objectives, which is popularly referred to as the "Green Book". Where Ontario Criteria have not been developed, (eg. for most organic chemicals), it is appropriate to use criteria developed in other jurisdictions or by the World Health Organization.

12. When it is predicted that boundary criteria established using the above formula will be exceeded, it is acceptable to the Ministry, in exceptional cases, to permit the limited impairment of ground water off-site through the designation of a "Contaminant Attenuation Zone". Circumstances considered suitable for such a designation are set out at pages 14 and 15 of the guideline document included with Exhibit E - 154.

IV. Engineered Facilities Policy

13. Ministry Policy 14 - 15, "Engineered Facilities at Landfills that Received Municipal and Non - Hazardous Wastes", was recently approved by the Minister and is now official Ministry policy. The policy and accompanying guideline document is attached as Appendix "B" to this Witness Statement.

14. The "Ministry Interim Guideline on Engineered Facilities at Landfills" dated July 13, 1987 is currently before the Joint Board as Exhibit N - 475. Policy 14 - 15 and the accompanying guideline replace that document.

15. The essence of the Engineered Facilities Policy is that an applicant seeking approval for a landfill must address in the application,

a) the engineered facilities that are to be used at the site,

b) the length of time over which those facilities are required, and

c) how maintenance or replacement of those facilities will be provided for, if necessary.

An applicant should demonstrate that engineered facilities can function for as long as they are needed.

16. The policy and guideline apply to all engineered facilities associated with the control of contaminants produced by landfills including liners, leachate collection systems, covers, gas collection, interception and venting facilities, monitoring facilities, leachate treatment facilities, facilities for the control of contaminated ground water and facilities for "stabilizing" a landfill.

George M. Hughes

this area? Do you follow what I am getting at?

A. Yes. Perhaps I could answer this more simply. The original background is 50.

Q. That should be a pre-man-made, natural situation?

A. That is correct and the background we use here is 75 and your hypothetical first landfill is then 25 and it has added 25 to that and that's how you account for that other landfill.

Q. Okay.

A. It's in there as is the highway or whatever.

Q. I guess I have got in mind, and bear with me on the numbers, but if you had as you indicate up above on the first line a trivial increase of 150, that doesn't mean that you can come along five years later and say "Now we will add 150 plus the difference -- half the difference between 250 and 150"?

A. No, you can't do that.

Q. You can't do that?

A. No.

Q. Now, in the course of your evidence, or your answers to Mr. Tidball you made a statement or you referred to the best available technology. I gather that there isn't any specific

statement for landfills that you should use best available technology?

A. Not that I know of and I'll go one step farther. I'm not even sure what best available technology means because there are a number of definitions for it, but taken quite literally it means the best available technology. Some people worry about whether it's best available practical technology or best available -- it gets confusing after a while.

Q. I understand that that term has been used in what is called the MISA program which is designed as it indicates to address water pollution, particularly concerns with toxic discharges?

A. If you say so.

Q. Are you not familiar with that?

A. I don't deal at all with MISA.

Q. Have you never looked at the document itself?

A. I should be ashamed to admit it, but to be honest, no.

Q. No?

A. No. I have lots of things to do without reading things that are not directly related to my job. I'm ashamed to say so and I suppose I should have read MISA or been acquainted with it and I know

A. Not process. That's the wrong word. When I was with the Water Resources Branch I spent a great deal of my time reviewing proposals for landfills and assessing the hydrogeology of the sites and I was part of the review team and so forth and I have been involved in dozens of those.

Q. How long ago was that?

A. How long have I been with the Waste Management Branch? About five years. It would be about five years ago. I stopped doing it. I still give opinions, but by no stretch of the imagination could you consider any appreciable part of my work is in landfill site proposal review. Not now.

Q. It's very clear, is it not, that the guidelines for engineered facilities are to apply to engineered facilities no matter where they are located in the province?

A. That is correct.

Q. This is not a case-by-case situation, this is general guidelines for the entire province?

A. That's right.

Q. Are you aware of who it is who determines for the Ministry what the contaminating lifespan of an engineered facility is?

B - 930

MISA - White Paper

DEVELOPMENT OF COMPLEMENTARY PROGRAMS

The BAT approach for setting effluent limits will be complemented by the water quality impact approach for setting more stringent site-specific effluent limits needed to protect particularly sensitive receiving water bodies. For the water quality impact approach to be effective in setting effluents limits for toxics, existing water management policies and procedures must be revised and new receiving water quality impact assessment techniques must be developed.

Review of Existing Policies and Procedures. A number of related policies, guidelines and implementation procedures in the MOE publication "Water Management" (1984 edition) will be reviewed and revised to reflect the changes brought on by the MISA program. These will include such issues as mixing zones, receiving-stream design flows, definitions of technical terms (e.g., lethality, persistence) and development of additional ambient water quality objectives. All of these policies and procedures are essential to support the MISA program, and revisions will be completed by the end of 1988.

Pilot Studies. The Ministry of the Environment is conducting field studies at a number of pilot sites across the province to assess and evaluate the impact of various discharges on receiving-water environments. Water bodies with different beneficial uses (e.g., drinking water supply, fish habitats) are included in those sites selected. Special modelling and other assessment techniques, including the use of aquatic organisms as indicators of impacts on water quality, are being developed. These pilot studies will also be completed by the end of 1988.

B - 930

MISA - White Paper

MUNICIPAL–INDUSTRIAL STRATEGY FOR ABATEMENT

(MISA)

A Policy and Program Statement of the Government of Ontario on Controlling Municipal and Industrial Discharges into Surface Waters

June 1986

Ontario
Ministry of the Environment
Hon. Jim Bradley
Minister
Rod McLeod
Deputy Minister

MUNICIPAL-INDUSTRIAL STRATEGY FOR ABATEMENT (MISA)

A Policy and Program Statement of
the Government of Ontario
on Controlling Municipal and Industrial
Discharges into Surface Waters

June 1986

Ontario Ministry of the Environment

MINISTER'S FOREWORD

I am pleased to release the Government's White Paper entitled "Municipal-Industrial Strategy for Abatement (MISA)." This Paper describes my Ministry's new program to reduce the flow of toxic chemicals into our waterways.

The water pollution control system I inherited regulated only a limited number of conventional contaminants.

Yet scores of persistent toxic substances -- some thought to be cancer-causing or able to mutate genetic structure -- are of prime concern today. These chemicals are not adequately addressed by the pollution control system now in place. Furthermore, that system's major criterion governing industrial waste water discharges was concentration -- in other words, if you dilute, you could pollute.

That system was up-to-date a decade ago, but it is inadequate now and I am replacing it. A new set of tough measures designed to deal with persistent toxic chemicals will take its place.

For the first time, the total amount of each toxic contaminant from each polluter will be capped. This will be done by requiring each direct discharger to meet standards attainable by the best available pollution abatement technology.

MISA's best available technology provision will require pollution reductions -- sometimes great, sometimes small, depending on current performance -- from virtually every major discharger of contaminants into Ontario waterways.

Receiving water bodies will be analyzed to see if these stringent standards are enough to protect them. Where they are not sufficient, contaminant limits will be further reduced to protect local water quality.

In addition to reducing pollution from direct dischargers, MISA also seeks to cut contamination from the thousands of industries that discharge waste water into municipal sewer systems, which, in turn, discharge into our waterways. This will be accomplished by setting strict pollution control standards for municipal sewage treatment plant effluent.

Another key departure from past practice is the dynamic nature of the program. This is not a one-step exercise where each polluter must merely meet a single, lower discharge limit. We have included a provision for periodic re-examinations of every discharger. When re-examinations find better technology has been developed, or industry abatement standards have improved, or the receiving body of water is suffering, new and lower limits will be imposed.

The periodic re-examination provision drives MISA toward the goal of the virtual elimination of persistent toxic pollution from our waterways. This is an idealistic goal, yet I believe we have fashioned a program at once immediately practical and capable of getting us all the way to that distant destination.

DEVELOPMENT OF COMPLEMENTARY PROGRAMS

The BAT approach for setting effluent limits will be complemented by the water quality impact approach for setting more stringent site-specific effluent limits needed to protect particularly sensitive receiving water bodies. For the water quality impact approach to be effective in setting effluents limits for toxics, existing water management policies and procedures must be revised and new receiving water quality impact assessment techniques must be developed.

Review of Existing Policies and Procedures. A number of related policies, guidelines and implementation procedures in the MOE publication "Water Management" (1984 edition) will be reviewed and revised to reflect the changes brought on by the MISA program. These will include such issues as mixing zones, receiving-stream design flows, definitions of technical terms (e.g., lethality, persistence) and development of additional ambient water quality objectives. All of these policies and procedures are essential to support the MISA program, and revisions will be completed by the end of 1988.

Pilot Studies. The Ministry of the Environment is conducting field studies at a number of pilot sites across the province to assess and evaluate the impact of various discharges on receiving-water environments. Water bodies with different beneficial uses (e.g., drinking water supply, fish habitats) are included in those sites selected. Special modelling and other assessment techniques, including the use of aquatic organisms as indicators of impacts on water quality, are being developed. These pilot studies will also be completed by the end of 1988.

Ex. E-154

Ministry of the Environment -
Reasonable Use Guidelines

Ministry of the Environment
Ontario

M.O.E. Policy Manual

POLICY TITLE	WATER MANAGEMENT - GOALS, POLICIES, OBJECTIVES AND IMPLEMENTATION PROCEDURES OF THE MINISTRY OF THE ENVIRONMENT (REVISED MAY 1984)	NO. 15-01-01

Legislative Authority

Ontario Water Resources Act

Statement of Principles

To ensure the effective management of the Province's water resources, the following goals and policies contained in the publication Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment, November 1978 (Revised May 1984) shall be adhered to. Reference should be made to that publication for additional details of the guidelines, procedures and tables referred to in the following.

SURFACE WATER QUALITY MANAGEMENT

GOAL

TO ENSURE THAT THE SURFACE WATERS OF THE PROVINCE ARE OF A QUALITY WHICH IS SATISFACTORY FOR AQUATIC LIFE AND RECREATION.

Water which meets the water quality criteria for aquatic life and recreation (designated as the Provincial Water Quality Objectives, Table 1), will be suitable for most other beneficial uses, such as drinking water and agriculture. For the few parameters, where better water quality is required to protect these other beneficial uses in a given location, the appropriate criteria shall be applied in that location.

August 22, 1986

Point of Contact

Director,
Water Resources Branch

Effective Date

1 - - F 1986

POLICIES

1. Areas with Water Quality Better than the Objectives

In areas which have water quality better than the Provincial Water Quality Objectives, water quality shall be maintained at or above the Objectives.

2. Areas with Water Quality Not Meeting the Objectives

Water quality which presently does not meet the Provincial Water Quality Objectives shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the Objectives.

3. Effluent Requirements

Effluent requirement will be established on a case-by-case basis. In establishing effluent requirements, the characteristics of the receiving water body will be considered, as will Federal and Provincial effluent regulations and guidelines where applicable. The effluent requirements so derived will be incorporated into Certificates of Approval (under Section 24, Ontario Water Resources Act) and will specify both waste loadings and concentrations.

4. Hazardous Substances

Special preventive measures are required to deal with the release of known or potentially hazardous substances. Accordingly, the Ministry's policy is to:

i) prevent the release of those substances listed in Table 2 which are hazardous if released in any concentration:

ii) ensure that special measures are taken on a case-by-case basis to minimize the release of any substances for which Provincial Water Quality Objectives have not yet been established.

5. Mixing Zones

A mixing zone is defined as an area of water contiguous to a point source where the water quality does not comply with the Provincial Water Quality Objectives. Terms and conditions related to a mixing zone will be designated on a case-by-case basis and may be specified in Certificates of Approval, control orders, requirement and directions, or approvals to proceed under the Environmental Assessment Act. The size of the mixing zone shall be minimized to the greatest possible degree and under no circumstances is the mixing zone to be used as an alternative to treatment.

SURFACE WATER QUANTITY MANAGEMENT

GOAL

TO ENSURE A FAIR SHARING OF THE AVAILABLE SUPPLY OF WATER TO PROTECT BOTH WITHDRAWAL AND IN-PLACE USES OF WATER

POLICIES

1. Water Quality-Quantity Inter-relationships

The withdrawal of water from and discharge of water to surface water bodies will be controlled to assist in maintaining or restoring water quality for the protection of aquatic life and recreation.

2. Permits to Take Water

Surface water takings will be controlled to prevent interference with other uses of water wherever possible and to resolve such problems if they do occur.

3. Surface Water Conservation

All reasonable and practical measures should be taken to conserve the quantity of surface water in order to maximize its availability for existing or potential beneficial uses.

GROUND WATER QUALITY MANAGEMENT

GOAL

TO PROTECT THE QUALITY OF GROUND WATER FOR THE GREATEST NUMBER OF BENEFICIAL USES

In the majority of cases, human consumption will be the most important use of water to be protected, but there are other ground water uses such as agriculture with specific water quality requirements which will also be protected. Appropriate criteria for these two uses are given in Tables 4 and 5. In addition, protection of aquatic life (Table 1) is a consideration in cases where ground water is a significant component of streamflow.

POLICIES

1. Regulated* Sources of Contamination

The waste control requirements for proposed regulated waste discharges will be established on a case-by-case basis. As a general policy, water quality degradation will be controlled in order to protect reasonable uses, existing or proposed, of both ground and surface waters. The Ministry requirements relating to the quantity and the quality to the discharge will be specified and control measures may also be stipulated in the Certificate of Approval.

The treatment or elimination of pollutants from existing activities will be required where it is demonstrated that such measures are practicable and necessary to correct use impairment and will prevent further degradation or improve water quality. Where such measures are not practicable, the Ministry may require replacement of the affected supplies.

2. Unregulated** Sources of Contamination

All reasonable measures shall be undertaken to reduce or prevent the contamination of ground water by proposed or existing unregulated activities.

* Regulated refers to those activities which require specific approval under the Ontario Water Resources Act or the Environmental Portection Act.

** Unregulated refers to those activities which do not require specific approval under the Ontario Water Resources Act or the Environmental Protection Act.

GROUND WATER QUANTITY MANAGEMENT

GOAL

TO ENSURE THE FAIR SHARING AND CONSERVATION OF GROUND WATER

POLICIES

1. Permits to Take Water

Ground water takings will be controlled to prevent water supply interference wherever possible through a water taking permit program under Section 37 of the Ontario Water Resources Act.

2. Resolution of Interference Problems

In the event that a ground water taking authorized by permit interferes with another water supply obtained from any adequate source that was in use prior to the issuance of the permit, the party causing the interference shall restore the affected supply or reduce the taking to eliminate the interference.

3. Ground Water Conservation

All reasonable and practical measures shall be taken to promote the conservation of ground water.

Rev.2 - Mar.15/81

Ministry of the Environment
Ontario

M.O.E. Policy Manual

POLICY TITLE	INCORPORATION OF THE REASONABLE USE CONCEPT INTO MOE GROUNDWATER MANAGEMENT ACTIVITIES	NO. 15-08-01

Legislative Authority

Ontario Water Resources Act, R.S.O. 1980

Statement of Principles

This policy establishes the basis for determining the reasonable use of groundwater on property adjacent to sources of contaminants and explains the role of a reasonable use approach in the Ministry's various activities related to groundwater quality.

The policy is designed to facilitate implementation of the groundwater quality management policies and procedures contained in the publication "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment", which are based on protecting existing and potential reasonable uses of water. The reasonable use concept applies only to groundwater quality management.

The policy addresses the levels of contaminant discharges considered acceptable by the Ministry and the levels of contamination in water supplies which would warrant restoration of those water supplies.

Detailed information on the policy is contained in the document entitled "The Incorporation of the Reasonable Use Concept into the Groundwater Management Activities of the Ministry of the Environment", April 1986.

May 1, 1986

Point of Contact

Director, Water Resources Branch

Effective Date

April 25, 1986

THE INCORPORATION OF THE REASONABLE USE CONCEPT INTO THE GROUND WATER MANAGEMENT ACTIVITIES OF THE MINISTRY OF THE ENVIRONMENT

ONTARIO MINISTRY OF THE ENVIRONMENT
WATER RESOURCES BRANCH

SEPTEMBER 1986

Prepared by:

WATER MANAGEMENT STEERING COMMITTEE
WORKING GROUP V

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THE INCORPORATION OF THE REASONABLE USE CONCEPT INTO THE GROUND WATER MANAGEMENT ACTIVITIES OF THE MINISTRY OF THE ENVIRONMENT

1.0 PURPOSE AND OBJECTIVE

The basic purpose of this document is to establish procedures for the determination of what constitutes reasonable use of ground water on property adjacent to sources of contaminants and to explain the role of a reasonable use approach in the Ministry's various activities related to ground water quality. This is needed to facilitate implementation of the ground water quality management policies and procedures contained in "Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment," November 1978, Revised May 1984 (Water Management), which are based on protecting existing and potential, reasonable uses of water. The reasonable use concept applies only to ground water quality management. The Ministry's surface water quality management policies are presented in the booklet "Water Management". This document addresses the levels of contaminant discharges considered acceptable by the Ministry.

It is important to remember that this document identifies the Ministry's perception of the issues addressed and the solutions which the Ministry will employ or endorse. The Ministry can only insist on utilization of its own policies and guidelines when matters are under the Environmental Protection Act or the Ontario Water Resources Act, but its actions, even there, are usually subject to appeal. When the Environmental Assessment Act or the Consolidated Hearings Act

is utilized, the Ministry does not have the power to make decisions incorporating Ministry policies and perceptions; the decision-making power is elsewhere and the Ministry can only suggest and recommend.

In Section 2 the administrative and technical basis for adopting the Reasonable Use approach is outlined and discussed. In Section 3, terms are defined and the Reasonable Use concept is applied to the issuance of Certificates of Approval for the following Ministry-regulated activities; proposed landfills, operating landfills, landfills requesting approval for expansion, exfiltration lagoons and large sub-surface sewage systems. This document does not apply to the clean-up of contaminated ground water or to the restoration of ground water supplies that have been contaminated by "unregulated" sources of contamination such as closed landfills, and spills. These are addressed in Policy No 15-10, "Guidelines for the Resolution of Ground Water Quality Interference Problems".

2.0 ADMINISTRATIVE AND TECHNICAL BASIS FOR THE REASONABLE USE APPROACH

2.1 Ministry Policy

The Ministry's policy as presented in the November, 1978 publication "Water Management" referred to reasonable uses of ground water, to clearly indicate that the Ministry would require sufficient levels of environmental control to protect reasonable uses of the ground water.

Potential reasonable uses are also specified to indicate that the Ministry has concern not only for present but for future uses of ground waters in the Province. The policy is intended to assist in making decisions about current, and future activities of the Ministry. It is not intended that all waste disposal facilities be investigated immediately to

determine if they meet the levels for contaminant discharge described in this document.

2.2 Determination of Reasonable Use

The Ministry's decision as to what constitutes reasonable use and potential use of ground water on land associated with or adjacent to waste disposal sites will be made on a case-by-case basis. This is necessary because the wide variation in the quality, quantity and availability of ground water makes a fixed, standard approach impractical.

The responsibility for deciding what constitutes the reasonable use of the ground water and what uses should be protected will normally rest with the Regional Director. The Director will base his decision on input from a proponent and/or an assessment by his staff. If his decision becomes a major issue in a specific case, it could be made the subject of a public hearing.

Reasonable use and potential use must be established with respect to specific soil and water-bearing units in the subsurface and would apply to all of the ground lying beneath a particular property. As is discussed later in this Section, in most cases, the reasonable use of ground water will be for domestic consumption. However, when it can be demonstrated that there is some other reasonable use of ground water with different water quality requirements, then criteria appropriate to that use will be applied.

The decision as to the reasonable use of the ground water at a particular location shall be based on three major considerations:

a) the present use of the ground water,
b) its potential use, and
c) the amount and quality of the ground water that is available.

a) The present use of ground water in the vicinity. This is easily determined by a survey of the uses being made of the ground water by nearby land owners and from data in the Ministry's files. In most instances, the present use will be taken as the reasonable use.

b) Potential use of ground water in the vicinity. Where there is no current use of the ground water in the vicinity, criteria will be established on the basis of the potential use of that water. The judgement of potential reasonable use of the ground water will be based on the quality and quantity now present in the vicinity, and the current use of that particular resource in the general area. In addition, the work of planning agencies etc. may provide input to determine potential land use in the vicinity as this might affect the use of the ground waters.

c) The existing quality and quantity of the ground water in the vicinity. The existing quality of the ground water in the vicinity and the amount of that water which would be available to wells must be assessed. This can be accomplished by using data in the Ministry's files and a general knowledge of the hydrogeology in the area.

The potential use of ground water in Ontario will almost always be for domestic consumption. This is because:

a) There are virtually no parts of Ontario where the quantity of ground water that could be collected by a well will not meet the basic needs of a single family.

b) Although there are parts of Ontario where the quality of the ground water does not meet the Ontario Drinking Water Objectives, in most cases, individual owners have

used such waters on a continuing basis over many years (Section 3.4).

The presence of piped or surface water supplies is not necessarily justification for considering that there is no potential use for the ground water. However, it may be a contributing factor (Section 3.4) where other considerations, such as naturally poor quality, would detract from the usefulness of the ground water.

The desirable qualities of drinking water are specified in the document "Ontario Drinking Water Objectives". Water quality objectives for protection of fish and aquatic life and for agricultural use are stipulated in Tables 1 and 5 of "Water Management". Each publication contains, in addition to the numerical objectives, directions as to their application. In those instances where there is no Ministry of the Environment objective for a given parameter, the Regional Director may specify what is considered to be an appropriate objective based on current scientific evidence.

2.3 Other Land Uses

Related land uses which could be affected by contaminants transported by ground water, and which are compatible with a reasonable use approach, include: the use of the soil for agricultural activities, the use of the sub-surface for facilities such as sewers, electrical conduits or building foundations, or the use of the soil as fill.

2.4 General Technical Considerations

A number of general technical considerations have been taken into account in the development of this document.

A. The Ministry considers that the following positions represent good ground water management practice:

i) There are suitable environments in Ontario and adequate technology is available so that it is not necessary to degrade any subtantial ground water resource by waste disposal.

ii) Allocation of all of the attenuation capacity in a particular area to a single source of contaminants may not be prudent. This is because it may not be possible to prevent additional contaminant loadings in the future. This anticipated additional contaminant loading must be assessed on a case-by-case basis.

iii) Provision should be made, in the form of contingency plans, for alleviating unacceptable environmental impacts, in so much as possible, should this prove to be necessary in the future. Experience in the identification of previously unsuspected contaminants has shown that such a need should be anticipated.

B. It is not generally possible with present technology, to estimate accurately the quantity or the quality of contamination which will discharge from a waste disposal facility. Uncertainty factors on the order of at least five times are common in the measurement of parameters such as hydraulic conductivity. Therefore large safety margins should be incorporated into all estimates of contaminant discharge.

The safety margin that is appropriate would have to be assessed on a case-by-case basis depending on the complexity of the hydrogeologic environment, the degree of uncertainty in the assessment, and the consequences of failure of the system.

There is a higher level of certainty when an existing contaminant plume is present and can be used in an assessment than when no plume is present.

C. There are some practical differences in the hydrogeologic aspects of solid and liquid waste disposal facilities. These differences are associated with monitoring (the initiation and appearance of contaminant discharge) and contingency measures (the removal of the waste).

D. The use of land adjacent to a waste disposal facility, in addition to those uses associated with water supplies, can be affected by liquid or gaseous contaminants transported by the ground water or moving through the unsaturated zone in the subsurface. The protection of these uses is also the responsibility of the Ministry.

2.5 Environments Unsuitable for Waste Disposal

The Ministry may not support proposals for waste disposal facilities in the following environments:

1. Where no appreciable attenuation can be provided in the subsurface and an excessive amount of the attenuation required for acceptable discharge must be provided by dilution in surface waters.

2. Where only a relatively small amount of natural attenuation will be provided by the environment and an unusually large area is required for the attenuation of contaminants as compensation for that poor environment. For technical reasons, environments where this is necessary are generally quite expensive to evaluate and contingency plans in such environments are seldom practical.

3. Where the subsurface beneath the facility is particularly suited for a better use. For example, waste disposal may not be supported in an esker of sand and gravel where the esker might be needed at some future date for the development of a water supply.

4. Where the consequences of failure are unacceptable. For example, waste disposal may not be supported where failure or contaminant discharge might affect the sole source of a community water supply to an unacceptable degree.

3.0 THE APPLICATION OF THE REASONABLE USE APPROACH TO MINISTRY ACTIVITIES

3.1 Introduction

In this Section, the reasonable use concept is applied to:

(a) determining quantitatively the acceptable levels of various contaminants originating in Waste Disposal Sites and impinging on Adjacent Properties.

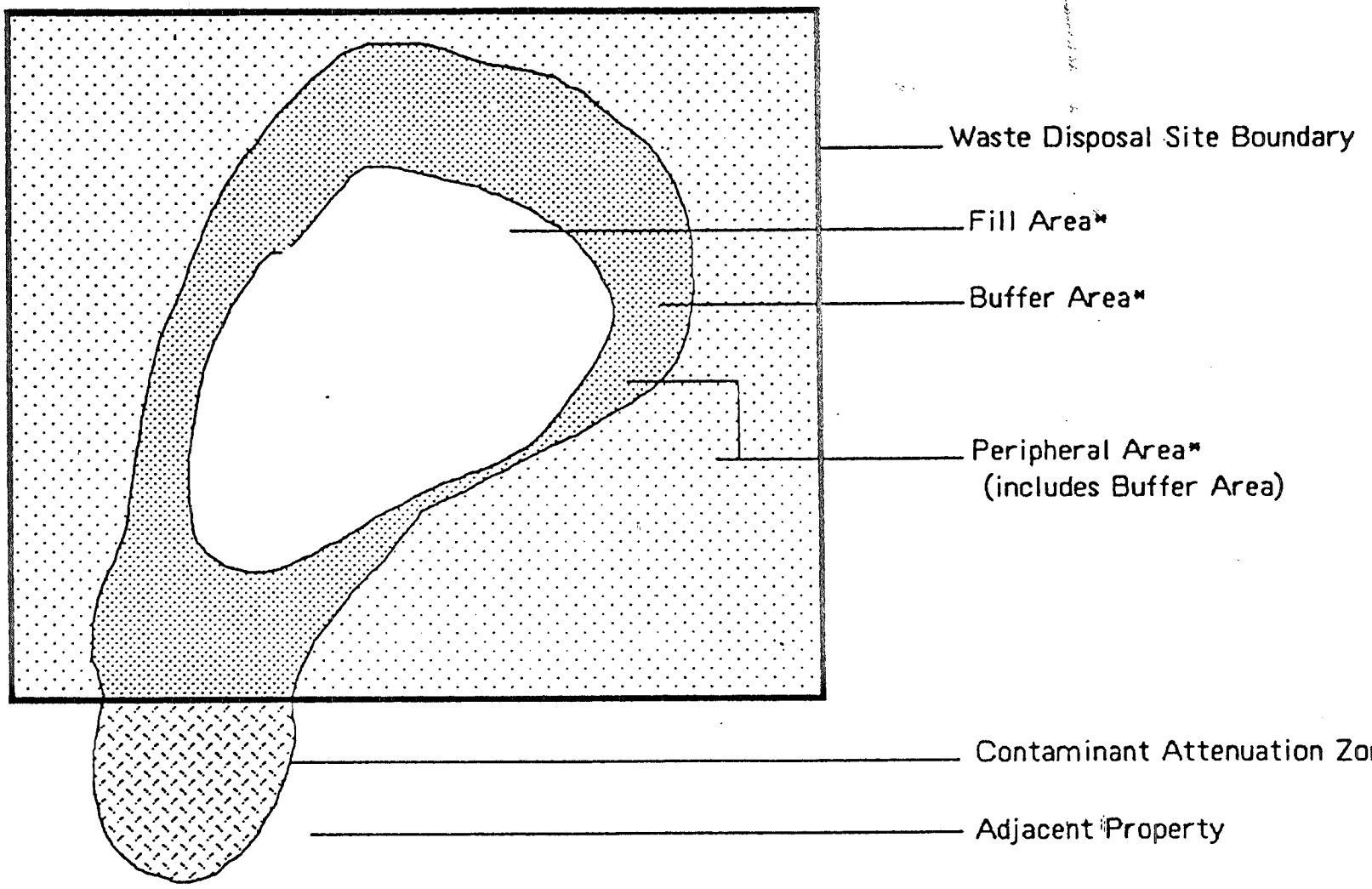
(b) assessing the suitability of a Contaminant Attenuation Zone, and a Waste Disposal Site.

Terms are specifically defined in Section 3.3 and are illustrated in an accompanying schematic diagram.

3.2 The Ministry of the Environment's Responsibility and Authority

The Ministry of the Environment is charged with the conservation of the ground water resources of the Province and the control of the use of these resources in an effective manner for the public good. To this end, the Ministry may wish to discourage the use of some environments for waste disposal and encourage the use of other environments. The

SOLID WASTE DISPOSAL SITE– SCHEMATIC VIEW



* See MOE document *Land Use and Waste Management Glossary* for definitions of terms

Ministry position is that Waste Disposal Sites should be placed in environments where their impact will be minimized, that acceptable disposal methods should be used and that these methods should be compatible with those particular environments.

For waste disposal activities the Ministry has the management authority to:

1) Issue a Certificate of Approval which would permit the use of property for contaminant attenuation or treatment. Discharge to neighbouring property must have no more than a negligible effect on the use of this property. The question of whether the effect is negligible, if challenged, could be established by the courts, which would decide if there is damage and how it can be measured in terms of dollars. This is inherent in the approach used by the Ministry in other situations, such as the issuance of air approvals.

2) Prevent the owner of a Waste Disposal Site from using the sub-surface beneath his property for waste disposal purposes if this use is not felt to be in the public interest.

This management authority is subject to the limitation and qualifications in Section 1.0.

3.3 Definition of Terms

For the purpose of this paper, the Ministry will consider three areas in assessing waste disposal proposals:

1. The Waste Disposal Site;
2. The Contaminant Attenuation Zone;
3. The Adjacent Property

These are illustrated in the accompanying diagram and defined in the following sections.

The terminology used in this discussion is adapted from the Ministry document titled "Land Use and Waste Management Glossary".

3.3.1 The Waste Disposal Site

For the general purposes of this Ministry, "Waste Disposal Site" is defined in Part 5 of the Environmental Protection Act to mean any land where waste is disposed or processed and includes any machinery, equipment or operations required for the treatment or disposal of the waste. Thus, a Part V Certificate of Approval for a Waste Disposal Site is issued for a parcel of land larger than the area where the waste will be deposited, as the adjoining land is necessary for proper site operations.

For the purposes of this paper, we are not considering Part V Waste Disposal Sites where treatment takes place, but only sites where disposal of the waste occurs. Also, for purposes of this paper, we will use the term Waste Disposal Site to include a large sub-surface sewage system or an exfiltration lagoon.

The most common Part V Waste Disposal Site at which disposal takes place is defined as a "Landfilling Site" in Regulation 309. The Waste Disposal Site comprises the area on or in which wastes are disposited, (the "Fill Area"), and any bordering land, (the "Peripheral Area"), as shown on the accompanying diagram.

Large sub-surface sewage disposal systems are described in Article 14.1 of the Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems.

The following comments apply to a Waste Disposal Site:

a. Future use of the land should be strictly controlled. Based on technical considerations, such controls should be permanent or continued until it can be shown that such control is no longer necessary.

b. As there are environments which the Ministry does not believe are appropriate for waste disposal, the Ministry will either oppose the use of such environments or will insist that stringent safeguards be incorporated in any design for the Waste Disposal Site. These safeguards may include provision for the collection and treatment of any contaminants which will be produced. Guidelines for identifying environments unsuitable for waste disposal are presented in Section 2.5 of this document.

3.3.2 The Contaminant Attenuation Zone

The purpose of designating a "Contaminant Attenuation Zone" is to allow, in exceptional cases, the limited impairment of use of off-site property by means of easements or other methods without imposing the severe restrictions on land use which apply to the Waste Disposal Site.

Where appropriate, a Contaminant Attenuation Zone may be designated. It is outside of the Waste Disposal Site and it is defined both with respect to the area of land which it underlies and also with respect to the depth at which it lies.

In the Contaminant Attenuation Zone, it is intended that contaminants will be naturally attenuated to levels compatible with the reasonable use of the Adjacent Property as discussed in Section 2.2 and in order to meet the criteria

specified in Section 3.5.1.1. Contaminant levels in the Contaminant Attenuation Zone may impair some uses of that Zone. The operator of the Waste Disposal Site must obtain the right to the use of this Zone by reaching agreement with the property owner. The agreement should be registered on the title to this land.

Circumstances and environments favouring the designation of a Contaminant Attenuation Zone are discussed in Section 3.4.

3.3.3 The Adjacent Property

The Adjacent Property is the land bordering the Waste Disposal Site or the Contaminant Attenuation Zone. Discharge of contaminants (leachate) to Adjacent Property will have no more than a negligible effect on the present or potential reasonable use of that property. This will ensure that:

a) the presence of the contaminant will not interfere with the construction, installation or good operation of any usual facility in the subsurface, such as utility conduits;

b) the soil will not be contaminated to a degree which would interfere with its use;

c) the ground water will not be contaminated to a degree which would impair its use, where:

(i) it is presently of acceptable quality;
(ii) it is in a location from which it could be practically obtained;
(iii) there is a potential use of the ground water for other purposes.

3.4 Circumstances and Environments Considered Suitable for a Contaminant Attenuation Zone

The Ministry may support an application for a Waste Disposal Site involving the acquisition of land or an easement for a Contaminant Attenuation Zone only under the following circumstances:

1. Where an alternate source of water is far superior to any associated with a Contaminant Attenuation Zone. Here the Ministry may support the use of the ground water for dilution and attenuation in a Contaminant Attenuation Zone and take the position that the effect on reasonable uses on Adjacent Property would be negligible because that ground water would not need to be used in any case.

   This circumstance could arise as follows:

   a. Where two water-bearing units are present, one being far superior to the other with respect to the quality, quantity and the accessibility of the water contained in it, the Ministry may accept the inferior unit as a Contaminant Attenuation Zone, provided that this will not interfere with the use of the superior unit.

   b. Where good supplies of water are available, either from surface water sources or from municipal systems, and the ground water supplies in a particular unit are marginal with respect to their quality and/or their quantity, the Ministry may support the use of that ground water as a Contaminant Attenuation Zone.

2) Where only an acceptably small, clearly defined and hydrogeologically restricted portion of a subsurface unit will be degraded and this subsurface unit is not likely to be required for a higher use.

This procedure would allow the Ministry to support the use of certain Crown Lands in Northern Ontario or well defined zones of ground water flow such as may be present in flood plains, as Contaminant Attenuation Zones despite their physical ability to yield ground water in "useful" quantities.

3) Under special circumstances and on a case-by-case basis where naturally high levels of iron, manganese and/or total dissolved solids (where these are associated with hardness) are present in the ground water and as a result, the limits imposed in Section 3.5.1.1 can not be met (see situations described in Section 3.5.1.2, Examples 2 and 3). This is because:

   a) Unlike the case in surface waters, concentrations of iron, manganese and total dissolved solids commonly in excess of the Provincial Drinking Water Objectives are naturally present in Ontario's ground waters. These ground waters are routinely used for domestic supplies.

   b) These parameters are not related to health, at the levels stated in the Provincial Drinking Water Objectives, and in addition can be removed from a water supply with commonly available techniques.

It is not practical to eliminate landfilling in a large percentage of the Province because of the natural presence of iron, manganese and total dissolved solids in excess of the Provincial Drinking Water Objectives.

4. Where, in exceptional cases in the judgement of the Regional Director, the most appropriate use of that environment would be as a Contaminant Attenuation Zone, although it is suitable for other purposes as well.

3.5 Landfills

3.5.1 The Assessment of Proposed Landfills.

3.5.1.1 Basic Approach - In accordance with the appropriate criteria for particular reasonable uses, such as those specified in "Water Management", a change in quality of the ground waters on the Adjacent Property will be acceptable only as follows:

> Quality cannot be degraded by an amount in excess of 50% of the difference between background and the quality criteria for any designated reasonable use except drinking water. In the case of drinking water, the quality must not be degraded by an amount in excess of 50% of the difference between background and the Provincial Drinking Water Objectives for non-health related parameters and in excess of 25% of the difference between background and the Provincial Drinking Water Objectives for health-related parameters. Background is considered to be quality of the ground water prior to any man made contamination.

In accordance with Section 3.2 it is the Ministry's judgement that such increases in contaminant levels will have no more than a negligible effect on the use of the Adjacent Property.

In assessing the amount of degradation that is acceptable, consideration is given to the natural, uncontaminated quality of the ground water, the present quality of the ground water and potential contamination of the ground water from all sources.

3.5.1.2 Examples of the Application of the Concept - Below are given examples of the application of this concept to three different situations:

Example 1 - Where the designated reasonable use of ground water allows no change in quality, no change is acceptable.

Example 2 - Where the designated reasonable use of the ground water is drinking water and the ground water quality is presently better than the Provincial Drinking Water Objectives, a lowering of water quality on the Adjacent Property will be acceptable in accordance with the formula stated above. (See Section 3.4, Part 3. for possible exception)

Example 3 - Where ground water quality is currently poorer than the Provincial Drinking Water Objectives, but the ground water is nonetheless in use as a drinking water source, then no decrease in water quality will be acceptable. (See Section 3.4, Part 3 for possible exception).

3.5.1.3 Examples of the Calculations - Two calculations are required to determine the amount of contamination that can discharge from a Waste Disposal Site onto the Adjacent Property. The first calculation addresses the total contaminant impact at that location from all sources of contamination. The second addresses the permissible impact from the particular Waste Disposal Site.

The maximum concentration (Cm) of a particular contaminant that would be acceptable (Section 3.2) in the ground water beneath the Adjacent Property is calculated in accordance with the following relationship:

$$Cm = Cb + x(Cr-Cb)$$

The terms are defined as follows:

Cb - This is the background concentration of the particular contaminant in the ground water before it has been affected by man

(Section 3.5.1.1). This allows consideration to be given to the amount of increase in contaminant level.

Cr - This is the maximum concentration of the particular contaminant that should, in accordance with the Province's water management policy be present in the ground water. This value is dependent on the use (Reasonable Use) to be made of that ground water (Section 2.2). It allows consideration of the total amount of contamination.

x - This is a constant that reduces the contamination to a level that is considered by the Ministry to have only a negligible effect on the use of the water. For drinking water is 0.5 for non-health related parameters or 0.25 for health related parameters. For other reasonable uses it is 0.5. (Section 3.5.1.1).

Levels of contamination greater than Cm may have an appreciable effect on the use of the Adjacent Property and the Ministry will not support an application for a Certificate of Approval for Waste Disposal Site with contaminant discharges which would cause this level to be exceeded.

The maximum concentration of a particular contaminant (Cw) originating in the Waste Disposal Site that can be permitted to reach the Adjacent Property and still not cause Cm to be exceeded can be calculated in accordance with the following relationship:

$$Cw = Cm - Cp - Co$$

The terms are defined as follows:

Cp - This is the concentration of the particular contaminant in the ground water at the time of assessment, (i.e. the present background). This water may already contain some contaminants (Section 3.5.1.1). These contaminant levels must be subtracted to determine the contaminant increment that can be permitted from the Waste-Disposal Site.

Co - This is the potential contaminant increase from other sources with a high degree of probability (Section 2.4, Part A, ii). For example potential chloride contamination from a highway under construction next to the site must be subtracted to determine Cw.

Using chloride as an example, the maximum allowed chloride level (Cm) in the ground water beneath the Adjacent Property and the maximum chloride discharge (Cw) to the Adjacent Property from a hypothetical Waste Disposal Site are calculated as follows:

a) The reasonable use of the ground water beneath the Adjacent Property has been determined to be for domestic supplies.

b) The Ontario Drinking Water Objective for chloride (Water Management, P.52) is 250 mg/L. This represents Cr.

c) The natural uncontaminated background concentration of chloride is estimated to have been 10 mg/L. This represents Cb.

d) The measured concentration of chloride at the time of the assessment is 40 mg/L. This represents Cp.

e) The expected additional chloride increase from a nearby highway that is presently under construction is estimated to be 20 mg/L. This represents Co.

f) Chloride is considered to be a non-health-related parameter and therefore the constant (x) is 0.5.

The maximum allowed concentration (Cm) of chloride beneath the Adjacent Property, in accordance with the relationship $Cm = Cb + x (Cr-Cb)$ is therefore:

$$10 + 0.5 (250-10) = 130 \text{ mg/L}$$

The maximum concentration of chloride (Cw) from the Waste Disposal Site that can be permitted to reach the Adjacent Property, in accordance with the relationship $Cw = Cm - Cp - Co$ is therefore:

$$130 - 40 - 20 = 70 \text{ mg/L}$$

It should be noted that the chloride ion will seldom be the critical contaminant parameter (i.e. the contaminant parameter which will most closely approach its maximum allowed value, Cm, and thus represent the limit to which the site is designed). However it is commonly used in contaminant investigations because of its usefulness as a "tracer". The critical contaminant is dependent on the characteristics of the wastes and the hydrogeologic environment and is determined on a case-by-case basis.

3.5.1.4 Site Assessment - The assessment of the proposed Waste Disposal Site should be carried out in accordance with any pertinent Ministry guidelines. In addition, Section 2.4 of this document "General Technical Considerations" should be

considered and in particular those parts relating to the provision of a safety margin in making estimates of contaminant discharges. (Part B.)

3.5.2 The Assessment of Operating Landfills

An Operating landfill is handled as follows:

a) An operating landfill should meet the same limits for contaminant discharge (Section 3.5.1.1) as a proposed landfill.

b) The judgement as to the amount of offsite impact that the landfill will produce may be based on actual offsite measurements of contaminant levels or on predictions of offsite contaminant levels which are based on onsite measurements. This reduces the requirements for a safety margin in calculations (Section 2.4, Part B).

c) If contaminant concentrations exceed the limits specified in Section 3.5.1.1 but are less than 100% of the particular water quality criteria, the landfill should be closed in a manner to minimize environmental damage, or the operation should be modified. It is acceptable to modify the landfill operation, for example, by installing a cover with low hydraulic conductivity, in order to meet the specified limits. However if these levels are exceeded, it may be prudent to require all landfilling, except that done in conjunction with closure or remedial activities, be terminated until the specified limits have been
met, or until monitoring data indicate that these limits will be met.

d) If contaminant discharge exceeds 100% of the particular water quality criteria and modifications in the design in accordance with c, above cannot be accomplished, the landfill should be closed. Determinations on the

replacement of contaminated water supplies and the abatement of the contaminant plume must be made on a case-by-case basis.

3.5.3 The Assessment of Landfills Requesting Certificates of Approval for Expansion.

A Certificate of Approval for a landfill requesting expansion will be handled in the same manner as would the Certificate of Approval for a new landfill or proposed landfill (i.e. it must meet the limits specified for contaminant discharge in Section 3.5.1.1).

3.6 Exfiltration Lagoons and Large Subsurface Sewage Disposal Systems

Exfiltration lagoons and large subsurface sewage disposal systems must meet the same criteria for operation and closure as landfills. (Section 3.3.1.1)

REASON/USE.2