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.

7. When the Ministry has the jurisdiction to deal with the approval of a landfill site under Part V of the **Environmental Protection Act**, the responsibility for making a determination on what constitutes the reasonable use of ground water would normally rest with the Regional Director. When the jurisdiction is with the Environmental Assessment Board or a Joint Board, the responsibility rests with the Board.

8. A determination as to what constitutes reasonable use is case specific and is based on the present use of the ground water, the future potential use of the ground water and the amount and quality of ground water available for use. In most cases, the potential reasonable use of ground water in Ontario will be domestic consumption.

9. I am informed that certain witnesses before the Joint Board have stated that the only reasonable use of ground water downgradient of site F is leachate attenuation. In my opinion, such a determination is possible within the confines of the policy and guideline, although I am unable to give an opinion on whether such a determination is appropriate in this case.

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

CURRICULUM VITAE

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BORN: SYDNEY, NOVA SCOTIA, AUGUST 14, 1929, CANADIAN CITIZEN.

EDUCATION

Ph.D., University of Illinois, Urbana, Illinois, 1962, Department of Geology. Thesis - The Glacial Geology of the Redwater and Morinville Areas, Alberta, Canada.

M.Sc., University of Alberta, Edmonton, 1959. Thesis - Study of Pleistocene Lake Edmonton and Associated Deposits.

Graduate Studies, University of Alberta, Edmonton, 1951-1952.

B.Sc., University of Alberta, Edmonton; Faculty of Arts and Science, Dept. of Geology, 1951.

EMPLOYMENT

SEPTEMBER 1983 - PRESENT	Supervisor, Landfill Disposal Technology Unit, Waste Management Branch, Ontario Ministry of the Environment, Toronto, Ontario.
NOVEMBER 1974 - SEPTEMBER 1983	Chief, Ground Water Protection, Water Resources Branch, Ontario Ministry of the Environment, Toronto, Ontario.
SEPTEMBER 1970 - NOVEMBER 1974	In charge of Northeastern Illinois Office of Illinois Geological Survey, Warrenville, Illinois.
1968 - SEPTEMBER 1970	Associate Geologist, Illinois State Geological Survey, Naperville, Illinois.
SPRING 1963 - 1968	Assistant Geologist, Illinois State Geological Survey, Naperville, Illinois.
SPRING 1962 - 1963	Assistant Geologist, Illinois State Geological Survey, Urbana, Illinois.
ACADEMIC YEARS - 1959, 1960, 1961	Half-time teaching assistant, Department of Geology, University of Illinois, Urbana, Illinois.
SUMMER 1958, 1959, 1960	Surficial mapping for the Research Council of Alberta in the Edmonton Area of Alberta.
MAY 1957 - SEPTEMBER 1957	Geologist - R. Adair Oil Management, Calgary, Alberta. Wellsite work in Western Canada.
MAY 1, 1952 APRIL 30, 1957	Geologist - Pan American Petroleum Corporation. Subsurface mapping and wellsite work in Western Canada.

MEMBERSHIP IN ORGANIZATIONS

National Water Well Association
The Society of the Sigma Xi
International Association of Hydrogeologists
Association of Professional Engineers of Ontario
American Institute of Hydrogeology

PUBLICATIONS

Bayrock, L.A. and G.M. Hughes, 1962, Surficial geology of the Edmonton District, Alberta: Alberta Research Council, Prelim. Report 62-6,40p.

Hackett, J.E. and G.M. Hughes, 1965, Controlled drilling program in Northeastern Illinois: Illinois Geological Survey Environmental Geology Notes, no. 1, 18 p.

Hughes, G.M., P. Kraatz and R.A. Landon, 1966, Bedrock aquifers of Northeastern Illinois: Illinois Geological Survey, Circ. 406, 15p.

Hughes, G.M., 1967, Selection of refuse disposal sites in Northeastern Illinois: Illinois Geological Survey, Environmental Geology Notes, no.17, 19p.

Farvolden, R.N., G.M. Hughes and R.A. Landon, 1967: Garbage and groundwater: Proc. Annual Meeting, Geological Association of Canada, Queens's University, Kingston, September 1967.

Hughes, G.M., R.N. Farvolden and R.A. Landon, 1969, Hydrogeology and water quality at a solid waste disposal site: Proceeding of the 7th Annual Engineering Geology and Soils and Engineering Symposium, Moscow, Idaho, April 9-11, 1969, p.116-130.

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Farvolden, R.N. and G.M. Hughes, 1969, Hydrogeologic factors in landfill design: Proceedings of the 16th Ontario Industrial Waste Conference, Niagara Falls, June 15-18, 1969, 8 p.

Hughes, G.M., R.A. Landon and R.N. Farvolden, 1971, Hydrogeology of solid waste disposal sites in Northeastern Illinois: An Interim Report to the U.S. Department of Health, Education and Welfare under Demonstration Grant, no. D01-U1-0006, 137 p.

Hughes, G.M., R.A. Landon and R.N. Farvolden, 1971, Hydrogeology of solid waste disposal sites in Northeastern Illinois: Final Report to the U.S. Environmental Protection Agency under Demonstration Grant, no. G06-EC-00006, 154p.

PUBLICATIONS CONT'D

Hughes, G.M., R.A. Landon and R.N. Farvolden, 1971, Summary of findings on solid waste disposal sites in Northeastern Illinois: Illinois Geological Survey Environmental Geology Notes, no.45, 25p.

Hughes, G., J.J. Tremblay, H. Anger and J. D'Cruz, 1971, Pollution of groundwater due to municipal dumps: Inland Waters Branch Department of Energy, Mines and Resources, Ottawa, Canada Technical Bulletin No. 42, 98p.

Farvolden, R.N., and G.M. Hughes, 1971, Hydrogeological implications in solid waste disposal: Groundwater Pollution Symposium; Proc. of the Moscow Symposium, Russia, August 1971, p.146-158.

Hughes, G.M., 1972, Hydrogeologic considerations in the siting and design of landfills: Illinois State Geological Survey, Environmental Geology Notes, no. 51, 22p.

Hughes, G.M. and K. Cartwright, 1972, Scientific and Administrative criteria for shallow waste disposal: Civil Engineering, March 1972, p. 70-73.

Hughes, G., 1973, Hydrogeology and geomorphology as factors in waste management: Proc. International Conference on Land for Waste Management, Ottawa, Oct. 1973, Canadian Society of Soil Science, p.119-125.

Terry, R.D. and G.M. Hughes, 1976, Pollution effects on Surface waters and ground waters: Journal Water Pollution Control Federation, vol. 48, no. 6., p.1420-1433. get

Griffin, R.A. et al, 1976, Attenuation of pollutants in municipal landfill leachate by clay minerals: Part 1, Column leaching and field verification: Illinois State Geological Survey, Environmental Geology Notes, no. 78, 34p.

Griffin, R.A., N.F. Shimp, J.D. Steel, R.R. Ruch, W.A. White and G M. Hughes, 1976, Attenuation of pollutants in municipal landfill leachate by passage through clay: Environmental Science and Technology, vol. 10, no. 13., p.1262-1268.

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Panel on Land Burial, National Research Council, 1976, The shallow land burial of low-level radioactively contaminated solid waste: Panel on Land Burial, National Academy of Sciences, Washington, D.C., 150 p.

POLICY TITLE	ENGINEERED FACILITIES AT LANDFILLS THAT RECEIVE MUNICIPAL AND NON-HAZARDOUS WASTES	NO 14-15-01

Legislative Authority

The Environmental Protection Act

Statement of Principles

In order to protect the environment and human health, the Ministry will review and evaluate applications for new landfills and landfill expansions in accordance with the following position statement:

An engineered facility must function as long as necessary for the protection of the environment.

If periodic or continuous maintenance or replacement is required, evidence must be provided by the applicant that this can and will be accomplished.

This policy is written in accordance with the Ministry's current policy 15-08 entitled "The Incorporation of the Reasonable Use Concept into the Ground Water Management Activities of the Ministry of the Environment".

Definitions

Contaminating Life Span	It is defined as the period of time during which the landfill will produce contaminants at levels that could have unacceptable impact if they were discharged into the surrounding environment.

Point of Contact

Director, Waste Management Branch

Effective Date

May 11, 1988

1.0	Scope	This policy applies to applicants for new or expanded landfill sites which receive municipal and non-hazardous wastes and to Ministry staff responsible for the review and evaluation of such proposals.
2.0	MOE Responsibility	The Ministry will review and evaluate all applications for new and expanded landfill sites in accordance with the covering statement of principles and the Ministry's governing Guideline document (noted below).
3.0	Applicant's Responsibility	The applicant will be responsible for providing Ministry staff with sufficient evidence to adequately review and evaluate his/her proposal.
	3.1 Service Life	It is the applicant's responsibility to define the service life of an engineered facility and indicate the frequency of replacement and the number of times it must be replaced.
	3.2 Contaminating Life Span	In doing so, the applicant must address the contaminating life span of the landfill, equate this with the proposed service life of the engineered facility and support any procedures he/she intends to use ensure that the service life of the facility exceeds the contaminating life span of the landfill.
4.0	Further Guidance	Further guidance with respect to the use of landfill liners, leachate collection and treatment facilities, landfill covers and rapid stabilization and leachate recycling is provided in the Ministry's "Guideline on Engineered Facilities at Landfills that Receive Municipal and Non-Hazardous Wastes" dated March 1988.

Copies of the above noted document can be obtained from the Ministry's Waste Management Branch

MINISTRY GUIDELINE

FOR ENGINEERED FACILITIES AT LANDFILLS

THAT RECEIVE MUNICIPAL AND NON HAZARDOUS WASTE

(APRIL 20, 1988)

This document addresses engineered facilities at sites receiving municipal and non hazardous wastes. Engineered facilities at sites receiving hazardous wastes, as defined by Regulation 309, will be dealt with on a case-by-case basis.

Some level of engineering is necessary for all modern landfills both for the protection of the environment from the discharge of unacceptable levels of liquid and gaseous contaminants, and for aesthetic reasons. The specific engineered facilities that are required on a particular landfill depend on the environmental conditions that are present and the type of waste, and thus can only be judged on a case-by-case basis. In some cases, this may entail only simple ditching or grading for the control of surface run off, in others complex leachate and gas control facilities may be required. (The scope of the term "engineered facility" is discussed at the end of this document).

The Ministry's "Reasonable Use" Policy (MOE Policy 15-08: The Incorporation of the Reasonable Use Concept into the Ground Water Management Activities of the Ministry of the Environment), sets limits to the level of ground-water contamination and applies to discharges from landfills. Landfills, including those with engineered facilities, must meet the requirements of this Policy.

POSITION STATEMENT

It is the Ministry's position that there are limitations to engineered facilities and it prefers sites in environments with characteristics that provide a high degree of natural protection (e.g. thick clay deposits).

The acceptability of an engineered facility for a new landfill or a landfill that is expanding will be judged in accordance with the following:

> "AN ENGINEERED FACILITY MUST FUNCTION AS LONG AS NECESSARY FOR THE PROTECTION OF THE ENVIRONMENT. IF PERIODIC OR CONTINUOUS MAINTENANCE OR REPLACEMENT OF AN ENGINEERED FACILITY OR ITS PARTS IS REQUIRED, EVIDENCE MUST BE PROVIDED BY THE APPLICANT THAT THIS CAN AND WILL BE ACCOMPLISHED. IT IS THE APPLICANT'S RESPONSIBILITY TO DEFINE THE SERVICE LIFE OF AN ENGINEERED FACILITY AND INDICATE THE FREQUENCY OF REPLACEMENT AND THE NUMBER OF

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TIMES IT MUST BE REPLACED. IN SO DOING, THE APPLICANT MUST ADDRESS THE CONTAMINATING LIFESPAN' (i.e. THE TIME PERIOD DURING WHICH THE LANDFILL WILL PRODUCE CONTAMINANTS AT LEVELS THAT COULD HAVE AN UNACCEPTABLE IMPACT IF THEY WERE TO BE DISCHARGED INTO THE SURROUNDING ENVIRONMENT) OF THE LANDFILL, EQUATE THIS WITH THE SERVICE LIFE OF THE PROPOSED ENGINEERED FACILITY, AND SUPPORT ANY PROCEDURES HE INTENDS TO USE TO ENSURE THAT THE SERVICE LIFE OF THE FACILITY EXCEEDS THE CONTAMINATING LIFESPAN OF THE LANDFILL". THE MINISTRY WILL REVIEW AND EVALUATE THE APPLICANT'S PROPOSAL.

Engineered facilities (or combinations of facilities) will meet the following requirements:

1. It must be possible to monitor the engineered facility to verify that it performs to specification. Monitoring must be able to warn of failure sufficiently in advance to allow contingency measures to be taken. Contingency measures are designed to accommodate any failure in the design of a landfill and are not a part of the normal operation during the life of the facility.

2. The contaminating lifespan of the landfill must be addressed in the contexts of the service lives of the various engineered facilities that are used to control contamination.

3. Provision must be made for the maintenance of an engineered facility and its operation for as long as is required under the Position Statement. A detailed outline of how funding will be provided, who will bear the short-term and ultimate responsibility for the facility, the length of time that the facility will be operating, and recommendations as to the conditions under which the facility can be closed down or no longer monitored or maintained must be provided in an application.

4. Manuals on the design of various types of engineered contaminant control facilities, such as covers and liners, are available. However, some of these are very specialized and are new technologies. Under these circumstances the Ministry will require technical supporting data on the performance of these systems.

5. If an applicant cannot specify the time period for the decommissioning of an engineered facility the Ministry will consider that the facility will be required indefinitely and provisions for its perpetual care, maintenance and replacement must be provided. This is the responsibility of the applicant.

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The Ministry will apply this Guideline to specific types of engineered facilities as discussed in the following pages. Other types of engineered facilities will be addressed if the need arises.

LANDFILL LINERS

Synthetic Membrane Liners: To function properly, a synthetic membrane liner must retain its integrity (i.e. function as designed) for the contaminating lifespan of the landfill. The state-of-the-art does not allow precise determination of rates of attenuation or degradation of leachate in lined landfills. Therefore, in the absence of data or site-specific information to the contrary, where complete attenuation of the contaminants in the leachate is necessary, the Ministry will require that the containment facilities be maintained in perpetuity. At the present time, synthetic membrane liners cannot meet this requirement and in addition they cannot be replaced when they fail.

The Ministry is also concerned about the difficulty in providing monitoring systems for landfills with synthetic membrane liners. Such systems must have appropriately long service lives and provide sufficiently early warning of failure to allow effective contingency actions, should these be necessary.

For these reasons, the Ministry will not support proposals that depend upon synthetic membrane liners to confine leachate in landfills in perpetuity.

Earth and Clay Liners: Earth and clay liners may serve to reduce leachate discharge and confine leachate for collection and to attenuate some of the contaminants in leachate migrating out of a landfill. They may be used alone or in conjunction with synthetic membrane or other types of liners. Applicants proposing to use earth or clay liners should address these matters in their submissions to the Ministry.

LEACHATE COLLECTION FACILITIES AND LEACHATE TREATMENT FACILITIES

To serve effectively leachate collection facilities and leachate treatment facilities must function for the contaminating lifespan of the landfill. The state-of-the-art does not allow precise determination of rates of attentuation or degradation of leachate within landfills. Therefore in the absence of data or site specific information to the contrary, where the complete attenuation of the contaminants in the leachate is necessary, the Ministry will require that these collection facilities and treatment facilities be maintained in perpetuity.

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Leachate collection facilities and leachate treatment facilities must be designed, constructed, operated and monitored by professional staff and require competent technical staff for their continued maintenance, repair and replacement. Where approved, the Ministry will require that adequate resources be dedicated to the maintenance of any leachate collection, treatment, transporting and disposal facilities for as long as the leachate remains a potential hazard to the environment.

LANDFILL COVERS

Synthetic Membrane Covers: Synthetic membrane covers are used to prevent or significantly decrease infiltration into a landfill in order to reduce the rate of leachate production. This reduction of infiltration retards decomposition and extends the contaminating lifespan of a landfill. Consequently, this type of cover is not encouraged by the Ministry in situations where it would delay stabilization of the wastes. An applicant proposing such a cover must establish the contaminating lifespan of the landfill and provide for maintenance and periodic replacement of the cover as long as required. In the absence of evidence to the contrary, this will be considered to be in perpetuity.

Synthetic membrane covers will impede the upward venting of gases, and in particular methane, and in so doing may increase the distance these gases migrate laterally. These concerns should also be addressed in submissions to the Ministry.

"Clay" Covers: Clay covers (covers incorporating fine textured earth materials) are also intended to reduce infiltration into landfills. Such covers require maintenance to ensure proper growth of vegetation and to prevent failure by erosion and fissuring. Resources for these maintenance activities should be identified by an applicant.

RAPID STABILIZATION AND LEACHATE RECYCLING

Rapid stabilization of a landfill is a process intended to accelerate the biodegradation of the waste and reduce the time period during which settlement is most rapid and the landfill produces its most highly contaminating leachate. Although the technology has been known for 15 to 20 years, and has been used in some operating landfills there is little documented information from practical successful operations.

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While rapid stabilization will accelerate the biological degradation and leaching of a landfill it does not create a contaminant-free waste. A "stabilized" landfill still produces methane and a contaminating leachate.

Leachate recycling, entails pumping the leachate produced from a landfill, back into the landfill. This is the basis for most rapid stabilization operations but is also used as a means of delaying the handling and disposal of leachate by temporarily storing this leachate in the landfill. In most instances this will be a short-term measure and leachate, will eventually accumulate to a volume that exceeds the storage capacity of the landfill. Disposal must then be made in a manner acceptable to the Ministry.

The Ministry is also concerned that leachate recycling will create added head on the base of the landfill and this will cause an increase in the amount of leachate discharge to the surrounding soils. These matters should be addressed by an applicant.

An important aspect of this Guideline is the requirement that, if the contaminating lifespan of the landfill is not addressed in an applicant's submission, the Ministry will assume that certain engineered facilities must function in perpetuity. Rapid stabilization of the landfill is the only known method of shortening this contaminating lifespan so that contaminants released to the environment can be attenuated by natural processes. In light of the shortage of practical field data on this process, submissions should be conservative and supported by practical contingency measures in the event that stabilization is not as effective as predicted.

CONCLUDING STATEMENT

It is recognized that this Guideline will restrict the use of engineered facilities as a means of landfilling in sensitive hydrogeologic environments. It is felt, however, that the level of control required by this Guideline is necessary to protect Ontario's clean environment and valuable ground and surface water resources. Where some reasonable level of natural protection is present or where practical contingency measures are possible, the Ministry will actively consider an applicant's proposal for engineered facilities so that new technology can be field tested and proven.

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SCOPE OF THE TERM ENGINEERED FACILITY

This guideline applies to all engineered facilities associated with the control of contaminants produced from landfills that receive municipal and non-hazardous wastes. This includes the design, installation and maintenance of:

a) Liners, or combinations of liners beneath landfills (plastic, membrane, earth, clay, etc.)

b) Landfill covers, (plastic, membrane, earth, clay, etc.)

c) Leachate collection facilities (drains, tiles, ditches, etc.)

d) Gas collection, interception and venting facilities.

e) Monitoring facilities (for ground and surface waters and for gas)

f) Leachate treatment facilities

g) Facilities for the control of contaminated ground water (purge wells, grout curtains, etc.)

h) Facilities for "stabilizing" a landfill or decreasing the time during which the landfill produces contaminants.

This Guideline applies to the assessment of new landfills or landfills requiring expansion. Although some of the principles on which the Guideline is based are applicable to closed landfills or landfills requiring remedial measures for contaminant control, the Guideline itself is not intended to be applicable to them. They must be dealt with on a case-by-case basis.

GH/sf

April 21, 1988
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PUBLICATIONS CONT'D

Hughes, G.M., 1977, Groundwater contamination and its control. Proceedings of the 24th Ontario Industrial Waste Conference, Ontario Ministry of the Environment, p.224-256.

Hughes, G.M., 1977, Some hydrogeologic considerations in landfill site evaluation: Internal report, Ontario Ministry of the Environment, 26p.

Cartwright, K., C.S. Hunt, G.M. Hughes and R.D. Brower, 1979, Hydraulic potential in Lake Michigan bottom sediments: Journal of Hydrology, v. 43 (1979) p.67-78.

stabilization of contained sludges; evaluation of mobility and attenuation of contaminants in the subsurface, and evaluation of compatibility of native clay soils with organic and inorganic wastes.

Study of lime residue materials at former disposal area located on Fighting Island in the Detroit River. The loose saturated nature of the materials required development of specialized procedures for access and sampling. The samples were analyzed for priority pollutants and volatile organic contaminants. Specialized cleaning, sampling, handling, and quality control techniques were utilized to ensure the quality of the samples.

Review of application for expansion of Tricil Hazardous Waste Landfill, Sarnia, Ontario. A detailed review of hydrogeologic and design and operations documents for expansion of an existing hazardous waste landfill was conducted on behalf of a citizen's group. The review included presentation of expert witness testimony before the Environmental Assessment Board; including recommendations for changes to proposed site operation and monitoring procedures.

Hydrogeologic study, and preparation of design and operations report for proposed industrial landfill near Whitby, Ontario. An extensive hydrogeologic study was conducted for a proposed industrial landfill to contain automobile shredder wastes and bag house dust wastes from a major steel mill. The investigation consisted of detailed drilling, sampling, monitoring well installation, and geochemical characterization of leachate properties of the waste. Computer modelling of contaminant transport was conducted to assess requirements for future monitoring, and contingency measures. A design and operations report has been prepared for an application for landfilling.

Investigation of the rate of leachate production at a municipal landfill in Essex County was assessed using a water balance analysis, which was modified to suit site conditions. The model was verified by comparing predicted leachate production with existing production rates for the site. The model was further implemented to predict leachate production rates for a number of closure alternatives. Recommendations were presented for the most suitable alternative, and for appropriate design measures to minimize leachate production rates.

Review of hydrogeologic investigation and site suitability for Area IV Candidate Municipal Landfill, Brampton, Ontario, as part of Peel Area Waste Management study. The review consisted of inspection of field drilling procedures and results provided by other consultants; presentation and interpretation of results to local citizen's groups; and review and factual verification of reports submitted to the Region.

Review of hydrogeologic investigation for proposed site expansion, Albion Municipal Landfill, Caledon, Ontario. The review consisted of inspection of field drilling procedures and results provided by other consultants; presentation and interpretation of results to local citizen's groups; and review and factual verification of reports submitted to the Region.

Investigation of leachate production and control at Erindale Landfill, Mississauga, Ontario. A study of leachate production rates at a closed municipal landfill located in the Credit River valley was conducted. The study