LANDFILL STANDARDS:

A GUIDELINE ON THE REGULATORY AND APPROVAL REQUIREMENTS FOR NEW OR EXPANDING LANDFILLING SITES

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PREFACE

This Guideline describes the regulatory and approval requirements for the design, operation, closure and post-closure care of new or expanding municipal (i.e. non-hazardous) waste landfilling sites. The new regulatory requirements are contained in Ontario Regulation 232/98 made under the Environmental Protection Act. The new regulation takes effect on August 1, 1998.

The Guideline is intended to help landfill owners, consultants, the public and other interested parties understand the new requirements. The Guideline includes a description of the new regulatory requirements along with supporting approval guidelines for use when obtaining an Environmental Compliance Approval under the *Environmental Protection Act*.

The regulatory requirements are given in this Guideline for the convenience of the reader only. A copy of Regulation 232/98 should be obtained and used in conjunction with the Guideline.

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1.0 INTRODUCTION

An efficient and effective waste management program can best be achieved when an integrated approach is taken in the delivery of waste management services. Although the Ministry of the Environment continues to emphasize the 3Rs (Reduce, Reuse and Recycle), landfilling remains a necessary component of waste management -- whether to manage 3Rs residuals or to dispose of wastes which are not amenable to reuse or recycling. To ensure Ontario landfills are state-of-the-art and fully protective of the environment, comprehensive new landfill standards have been established by the Ministry.

Ontario Regulation 232/98 made under Part V of the *Environmental Protection Act* takes effect on August 1, 1998 and contains detailed requirements for the design, operation, closure and post-closure care of municipal (i.e. non-hazardous) waste landfilling sites. The new requirements apply to new or expanding landfilling sites where the total waste disposal volume of the site is greater than 40,000 cubic metres. The requirements do not apply to small sites (i.e. sites smaller than -- or equal to -- 40,000 cubic metres) or to existing sites which are not being expanded. For small and existing sites, the existing requirements under the Act and Regulation 347 remain in effect.

This Guideline has been prepared to help landfill owners, consultants, the public and other interested parties understand the new standards. For each standard, the Guideline gives the regulatory requirements and provides approval guidelines containing further information or details on issues to be addressed in complying with the regulation and obtaining an Environmental Compliance Approval.

Chapter 2 of the Guideline briefly describes the legislative framework within which the landfill standards operate and provides a summary of the new standards. The new standards are described in detail in the remaining chapters, as follows:

- **Chapter 3** - Application and Ownership
- **Chapter 4** - Design
- **Chapter 5** - Financial Assurance
- **Chapter 6** - Operations

Users of this Guideline should note that the regulatory requirements have been included here for convenience only. A copy of Regulation 232/98 should be obtained and used in conjunction with the Guideline.

2.0 LEGISLATION AND APPROVALS

2.1 Environmental Protection Act

In Ontario, landfilling sites and other waste management activities are subject to Part V of the Environmental Protection Act and the regulations made under the Act. The basic legislative framework for waste management is defined in Part V and the regulatory requirements for the design and operation of waste disposal sites are included in Regulation 347. For new or expanding landfilling sites, these regulatory requirements are superseded by Regulation 232/98.

Section 27 of the Act requires that an Environmental Compliance Approval be obtained from the Ministry of the Environment for the establishment, operation, alteration or enlargement of a landfilling site. To obtain approval for a new or expanding landfilling site, a detailed assessment of the site as required by Regulation 232/98 must be carried out to identify any potential effects on the environment and to show how these potential effects can be satisfactorily addressed. The basis for this assessment and the requirements for site design and operation are given in Regulation 232/98. The Environmental Compliance Approval process takes the landfill standards and refines them as necessary to reflect the particular setting and conditions at each landfill. The resulting Environmental Compliance Approval will define how large the site is to be, the types of waste to be accepted, and any necessary conditions for design and operation. The approval will also describe how the site is to be closed and the measures to be taken following closure to ensure the site is properly maintained and monitored for the long term protection of the environment.

2.2 Regulation 347

Regulation 347 is the general waste management regulation under Part V of the Environmental Protection Act. Regulation 347 provides definitions of waste management terms, defines different classes of waste, and provides standards for the design and operation of landfilling sites (other than new or expanding landfilling sites now covered by Regulation 232/98) and other waste management facilities. For existing and small municipal waste landfilling sites (i.e. sites less than -- or equal to -- 40,000 cubic metres), the existing requirements given in Section 11 of Regulation 347 remain in effect. Additional or more detailed requirements for waste sites and systems are addressed as appropriate through the Environmental Compliance Approval process.
Regulation 347 also defines when waste is considered hazardous or non-hazardous. Hazardous waste is defined by listing some specific wastes as being hazardous, and by identifying certain hazardous waste characteristics and tests. Non-hazardous waste is called “municipal” waste in Regulation 347. The new landfill standards in Regulation 232/98 only apply to sites accepting “municipal” waste.

2.3 Other Acts and Approvals

The focus of this Guideline is on the regulatory and approval requirements under Part V of the *Environmental Protection Act*. Landfilling sites, however, may also be subject to approval under the Environmental Assessment Act. Many landfill proposals, particularly larger sites may require approval under the *Environmental Assessment Act*. Under the *Environmental Assessment Act*, a broader view of the environment is taken and issues beyond the effects on the natural environment must be addressed. For a municipally owned landfilling site, Regulation 334 pursuant to the *Environmental Assessment Act* (EAA) identifies when a proposal is subject to EAA approval. For private sector landfills,

proposals are made subject to EAA requirements by being individually designated through regulation. Typically, sites larger than 40,000 cubic metres are designated, however, this may not always be the case. Once a landfill is subject to EAA approval, the decision to hold a public hearing and give approval for the undertaking rests with the Ministry. Regulation 101/07 under the *Environmental Assessment Act* also needs to be considered. This regulation defines what waste projects are subject to the EAA process.

2.4 Summary of the New Landfill Standards

The new landfill standards contained in Regulation 232/98 include requirements for design, operation, closure, post-closure care and financial assurance. The standards apply to all new or expanding municipal (i.e. non-hazardous) waste landfilling sites larger than 40,000 cubic metres. The new standards are effective on August 1, 1998 and cover issues such as:

- design specifications for groundwater protection including a **site specific design** option and two generic design options,
- mandatory **air emissions control** for sites larger than 3 million cubic metres,
- the assessment of groundwater and surface water conditions;
- design requirements for buffer areas, final cover design, surface water and landfill gas control, and the preparation of a **site design report**,
- operation and monitoring requirements for site preparation, groundwater and surface water **monitoring**, daily cover, record keeping and reporting,
- requirements for a leachate **contingency plan**,
- site closure and post-closure care provisions; and
- **financial assurance** requirements for private sector landfills.

The regulatory requirements concerning which sites the new standards apply to, the effective date of the Regulation, and the requirements for site ownership are described in Sections 3.1 and 3.2 of this Guideline. **Definitions** for certain terms used in the Regulation are included at the end of the Guideline.

The new standards are described in detail in Chapters 4.0 to 6.0 of this Guideline. For each of the standards, the Guideline describes the new **regulatory requirements** as given in Regulation 232/98 and provides additional information in the form of **approval guidelines** on the types of issues and details to be addressed through the Environmental Compliance Approval process. The approval guidelines in the Guideline complement the regulatory requirements and indicate the Ministry's expectations with respect to these matters. The use of approval guidelines allows the site specific aspects of landfill design and operation to be tailored to the conditions of the particular site.

3.0 APPLICATION AND OWNERSHIP

3.1 Application

The new landfill standards apply to new or expanding landfilling sites accepting municipal (i.e. non-hazardous) waste. The standards apply whether the site is owned by a municipality or a private landfill operator. The new standards do not apply to small landfills or to existing sites which are not being expanded. For purposes of the standards, a small landfill is considered to be a site with a total waste disposal volume of 40,000 cubic metres or less. For small or existing landfills, the existing requirements under Regulation 347 and the Environmental Protection Act (the Act) remain in effect. Once a site has received approval under the new standards, the site continues thereafter to be governed by these standards.

The new standards take effect on August 1, 1998. The standards do not apply to an application under Part 2.1 of the Act received by the Director prior to this date unless the landfill owner gives written notice asking that they apply. This notice must be provided prior to the issuance of the Environmental Compliance Approval or January 1, 1999, whichever comes first.

The regulatory requirements defining which landfilling sites are affected by the new standards and when the standards take effect are given in Sections 2 and 33 of Regulation 232/98, and are as follows:

Application

2. (1) This Regulation applies to the following landfilling sites:

1. *Every landfilling site that comes into existence on or after August 1, 1998 and that is intended at the time it comes into existence to have a total waste disposal volume of more than 40,000 cubic metres and to accept only municipal waste for disposal.*
2. *Every landfilling site for which an alteration, enlargement or extension is proposed on or after August 1, 1998 that involves an increase in the site's total waste disposal volume, if the site is intended after the alteration, enlargement or extension to have a total waste disposal volume of more than 40,000 cubic metres and to accept only municipal waste for disposal.*

(2) Subsection (1) does not apply with respect to a landfilling site in respect of which an application for a Certificate of Approval has been received by the Director under Part V of the Act before August 1, 1998, unless the operator or owner of the landfilling site gives written notice to the Director that the operator or owner wants this Regulation to apply.

(3) The notice under subsection (2) must be given before the earlier of the following dates:

1. *The date the* Environmental Compliance Approval *or provisional approval is issued.*
2. *January 1, 1999.*

(4) The standards, procedures and requirements set out in this Regulation do not apply to the extent that terms and conditions set out in a Environmental Compliance Approval.

Commencement
33. This Regulation comes into force on August 1, 1998.

3.2 Ownership

The party responsible for the landfilling site as discussed in Regulation 232/98 must have sufficient control of the site to ensure any necessary monitoring, maintenance, environmental control or remedial activities can be carried out to protect the environment. As a result, the applicant or holder of the Environmental Compliance Approval as required by Regulation 232/98 must own the entire site, including the waste fill area and the buffer area, unless the site is located on Crown land. In other cases, however, where additional land adjacent to a site is needed for the attenuation of contaminants (i.e. leachate or landfill gas), a Contaminant Attenuation Zone may be acceptable. To establish a Contaminant Attenuation Zone, the landfill owner must acquire property rights to use the adjacent land for purposes including contaminant attenuation, monitoring and remediation as required by Regulation 232/98. These rights must be held for the contaminating life span of the site.

The regulatory requirements concerning ownership of landfilling sites and Contaminant Attenuation Zones are given in Sections 3, 4 and 5 of Regulation 232/98 and are as follows:

Landfilling Site

3. The holder of an Environmental Compliance Approval for a landfilling site must own the entire site in fee simple, unless the site is on Crown land.

Contaminant Attenuation Zone

4. (1) If a contaminant attenuation zone is necessary for proper operation of a landfilling site, the holder of an Environmental Compliance Approval *for the landfilling site must own property rights respecting the contaminant attenuation zone, unless,*

(a) the contaminant attenuation zone is on Crown land and the Crown has agreed in writing to the use of the land for that purpose; or
(b) the contaminant attenuation zone is on a public road and the road authority has agreed in writing to the use of the land for that purpose.

(2) The holder of the Environmental Compliance Approval must continue to own the property rights for all of the contaminating life span of the site.

(3) The ownership of the property rights must include the right to,
(a) discharge contaminants from the landfilling site into the contaminant attenuation zone;
(b) enter into the contaminant attenuation zone and onto the surface above the contaminant attenuation zone for purposes of testing, monitoring, intercepting contaminants and carrying out remedial work;
(c) install, operate and maintain works, for the purposes mentioned in clause (b), in or above the contaminant attenuation zone, including on the surface above the contaminant attenuation zone; and

(d) prevent the owner of the land in which the contaminant attenuation zone is located from paving, erecting a structure or making any use of land above or in the vicinity of the contaminant attenuation zone that would interfere with the functioning of the contaminant attenuation zone or with the exercise of any of the rights mentioned in this subsection.

Changes

5. The holder of an Environmental Compliance Approval or the applicant for an Environmental Compliance Approval for a landfilling site shall notify the Director in writing within 30 days after any change in his, her or its identity or status or any change in ownership of the site or ownership of property rights in the contaminant attenuation zone.

Contaminant Attenuation Zones are also discussed in Section 4.2 of this Guideline.

4.0 DESIGN

4.1 Design Specifications

Regulation 232/98 was created to ensure that New or Expanding Landfilling Sites are:

- Are designed for groundwater and surface water protection;
- Minimize impacts to the environment from site operations; and
- To facilitate site closure and post-closure care.

To accomplish these goals, Regulation 232/98 requires that a report be prepared containing plans and specifications on the design of the site. The design report must address matters such as:

- the proposed site boundaries, buffer area, waste fill area and contours, surface water control works, on-site roads and structures, and final cover design,
- the design of any liner and leachate collection system or landfill gas control works needed for the site,
- monitoring facilities for groundwater, leachate and surface water,
- a contingency plan for leachate control, and
- site closure and post-closure care requirements.

The regulatory requirements for preparing a landfill design report and the issues to be addressed are described in Subsection 4.1.1 of this Guideline.
In addition to the regulatory requirements described in Subsection 4.1.1, there are a number of other separate landfill standards dealing with specific aspects of landfill design as required by Regulation 232/98 which must be addressed. These other standards provide additional details on issues such as groundwater protection, surface water control, and subsurface migration of landfill gas. Where reference is made in these other standards to the preparation of a written report, the written report can be combined, as appropriate, with the design report described in Subsection 4.1.1. These other standards are dealt with in Sections 4.2 to 4.14 of this Guideline.

4.1.1 Regulatory Requirements

Regulation 232/98 requires that a design report be prepared for a landfilling site. This requirement is given in Section 6 of the Regulation and is as follows:

Design Specifications

6. (1) A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report has been prepared in accordance with this section.

(2) The report must describe the design of the landfilling site and must contain,

(a) a legal survey of the site;

(b) an up to date plan and description of the site and the area within 500 metres of the site that covers,

(i) all property and property boundaries,

(ii) all buildings, roads and utility corridors,

(iii) land contours, surface water drainage, water bodies, rights-of-way and other easements,

(iv) forested areas,

(v) land uses and land use designations, and

(vi) property conditions not otherwise covered in subclauses (i) to (v);

(c) detailed plans, specifications and descriptions for the design of the site, including,

(i) a plan and description of the waste fill area, base contours for waste disposal, base contours for any leachate collection system, top contours for waste disposal and top contours with final cover,

(ii) the total waste disposal volume,

(iii) a materials balance between the sources of soils, on or off the site, and the uses of soils on the site,

(iv) a hydrogeological assessment of the suitability of the site for the landfilling of municipal waste that considers the geologic and hydrogeologic conditions of the site, the design of the site and the monitoring and contingency plans,

(v) a geotechnical assessment of the suitability of the site for the landfilling of municipal waste that considers bearing capacity, differential settlement and slope stability during construction, operation and after closure, and that addresses the potential effects on any liner or leachate collection system,

(vi) a description of the expected quality and quantity of leachate,

(vii) detailed plans, specifications and descriptions of any liner system necessary to control leachate, including construction and quality assurance and quality control procedures for the liner materials and liner system installation,

(viii) detailed plans, specifications and descriptions of any leachate collection, treatment and disposal system necessary to control leachate, including construction and quality assurance and quality control procedures for the system components and system installation,

(ix) an assessment of the potential for subsurface migration of landfill gas at the site and of any control system necessary for monitoring or controlling the migration,

(x) detailed plans, specifications and descriptions of any system necessary for controlling landfill gas by venting it or by collecting and burning or using it, including construction and quality assurance and quality control procedures for the system components and system installation,

(xi) an assessment of the potential impacts on surface water features that may be caused by the site or operations at the site,

(xii) detailed plans, specifications and descriptions of the system for collecting, directing and discharging surface water, including details of any sediment control or other features and including construction, quality assurance and quality control procedures for the system components and system installation,

(xiii) detailed plans, specifications and descriptions of monitoring facilities for leachate, ground water, surface water and, where appropriate, landfill gas,

(xiv) an assessment of potential noise impacts due to operations at the site and to local trucking related to operations at the site, including an evaluation of any proposed noise control measures,

(xv) an assessment of potential visual impacts on nearby properties due to the site and site operations,

(xvi) detailed plans, specifications and descriptions of the buffer area and ancillary facilities, including any screening, landscaping, fencing, weigh scales, buildings, structures, access roads, internal roads, holding areas for cover material, holding areas for rejected waste or materials for recycling, and other holding areas,

(xvii) detailed plans, specifications and descriptions of the contaminant attenuation zone, if one is necessary,

(xviii) an estimate of the contaminating life span of the site with respect to contaminants involved in the subsurface migration of landfill gas and an estimate of the service life of any engineered facilities associated with the subsurface migration of landfill gas,

(xix) an estimate of the contaminating life span of the site with respect to contaminants in leachate, unless a new landfilling site is being established and the design for ground water protection features of the site meets the criteria set out in subsection 10 (4) or (5),

(xx) an estimate of the service life of every engineered facility associated with leachate, which may be specified as the service life provided for in Schedule 1, 2, 3 or 4 if the engineered facility meets the relevant conditions set out in that Schedule,

(xxi) details of any facilities intended to control or change the contaminating life span of the landfilling site,

(xxii) contingency plans that can be implemented to control and dispose of leachate produced in a quantity greater than expected or with a quality worse than expected, including specifications and descriptions in sufficient detail to demonstrate the feasibility of the plans,

(xxiii) contingency plans that can be implemented to control and dispose of landfill gas migrating in the subsurface in a quantity greater than expected or with a quality worse than expected, including specifications and descriptions in sufficient detail to demonstrate the feasibility of the plans,

(xxiv) a description of the source, nature and quality of daily cover, including, with respect to material not normally used for daily cover, a discussion of its benefits and limitations, a description of quality assurance and quality control procedures for daily cover and a description of application rates and application procedures for daily cover, including the frequency and timing of application of daily cover if other than at the end of each working day,

(xxv) a description of the nature, quality and quantity of final cover, including construction details and quality assurance and

quality control procedures for the materials to be used and their installation,

(xxvi) a site closure plan, including details of the proposed end use of the site, the appearance of the site after closure, revegetation, landscaping, the construction of new facilities, and the removal of existing facilities to facilitate closure, post-closure care and site end use, and

(xxvii) a summary of the main characteristics of the landfilling site, including the maximum daily quantity of waste that will be accepted for disposal, the estimated annual average quantity of waste that will be accepted for disposal, the area of the landfilling site, the area of the waste fill area, the total waste disposal volume, the estimated waste disposal capacity in tonnes, any subcategories of municipal waste that are not expected to be received or that will not be accepted for disposal, and the estimated date of site closure.

4.1.2 Approval Guidelines

As described in Subsection 4.1.1 above, Regulation 232/98 requires the preparation of a landfill design report and identifies the issues which are to be addressed. All the design features are typically discussed and shown in this report to show the features readily confirm that the design will be acceptable and its construction will be practical. Final, detailed construction plans and specifications would normally be dealt with through conditions of approval and not be required prior to the issuance of an Environmental Compliance Approval.

More detailed provisions dealing with specific aspects of landfill design are described separately in Sections 4.2 to 4.14 of this Guideline.

4.2 Buffer Area

The buffer area is the green belt or zone located on the site between the waste fill area and the site boundaries. The buffer area allows for contaminant attenuation and provides space around the perimeter of the waste area in which various monitoring, maintenance and environmental control activities can take place. The regulatory requirements for the minimum size of the buffer area are described in Subsection 4.2.1 of this Guideline. Additional information on the buffer area is included in the approval guidelines given in Subsection 4.2.2.

4.2.1 Regulatory Requirements

Regulation 232/98 sets a minimum requirement for the size of the buffer area at a landfilling site. This requirement is given in Section 7 of the Regulation and is as follows:

Buffer Area

7. (1) The owner and the operator of a landfilling site shall ensure that the waste fill area is completely surrounded by buffer area in accordance with this section.

(2) The buffer area shall be at least 100 metres wide at every point.

(3) Subsection (2) does not apply to a buffer area if the buffer area is at least 30 metres wide at every point and a written report confirms that,

(a) the buffer area provides adequate space for vehicle entry, exit, turning, access to all areas of the site and parking;

(b) the buffer area provides adequate space on the surface of the site for all anticipated structures, equipment and activities; and

(c) the buffer area is sufficient to ensure that potential effects of the landfilling operation do not have any unacceptable impact outside the site.

(4) For the purpose of clause (3) (c), potential effects include surface runoff, litter, vectors, vermin, leachate, subsurface migration of landfill gas and aesthetic effects.

4.2.2 Approval Guidelines

A buffer area provides space around the perimeter of the waste area in which contaminant attenuation may occur, and various monitoring, maintenance and environmental control activities can take place. The buffer area may contain a site access road, site services and buildings, groundwater monitoring wells, landscaping and visual screening. The regulatory requirements described in Subsection 4.2.1 specify a 100 metre wide buffer area, but allow this to be reduced to not less than 30 metres if shown to be appropriate based on a site specific assessment. A minimum 30 metre buffer area has been established to ensure there is sufficient site access for site monitoring, maintenance and remedial measures.

As discussed in Section 3.2 of this Guideline, unless the site is located on Crown land, the landfill owner as required by Regulation 232/98 must own the entire landfilling site including the waste fill area and the buffer area. In some cases, however, additional land adjacent to the on-site buffer area may be needed for leachate or landfill gas attenuation. This off-site land is defined as a Contaminant Attenuation Zone and the landfill owner as required by regulation 232/98 must acquire the rights to use this land for purposes such as contaminant attenuation, monitoring and remediation. Ownership of these rights would have to be registered on title for the property containing the Contaminant Attenuation Zone. Contaminant Attenuation Zones are dealt with in Section 3.2 of this Guideline.

4.3 Hydrogeological Assessment

An assessment of the hydrogeologic setting of a landfilling site is necessary to properly design the site, and to ensure the site can be effectively monitored and an acceptable contingency plan can be developed. Regulation 232/98 includes a basic requirement that the geologic and hydrogeologic conditions of the landfilling site be assessed. The regulatory requirement is included in Subsection 4.3.1 of this Guideline. A more detailed description of the type of information typically included in the assessment, the kinds of analyses which are typically undertaken, and the issues typically addressed is included in the approval guidelines given in Subsection 4.3.2. The approval guidelines address both the regional area in which the site is located, and the detailed study of site conditions. For the detailed site study, the assessment deals with matters such as those detailed in Table 1.

Table 1: Hydrogeological Assessment Requirements

Item No.	*Task*
i.	the drilling of boreholes and obtaining samples to characterize soil or bedrock conditions at the site.
ii.	the measurement of groundwater levels and pressures to define groundwater flow characteristics.
ii.	the collection of groundwater samples to assess groundwater quality.
iv.	the interpretation of collected data including the preparation of site and piezometric contour plans, the determination of groundwater flow paths and contaminant attenuation capabilities, and the identification of any unstable soils or geologic conditions.
v.	an assessment of the suitability of the site for landfilling with respect to the design, monitoring and contingency plan requirements.

A hydrogeological assessment is required for all landfilling sites including sites which are to be designed in accordance with the generic designs (refer to Section 4.5 of this Guideline) specified in the Regulation. Although the generic designs are fully protective of groundwater quality, a hydrogeological assessment is needed to ensure that the conditions for use of the generic designs are present, and to ensure that effective groundwater monitoring and leachate contingency plans can be developed for the site. A good understanding of the geologic and hydrogeologic conditions of a site is also needed for site construction purposes.

4.3.1 Regulatory Requirements

Regulation 232/98 requires that the geologic and hydrogeologic conditions of a landfilling site be assessed. This requirement is given in Section 8 of the Regulation and is as follows:

Hydrogeological Assessment

8. (1) A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report on the geologic and hydrogeologic conditions of the site and ground water protection for the site has been prepared in accordance with this section.

(2) The report must contain,

(a) plans, specifications and descriptions of the geologic and hydrogeologic conditions of the site and the area in which the site is located; and

(b) an assessment of the suitability of the site for the landfilling of municipal waste, taking into account,

(i) the design of the site, including existing features and features that will be implemented to control the expected production of leachate and the expected subsurface migration of landfill gas,

(ii) regional and site specific geologic and hydrogeologic conditions,

(iii) the ability to identify future impacts on the ground water by monitoring,

(iv) the feasibility of contingency plans that can be implemented to control leachate produced in a quantity greater than expected or with a quality worse than expected, and

(v) the feasibility of contingency plans that can be implemented to control landfill gas migrating in the subsurface in a quantity greater than expected or with a quality worse than expected.

4.3.2 Approval Guidelines

The objectives of a hydrogeological assessment are to: determine the physical, hydraulic and chemical properties of the surficial materials (and bedrock where appropriate); define groundwater flow characteristics and potential contaminant plume migration pathways; determine the structural integrity of the subgrade to support the landfill (including its construction) and any overlying facilities; determine the availability and suitability of the soil for cover and liner uses; establish a groundwater monitoring network; and determine the feasibility of the contingency plans for contaminant control. The following guidelines provide a more detailed description of the information and analytical needs, and the types of issues which are typically addressed in the assessment.

The hydrogeological assessment of a landfilling site typically includes a discussion on the information identified in Table 2:

Table 2: Hydrogeological Assessment Submission Information

Item No.	Task
a.	A general description of the geologic and hydrogeologic conditions of the (regional) area in which the site is located. This description should include a description of the stratigraphy, groundwater quantity and quality, groundwater movement, and should characterize the significance of groundwater resources and the use made of these resources.
b.	A detailed description of the geologic and hydrogeologic conditions occurring at the site based on a detailed investigation of the site which establishes soil, rock and groundwater conditions, including: (i) the drilling of boreholes hydraulically upgradient and hydraulically downgradient of the potential waste fill area and in other locations, including areas adjacent to the site where necessary, to a depth and in a manner sufficient to: ▪ provide soil samples of a number and type to adequately characterize the thickness and nature of soil units underlying the site; ▪ provide soil samples of a number and type for laboratory analysis of physical and/or chemical properties; ▪ permit, as necessary, the geological and/or geophysical logging of boreholes;

	▪ permit installation, as necessary, of groundwater monitoring facilities; ▪ permit other tests of soil and/or borehole properties, as necessary; and ▪ permit testing of bedrock properties, as necessary; (ii) the use of drilling, coring, drive-points, test pitting, trenching and/or other means of soil excavation/sample extraction to obtain representative samples of soil and/or rock for the testing of soil and/or rock properties and chemistry/quality; (iii) the installation in boreholes of groundwater monitoring facilities in a manner appropriate for the collection of groundwater samples or the measurement of groundwater levels or hydraulic pressures representative of the hydrostratigraphic units at the site; (iv) the development and purging of groundwater monitoring facilities, as necessary, in a manner and over a period of time sufficient to ensure that water level/hydraulic pressure data collected in the groundwater monitor and/or groundwater samples collected from the groundwater monitor are representative of hydrogeologic conditions at the site; (v) the collection, in a manner which ensures data are representative of a sufficient number of measurements of groundwater level/hydraulic pressure in groundwater monitoring facilities to confirm, as necessary: ▪ that the groundwater monitor is functioning properly; and ▪ attainment of static water level; and to establish, as necessary, ▪ differences in water level/hydraulic pressure both laterally and vertically at the site; (vi) the collection of groundwater samples from groundwater monitoring facilities in a manner that ensures these samples are in a sufficient number and over a sufficient period of time to establish the potential seasonal and/or spatial/depth variability of groundwater chemistry/quality; (vii) the analysis of groundwater samples from groundwater monitoring facilities for the parameters listed in Schedule 5, column 1, unless alternative parameters are considered more appropriate; and (viii) the use of pumping tests, slug tests and other procedures, as necessary, to measure the in-situ permeability of geologic materials at the site;
c.	An interpretation of the results of the detailed investigation of the site, including the following plans, specifications and descriptions under existing conditions, during site construction and operation, and following site closure:

	(i) a contour plan of the ground surface, showing surface watercourses and bodies of surface water, if any; (ii) a contour plan of the water table, showing expected directions of groundwater movement; (iii) piezometric contour plans for each aquifer, showing expected directions of groundwater movement; (iv) a description of any aquifers and their interconnection, with generalized estimates of groundwater flow; (iv) a description of the background quality of the groundwater, and the existing and potential uses of the groundwater; (v) site plans and cross sections of the hydrogeologic conditions; (vi) the identification of any unstable soils or unstable bedrock; (vii) a description of the flow velocity and volumetric flow rate in the aquifers; (ix) a water balance analysis considering precipitation, surface water drainage, infiltration, groundwater flow, exfiltration and evapotranspiration; and (x) the potential flow paths and contaminant attenuation capabilities in the event leachate leaves the waste fill area in planned or unplanned quantities.
d.	An assessment of the suitability of the site for waste disposal purposes considering the regional and site specific geologic and hydrogeologic conditions, the design of the site, the monitoring of potential groundwater impacts, and the contingency plans for the control of leachate and landfill gas.

4.4 Surface Water Assessment

The assessment of the surface water conditions on and in the vicinity of a landfilling site, and of any surface water features which are to receive a discharge from the site is an important part in determining the suitability, design and monitoring requirements for the site. As described in Subsection 4.4.1 below, Regulation 232/98 includes a basic requirement that a surface water assessment be carried out. Further details on the type of information typically obtained and the analyses to be performed are included as approval guidelines in Subsection 4.4.2. The approval guidelines address matters such as:

- a description of the area (watershed) in which the site is located and the surface water features nearby the site,
- a detailed investigation and description of the surface water conditions on the site and any surface water features receiving a direct discharge from the landfilling site,
- a water quality assessment program, based on an extensive list of monitoring parameters, and

- an assessment of the suitability of the site for landfilling.

4.4.1 Regulatory Requirements

Regulation 232/98 requires that the surface water conditions at and in the vicinity of a landfilling site be assessed. This requirement is given in Section 9 of the Regulation and is as follows:

Surface Water Assessment

9. (1 A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report on the surface water conditions of the site and surface water protection for the site has been prepared in accordance with this section.

(2) The report must contain,

(a) plans, specifications and descriptions of the surface water features on the site, the surface water features that will receive a direct discharge from the site and the surface water features of the area in which the site is located; and

(b) an assessment of the suitability of the site for the landfilling of municipal waste, taking into account,

(i) the design of the site, including existing features and features that will be implemented to control the expected production of leachate, the flow of surface water, and erosion and sedimentation resulting from the flow of surface water,

(ii) the surface water features on the site, the surface water features that will receive a direct discharge from the site and the surface water features of the area in which the site is located,

(iii) the ability to identify future impacts on the surface water features by monitoring, and

(iv) the feasibility of contingency plans that can be implemented to control surface water impacts resulting from the production of leachate in a quantity greater than expected or with a quality worse than expected.

4.4.2 Approval Guidelines

The objectives of the surface water assessment are to: define existing surface water conditions on and in the vicinity of the site; determine the potential effects of surface water coming onto the site; determine the potential effects of runoff discharging from the site; and establish a surface water monitoring network. The following guidelines provide further details on the information and analytical needs, and the types of issues which are typically addressed in the assessment.

The surface water assessment for a landfilling site typically includes a discussion on the information in identified in Table 3:

Table 3: Surface Water Assessment

Item No.	Task
a.	A general description of the surface water features of the area (watershed) in which the site is located.
b.	A description of the surface water features occurring within 500 m of the waste fill area of the site. This description should be based on contributing and receiving drainage, catchment, subwatershed or watershed areas that are sufficiently large to allow an assessment of the range and extent of potential effects. The description should include a description of surface water features such as flood plains, natural watercourses and water bodies, municipal drains, drainage paths and boundaries.
c.	A detailed surface water investigation to assess water quality, quantity and habitat conditions of the surface water features identified on the site, any surface water features flowing through the site, and any surface water features that are to receive a surface water discharge from the site, including: (i) a surface water quantity program to assess current streamflow conditions, including low flow characteristics and stream-aquifer interaction, that includes periodic measurements of streamflow; (ii) a surface water quality program to assess current surface water quality to establish seasonal variations over a period of one year, with surface water samples obtained: ▪ once for any compounds known to be commonly in industrial or agricultural use in the proposed site's watershed to assess whether any of these should be included in the surface water monitoring program; ▪ semi-annually and analyzed for the parameters listed in Schedule 5, column 3; and ▪ on six other occasions analyzed for the parameters listed in Schedule 5, column 4; and unless alternative parameters and frequencies are considered more appropriate. (iii) a benthic community inventory where considered appropriate based on factors such as the location, sensitivity or use of the surface water feature.
d.	An interpretation of the results of the detailed surface water investigation of the site, any surface water features flowing through the site, and any surface water features that are to receive a direct discharge from the site, including: (i) plans showing all existing surface water features; (ii) a description of current surface water quality, and the existing and proposed surface water uses, including: ▪ a summary of sampling results; ▪ a review of data available from other sources, including the Ministry's provincial surface water quality monitoring network for any stations upstream or downstream of the site; (iii) a detailed hydrologic assessment of the surface water features, including:

	▪ changes to the frequency, magnitude and duration of streamflow at key locations entering, passing through and discharging from the site; ▪ changes to surface water flood levels within watercourses entering, passing through and discharging from the site that have an upstream drainage area greater than 125 ha; ▪ changes to average annual water budgets, including evapotranspiration, infiltration, surface runoff and groundwater recharge/discharge volumes expressed over the site area and the contributing drainage area; and ▪ changes to temperature and average annual sediment loading to receiving watercourses at key locations discharging from the site. (iv) the potential leachate flow paths and location of any intersection with surface water features within 500 m of the waste fill area.
e.	An assessment of the suitability of the site for waste disposal purposes considering the area in which the site is located, on-site and receiving surface water features, the design of the site, and the contingency plan for the control of leachate.

4.5 Design Criteria for Groundwater Protection

Groundwater protection is fundamental to good landfill design. Groundwater is often the primary source of rural and urban water supply, and may be a significant contributor to streamflow. Preventing groundwater contamination is particularly important because of the difficulty and cost of restoration. Once contaminated, it may take many years to cleanup groundwater.

Regulation 232/98 includes two approaches for designing a landfill to protect groundwater quality. The first approach, called site specific design, allows the proponent to design the landfill to suit the local environmental setting provided the Ministry's Reasonable Use limits for groundwater protection are met at the property boundary. The second approach allows the proponent to select one of two generic designs which have been specified in the standards. The generic designs have been developed such that they will meet Reasonable Use limits within a broad range of hydrogeologic settings, as defined for their use.

Reasonable Use Guideline

To protect groundwater resources, landfills must be designed to meet stringent contaminant limits in accordance with the Ministry's Reasonable Use Guideline (1994) as described in Section 10 of Regulation 232/98. The Reasonable Use Guideline establishes limits for the allowable concentrations of contaminants based on background groundwater quality and the reasonable use of groundwater on adjacent property. The limits are set such that there would not be any significant effect on the use of the groundwater on the adjacent property.

As the reasonable use of groundwater is commonly drinking water, the Reasonable Use limits are typically set on this basis. As a result, the quality of groundwater may not be degraded by an amount in excess of:

- 50% of the difference between background and the Ontario Drinking Water Objectives for non-health related parameters (e.g. chloride), or
- 25% of the difference between background and the Ontario Drinking Water Objectives for health related parameters (e.g. lead).

In cases where the reasonable use of groundwater is other than drinking water, for example where background groundwater quality is poor, the Reasonable Use Guideline allows alternative concentration limits to be set. These alternative limits would be determined on a case-by-case basis.
The Reasonable Use Guideline has been incorporated in Regulation 232/98. The Reasonable Use requirements have been included directly as performance specifications for the site specific design approach, and have been incorporated in the development of the two generic designs.

Site Specific Design
The site specific design approach included in the Regulation gives the site owner flexibility to design the landfilling site to suit the local environmental setting, provided the Reasonable Use limits for groundwater protection are met. This is a performance based standard with the acceptability of a design judged on its ability to meet the Reasonable Use limits at the property boundary. The Regulation specifically sets out how these limits are determined, on the basis that groundwater is used for drinking purposes, but allows for the setting of other limits in other circumstances. Under this approach, a proponent may design a natural attenuation site, or an engineered site which incorporates a liner and leachate collection system. To obtain approval for the design, sufficient information on the site setting and the performance of the design as required in Regulation 232/98 must be presented to show that the Reasonable Use limits will be met.
To assist with site specific design, the Regulation also includes design criteria such as:

- identification of the chemical parameters to be used in design,
- waste and leachate characteristics for the identified parameters,
- decay constants (i.e. half-lives) for the organic parameters, and
- the service lives which can be used in design for certain liner and leachate collection systems.

These design criteria may be used in the design of a municipal waste landfilling site. A site which has been properly designed using these criteria will fully protect groundwater quality. Use of these criteria, however, is not mandatory and a proponent may use alternative design criteria where they can be shown to be appropriate. For example, alternative criteria may be more appropriate for the landfilling of a particular industrial waste, or for a site located in a geographic area where more representative leachate data is available. Design criteria have been included in the landfill standards as tools to help in landfill design. The criteria are not intended to prevent proponents from obtaining and using other, more representative criteria if they wish.

Generic Design Options
The Regulation includes two generic design options which incorporate specific liner and leachate collection system designs. To ensure the generic designs can be used within a broad range of hydrogeologic settings, the designs have been developed such that the Reasonable Use limits for groundwater protection will be met without reliance on contaminant attenuation in the landfill buffer area. In a hydrogeologic setting where

there is significant natural groundwater protection, the level of engineering in the generic designs may not be necessary and the site specific design approach could be followed. Similarly, a site specific design could be undertaken where it can be shown that the design criteria for the proposed site (e.g. the expected leachate characteristics) are different from those given in the Regulation. The advantage of using the generic designs is the added certainty they bring to the approval process.

The two generic design options differ with respect to their level of engineering and the quantity of waste which they can accommodate. The double composite liner design (i.e. Generic Design Option II) allows a greater quantity of waste to be deposited at a particular site, but the level of engineering is greater. Where less complex engineering is desired and the site area is large enough to accept the total quantity of waste to be deposited, a proponent may wish to use the single composite liner design (i.e. Generic Design Option I). The choice between the two designs will depend on the particular circumstances of the proposal.
A schematic view of a landfill incorporating the generic design approach is shown in Figure 1. The components of the two generic designs are shown in Figures 2 and 3, and are as follows:

a. Generic Design Option I - Single Liner

This generic design (shown in Figure 2) consists of the following components:

- a single composite liner consisting of a 1.5 millimetre (60 mil) thick high density polyethylene (HDPE) geomembrane liner, over a 0.75 metre thick compacted clayey liner;
- a natural, or constructed, 3 metre thick attenuation layer below the single composite liner; and
- a leachate collection system above the composite liner,
- provided the infiltration rate through the landfill cover is greater than or equal to 0.15 metres per year, and the maximum waste loading is no greater than the amount shown in Table 5 for the background chloride concentration for the site.

b. Generic Design Option II - Double Liner

This generic design (shown in Figure 3) consists of the following components:

- two composite liners with:
    - a primary (upper) liner consisting of a 1.5 millimetre (60 mil) thick high density polyethylene (HDPE) geomembrane liner over a 0.75 metre thick compacted clayey liner; and
    - a secondary (lower) liner consisting of a 2 millimetre (80 mil) thick high density polyethylene (HDPE) geomembrane liner over a 0.75 metre thick compacted clayey liner.
- a natural, or constructed, 1 metre thick attenuation layer below the lower composite liner; and

- two leachate collection systems with the first located above the upper composite liner, and the second located between the upper and lower composite liners,

provided the infiltration rate through the landfill cover is greater than or equal to 0.15 metres per year, and the maximum waste loading is no greater than the amount shown in Table 5 for the background chloride concentration for the site.

The generic designs have been developed using contaminant transport modelling to assess performance of the liner and leachate collection systems relative to meeting the Ministry's Reasonable Use limits. Input parameters (design criteria such as waste and leachate characteristics) used in the computer modelling were the same as those included in the Regulation and referred to above under Site Specific Design.

Figure 1: Generic Design Approach

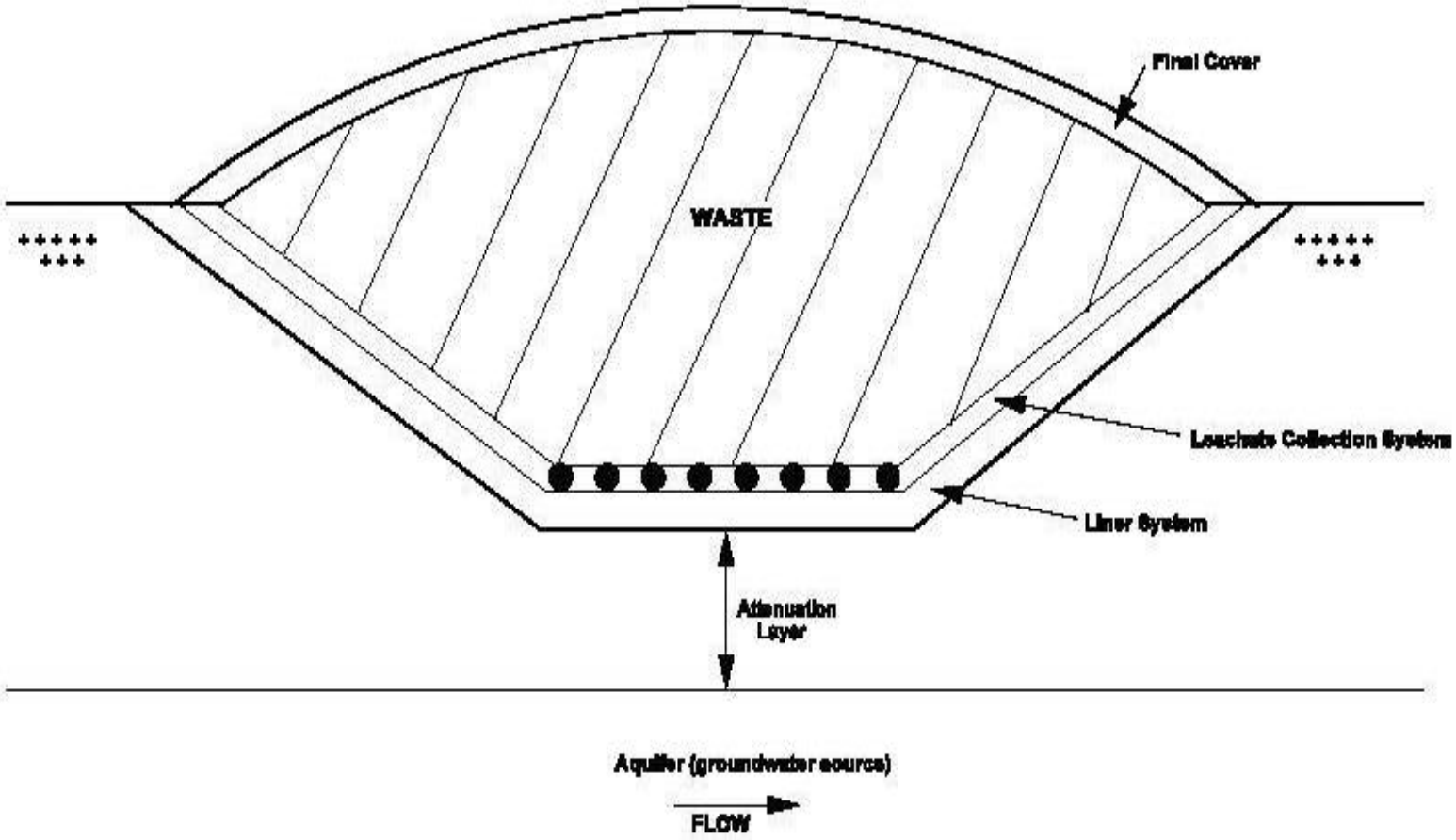


Figure 2: Generic Design Option I Single Composite Liner

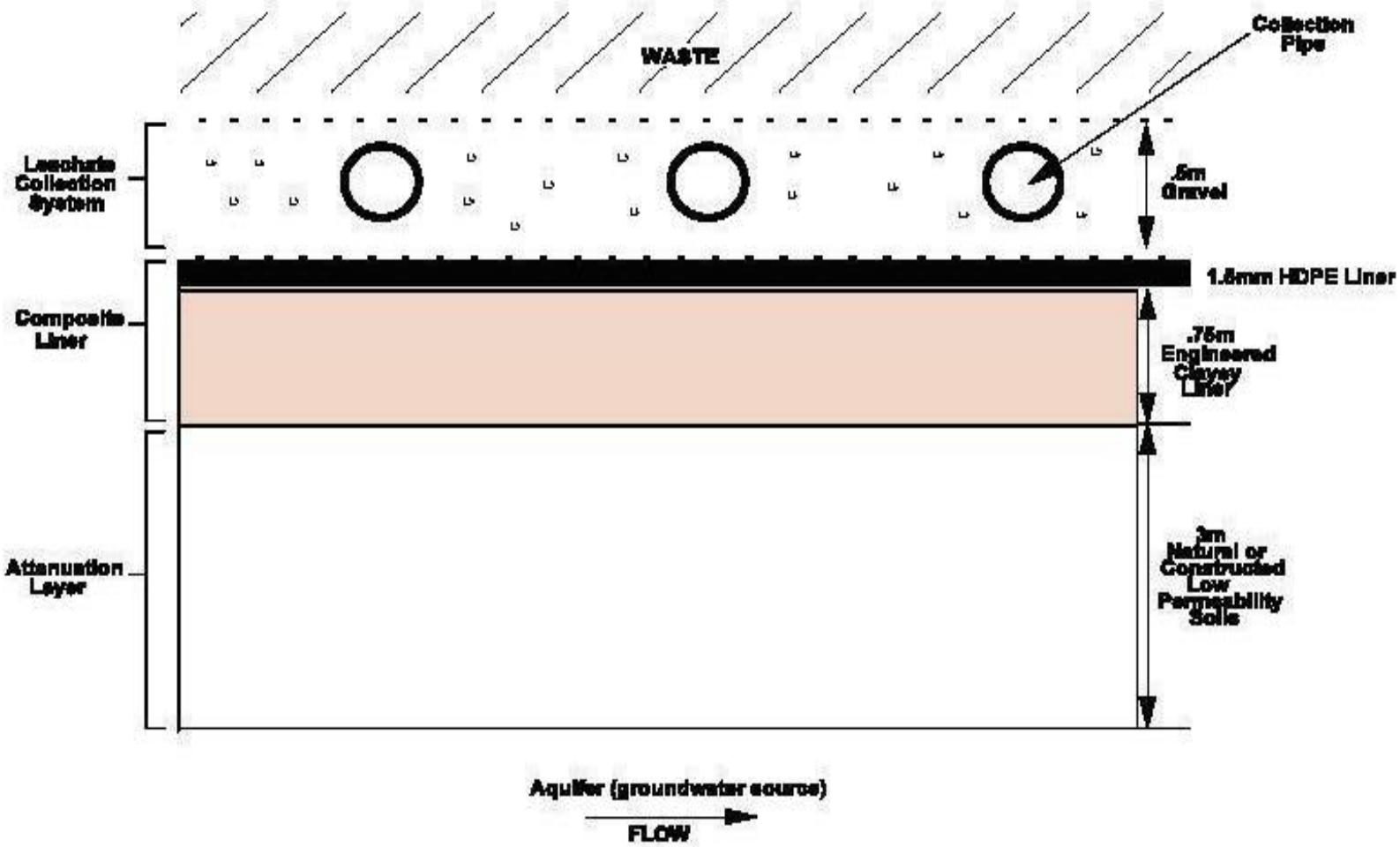
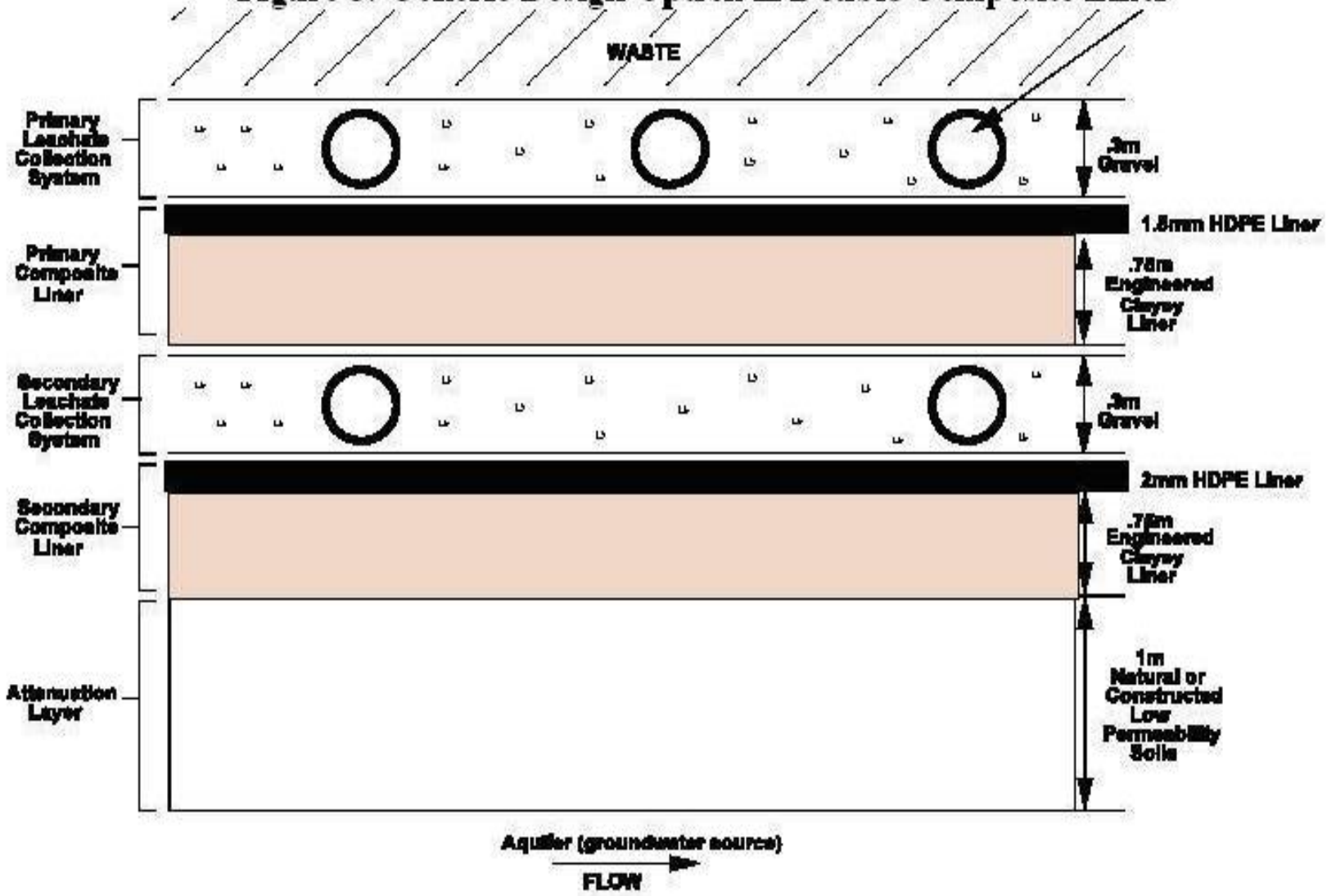


Figure 3: Generic Design Option II Double Composite Liner



4.5.1 Regulatory Requirements

Regulation 232/98 includes two approaches to landfill design, either of which may be used for groundwater protection. The site specific design approach allows the owner to design the landfill to suit the local environmental setting provided the Ministry's Reasonable Use limits are met. The generic design approach allows the owner to use one of two generic designs specified in the standards. The site specific and generic design approaches are given in Section 10 of the Regulation and are as follows:

Ground Water Protection

10. (1) A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report describing the design for the ground water protection features of the site has been prepared in accordance with this section.

(2) The design for the ground water protection features of the site must,

(a) if a new landfilling site is being established, meet the criteria set out in subsection (3), (4) or (5); or

(b) if the total waste disposal volume of an existing landfilling site is being increased, meet the criteria set out in subsection (3).

[Site Specific Design]

(3) The design for the ground water protection features of a landfilling site complies with subsection (2) if it meets the following criteria:

1. *The objective of the design must be that the site will not cause the concentration of any contaminant listed in Column 1 of Table 4 to exceed the maximum allowable concentration for the contaminant in the ground water at any point on any adjacent property.*

2. *For the purpose of paragraph 1, the maximum allowable concentration for a contaminant shall be determined in accordance with the following formula:*

   Cm = Cb + X(Cr - Cb),
   where,
   Cm is the maximum allowable concentration for the contaminant,
   Cb is the background concentration of the contaminant in the ground water of the receptor aquifer,
   Cr is the health related drinking water objective for the contaminant or the aesthetic drinking water objective for the contaminant, whichever is applicable, as set out in column 5 or 6 of Table 4, and
   X is,

   (a) 0.25, if Cr is a health related drinking water objective, or

   (b) 0.50, if Cr is an aesthetic drinking water objective.

3. *The initial source concentration, mass as a proportion of total (wet) mass and half-life in leachate set out in Columns 2, 3 and 4 of Table 4 must be used for the purposes of evaluating the design with respect to the objective set out in paragraph 1.*

4. *The design must consider both advective and diffusive contaminant transport and must include examination of the effect of the failure of any engineered facilities when their service lives are reached.*

5. *A service life set out in Schedule 1, 2, 3 or 4 for an engineered facility may be used for the purpose of evaluating the design with respect to the objective set out in paragraph 1 if the relevant conditions set out in that Schedule are met.*

6. *Despite paragraphs 1, 2 and 3, if it is appropriate because of the nature of the waste or because the reasonable use of the ground water on the adjacent property is other than for drinking water, the Director may,*

    i. *for the purposes of evaluating the design with respect to the objective set out in paragraph 1,*

        A. *require or permit the use of values specified by the Director for Cr and X in the formula set out in paragraph 2, instead of the values set out in that paragraph, and*
        B. *require or permit the use of an initial source concentration, mass as a proportion of total (wet) mass or half-life in leachate specified by the Director instead of the initial source concentration, mass as a proportion of total (wet) mass or half-life in leachate set out in Column 2, 3 or 4 of Table 4, or*

    ii. *require or permit the objective of the design to be based in whole or in part on contaminants other than those listed in Column 1 of Table 4 and, for the purpose of evaluating the design with respect to that objective,*

        A. *require or permit the use of values specified by the Director with respect to each of the other contaminants for Cr and X in the formula set out in paragraph 2, and*
        B. *require or permit the use of an initial source*

            concentration, mass as a proportion of total (wet) mass or half-life in leachate specified by the Director with respect to each of the other contaminants.

[Generic Design Option I - Single Liner]

(4) The design for the ground water protection features of a new landfilling site that is being established complies with clause (2) (a) if it meets the following criteria:

1. *The maximum waste loading for any given background concentration of chloride in the ground water of the receptor aquifer must not be*

more than the value set out for that concentration in Column 1 of Table 5.

2. *The infiltration rate through the final cover of the landfilling site must be greater than or equal to 0.15 metres per year.*
3. *There must be, at the base of the waste fill zone, a natural or engineered layer of soil in which attenuation of contaminants from the wastes in the site may take place and that meets the following conditions:*
   - i. *The layer must be at least three metres thick.*
   - ii. *The layer must consist of material that is relatively homogeneous.*
   - iii. *The layer must have a hydraulic conductivity less than or equal to 1×10^{-7} metres per second.*

4. *The waste fill zone must have a ground water protection system above the attenuation layer referred to in paragraph 3 and below the waste consisting of, from bottom to top,*
   - i. *a primary liner consisting of,*
     - A. *a clayey liner at least 0.75 metres thick that meets the conditions set out in Schedule 4 for an unlimited service life, has a hydraulic conductivity of not more than 1×10^{-9} metres per second, and has an organic carbon content of at least 0.1 per cent, and*
     - B. *a high density polyethylene (HDPE) geomembrane liner at least 1.5 millimetres thick that meets the conditions set out in Schedule 3 for a 150 year service life, and*
   - ii. *a primary leachate collection system that meets the conditions set out in Schedule 1 for a 100 year service life.*

[Generic Design Option II - Double Liner]

(5) The design for the ground water protection features of a new landfilling site that is being established complies with clause (2) (a) if it meets the following criteria:

1. *The maximum waste loading for any given background concentration of chloride in the ground water of the receptor aquifer must not be more than the value set out for that concentration in Column 2 of Table 5.*

2. *The infiltration rate through the final cover of the landfilling site must be greater than or equal to 0.15 metres per year.*

3. *There must be, at the base of the waste fill zone, a natural or engineered layer of soil in which attenuation of contaminants from the wastes in the site may take place and that meets the following conditions:*

i. The layer must be at least one metre thick.
ii. The layer must consist of material that is relatively homogeneous.
iii. The layer must have a hydraulic conductivity less than or equal to 1×10^{-7} metres per second.

4. The waste fill zone must have a ground water protection system above the attenuation layer referred to in paragraph 3 and below the waste consisting of, from bottom to top,

i. a secondary liner consisting of,

A. a clayey liner at least 0.75 metres thick that meets the conditions set out in Schedule 4 for an unlimited service life, has a hydraulic conductivity of not more than 1×10^{-9} metres per second, and has an organic carbon content of at least 0.1 per cent, and
B. a high density polyethylene (HDPE) geomembrane liner at least 2.0 millimetres thick that meets the conditions set out in Schedule 3 for a 350 year service life,

ii. a secondary leachate collection system that meets the conditions set out in Schedule 2 for a 1000 year service life,

iii. a primary liner consisting of,

A. a clayey liner at least 0.75 metres thick that meets the conditions set out in Schedule 4 for an unlimited service life, has a hydraulic conductivity of not more than 1×10^{-9} metres per second, and has an organic carbon content of at least 0.1 per cent, and

B. high density polyethylene (HDPE) geomembrane liner at least 1.5 millimetres thick that meets the conditions set out in Schedule 3 for a 150 year service life, and
iv. a primary leachate collection system that meets the conditions set out in Schedule 1 for a 60 year service life.

[Background Concentration]

(6) For the purpose of this section, the background concentration of a contaminant in the ground water of the receptor aquifer is the median value for that contaminant based on all ground water samples taken from the receptor aquifer in accordance with the following rules:

1. At least five samples must be taken.
2. The samples must be taken at or near the site boundary where the potential impact is being examined.
3. The samples must not be taken from locations known to be or likely to be contaminated by human activity.

TABLE 4: Leachate Characteristics (Regulation Section 10)					
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Contaminant	Initial Source Concentration (mg/L)	Mass as a Proportion of Total (wet) Mass of Waste (mg/kg)	Half-Life in Leachate (years)	Health Related Drinking Water Objective (mg/L)	Aesthetic Drinking Water Objective (mg/L)
1. Benzene	0.02	0.014	25	0.005	n/a
2. Cadmium	0.05	0.035	n/a	0.005	n/a
3. Chloride[1] 150,000 t/ha increasing to 250,000 t/ha	1,500 increasing to 2,500	1,800	n/a	n/a	250
4. Lead	0.6	0.42	n/a	0.01	n/a
5. 1,4 Dichloro-benzene	0.01	0.007	50	n/a	0.001
6. Dichloro-methane	3.3	2.3	10	0.05	n/a
7. Toluene	1	0.7	15	n/a	0.024
8. Vinyl Chloride	0.055	0.039	25	0.002	n/a

Notes:

1. The initial source concentration of chloride is taken to vary linearly between 1,500 and 2,500 milligrams per litre with maximum waste loading between 150,000 and 250,000 tonnes per hectare.
2. Half-lives may be used in considering a decrease in source concentration with time and for estimating the contaminating life span.

TABLE 5 Maximum Waste Loadings for Generic Design Options (Regulation Section 10)		
Background Chloride Concentration (mg/L)	Maximum Waste Loading (m^3/ha)	
	Column 1	Column 2
	Single Liner Design Option (Subsection 10(4))	Double Liner Design Option (Subsection 10(5))
0	98,500	287,000
10	100,500	295,500
20	102,500	299,500
30	104,000	303,000
40	106,000	307,000
50	107,500	310,500
60	109,000	314,000
70	110,500	317,500
80	112,000	321,500
90	113,500	325,000
100	115,000	328,500
110	117,000	332,000
120	118,500	335,500
130	120,000	339,000
140	121,500	343,000
150	123,500	346,500
160	125,000	350,000
170	126,500	353,500
180	128,000	357,000
190	129,500	360,500
200	131,000	363,500
210	132,500	366,500
220	134,500	370,000
230	136,000	373,000
240	137,500	376,000
250 or more	139,000	380,000

Note: If the Background Chloride Concentration falls between two values in Table 5, the appropriate limiting value shall be interpolated from the values in Column 1 or 2, whichever applies. These values are considered to vary linearly with the values for chloride.

4.5.2 Approval Guidelines

The regulatory requirements for groundwater protection are described above in Subsection 4.5.1. Both the site specific and generic design approaches incorporate the Ministry's Reasonable Use limits and will ensure groundwater is protected. The Reasonable Use limits have been included directly into the specifications for the site specific design approach and were used in the development of the two generic designs. Regardless of which design approach is followed, a hydrogeological assessment (refer to Section 4.3 of this Guideline) is required by Regulation 232/98. In site specific design, a hydrogeological assessment is needed to determine what type of design is appropriate -- whether the site is to be a natural attenuation site, or an engineered site which incorporates a liner and leachate collection system. For the generic designs, although the designs will protect groundwater quality, a hydrogeologic assessment is still necessary to ensure that the conditions for use of the designs are met (i.e. attenuation layer and background chloride concentration). In both the site specific and generic design cases, a good understanding of the geologic and hydrogeologic setting is needed to ensure that effective groundwater monitoring and leachate contingency plans can be developed, and for site construction purposes.

Where a generic design is to be used, an owner must show how the generic design features (as discussed in Section 6 of Regulation 232/98) are to be incorporated in the design of the particular landfill (i.e. given the varying site sizes, depths, base side slopes, etc.). For example, the single composite generic design incorporates a primary leachate collection system which has a 100 year design service life. This collection system is expected to require replacement by some alternative system, such as a perimeter leachate collection system, to control leachate mounding and prevent leachate breakout at surface. For the double composite generic design, which incorporates a 60 year primary collection system, similar provisions would have to be made. Considerations such as these typically are addressed in the design report required for the site (refer to Section 4.1 of this Guideline).

For planning post-closure care activities for a site utilizing the single or double composite generic design, the contaminating life span for leachate impact on groundwater (based on the minimum infiltration rate of 0.15 metres per year) is 160 years and 360 years, respectively. By this time, the geomembrane(s) are assumed to have failed and the discharge rate through the compacted clayey liner(s) at the base of the site equals the infiltration rate (i.e. 0.15 metres per year) through the final top cover. The landfill can then be allowed to discharge passively into the groundwater environment.

4.6 Groundwater Protection System

As described in Section 4.1 of this Guideline, Regulation 232/98 requires that a design report be prepared for the site. The design report is to contain plans and specifications on the design of any liner or leachate collection system to be used for groundwater protection. A detailed description of the type of information to be provided on the liner and leachate collection system design is included in the approval guidelines given in Subsection 4.6.2 below. The information to be provided as required by Regulation 232/98 covers issues such as the site foundation, bottom liners (i.e. compacted clay, geomembrane, or geosynthetic clay liners), leachate collection systems, and construction quality control and assurance procedures.

4.6.1 Regulatory Requirements

The regulatory requirement to prepare plans and specifications for the groundwater protection system is included in the Design Specifications requirements in Section 6 of Regulation 232/98 as described in Section 4.1 of this Guideline.

4.6.2 Approval Guidelines

Information on the groundwater protection system as required by Section 10 of Regulation 232/98 must be included in the design report required for a landfilling site (refer to Section 4.1 of this Guideline). The following guidelines provide a detailed description of the information which is typically discussed in the reports.
Irrespective of whether the groundwater protection system is designed in accordance with the site specific design approach or using one of the two generic designs (refer to Section 4.5 of this Guideline), where a liner or leachate collection system is to be constructed at a site, Regulation 232/98 requires the report on the design specifications for the site to include a discussion on the following plans, specifications and descriptions:

a. Foundation and Clayey Liner Design

For the site foundation, and any clayey liner which is to be constructed at the site, the report typically discusses the information detailed in Table 6a:

Table 6a: Foundation and Clayey Liner Design

Item No.	Information
i.	A description of the foundation design and materials of construction, including a discussion of the capability of the foundation to support any expected static and dynamic loadings.
ii.	Data showing fluctuations in the depth of the water table and the seasonal high and low watertable in relation to the foundation or liner system.
iii.	Sufficient data to evaluate the engineering properties of the foundation and, if proposed, the clayey liner materials. This should include data relating to the Atterberg limits, organic carbon content, grain size distribution, mineralogy, strength, hydraulic conductivity, compressibility and, when appropriate, compaction curves. The report should also clearly indicate other parameters used by the designer (e.g., diffusion coefficients, partitioning coefficients [Koc], effective porosity, any other parameter used in the design or analysis) and provide data and/or references supporting the choice of these parameters.
iv.	To address the issue of clay/leachate compatibility, data showing that there will be no significant increase in hydraulic conductivity or reference given to tests that have been conducted on soil that is mineralogically similar using a leachate similar to that anticipated for the site.
v.	Engineering analyses, based on the data gathered through subsurface exploration and laboratory testing programs, that provide:

	▪ estimates of the total and differential settlement, including immediate settlement and primary and secondary consolidation, with particular attention paid to any maintenance holes; ▪ estimates of the bearing capacity and stability of the foundation which demonstrate that the allowable bearing capacity will not be exceeded, with particular attention paid to any maintenance holes; ▪ estimates of the potential for bottom heave or blow-out due to hydrostatic or gas pressures; ▪ evidence that the foundation is capable of providing adequate support for operating and construction equipment; ▪ evidence that the side slopes of the landfill will be stable at all times during and following construction (this includes the side slopes to the base of the landfill as well as the cover) allowing for all possible failure mechanisms (including the potential for sliding within or between any layers in any liner, leachate collection system and gas collection system).
vi.	A description of construction and installation procedures. If a compacted clayey liner is proposed, include details regarding the control of compaction water content, lift thickness, equipment to be used, scarification between lifts, limits on clod size, removal of stones, and procedures to avoid desiccation of the clayey liner. Liner test sections should be constructed to develop and confirm construction procedures.
vii.	A description of the inspection, monitoring, sampling and testing methods and frequencies to be employed to assure that the foundation and, where present, liner(s) meet the design requirements.
viii	A description of any soil additives that are proposed, the concentrations to be added and the methods that will be used to mix and spread the material.

b. Geomembrane Liner

If a geomembrane liner is proposed, the information in Table 6b is also typically discussed in the report:

Table 6b: Geomembrane Liner

Item No.	Information
i.	A description of the proposed geomembrane (type, thickness, texture, etc.).
ii.	The design requirements and technical specifications for the geomembrane (e.g. thickness, density, melt index, carbon black dispersion, tensile properties, tear

	resistance, puncture resistance, stress crack resistance, Oxidative Induction Time (both initial OIT and OIT after oven aging at 85 degrees C for 90 days), and ultraviolet resistance).
iii.	Requirements for delivery, storage, installation and sampling of the geomembrane.
iv.	Calculations of the physical stress, including those due to: ▪ differential settlement of the foundation soils; ▪ strain requirements at the anchor trench; and ▪ strain requirements over long, steep side slopes;
v.	A statement on the chemical compatibility of the liner, (other than a high density polyethylene (HDPE) liner) and the leachate, and cite the basis for the statement.
vi.	A description of how the short-term stresses such as equipment traffic during installation and thermal effects during construction and operation will be taken into account. The liner must be able to withstand the stresses resulting from application of the protection layer placed between the liner and the leachate collection system.
vii.	A demonstration that there will be adequate friction between the components of the liner system so that slippage and sloughing does not occur on the slopes of the facility. Specifically, using design equations, evaluate: ▪ the ability of the geomembrane to support its own weight on the side slopes; ▪ the ability of the geomembrane to withstand down-drag during and after waste placement; ▪ the suitability of the anchorage configuration for the geomembrane; and ▪ the stability of any protection layer above the geomembrane.
viii.	Installation specifications, including details regarding: ▪ visual inspection of the suitability of the subgrade; ▪ methods of dealing with thermal expansion and contraction that will prevent impairment of the geomembrane's service life; ▪ methods of protecting the geomembrane during shipping, storage and handling; ▪ deployment of the geomembranes at the construction site (include a panel layout plan), seam preparation, seaming methods, seaming temperature

	constraints; ▪ Procedures to be adopted to prevent desiccation of the underlying compacted clayey liner during and subsequent to the placement of the geomembrane.
ix.	Inspection activities, including both non-destructive and destructive quality control field testing of sheets and seams during installation of the geomembrane. Describe how the following will be taken into account: ▪ ambient temperature at which seams are made; ▪ relative humidity; ▪ control of panel uplift by wind; ▪ wrinkles; ▪ effects of cloud cover and direct sunlight on geomembrane temperature; ▪ water content of the subsurface beneath the geomembrane; ▪ supporting surface on which the seam is bonded; ▪ skill of the seaming crew; ▪ quality and consistency of the chemical or welding material; ▪ proper preparation of the liner surfaces to be joined; and ▪ the cleanliness of the seam interface (e.g., amount of airborne dust).
x.	A specification for liner strength and the calculations defining the minimum strength requirement considering: ▪ internal and external pressure gradients; ▪ stresses resulting from settlement, compression or uplift; ▪ climatic conditions; ▪ installation stresses; and ▪ operating stresses.
xi.	A specification for the geomembrane protection layer that will be placed between the geomembrane and the leachate collection system, including the method of placement.

c. Geosynthetic Clay Liner (GCL)

If a geosynthetic clay liner (GCL) is proposed for a site specific design, the information in Table 6c is typically discussion in the report:

Table 6c: Geosynthetic Clay Liner

Item No.	Information
i.	A description of the proposed GCL including sufficient data to evaluate the engineering properties of the GCL. This should include data relating to Atterberg limits, organic carbon content, mineralogy, shear strength, hydraulic conductivity and hydrated thickness under field stress conditions (based on tests with a permeant with a chemical composition similar to the expected landfill leachate). The hydraulic conductivity tests supporting the design hydraulic conductivity must have been conducted on samples hydrated to simulate expected field hydration and permeated with a sufficient number of pore volumes of permeant such that either (a) the concentration of the parameter in the effluent chemistry exceeded 90% of that in the influent, or (b) it exceeds the number of pore volumes that could reasonably pass through the GCL during the contaminating life span of the landfill (whichever is less). The report should also clearly indicate other parameters used by the designer (e.g., diffusion coefficients, partitioning coefficients [Koc], effective porosity, any other parameter used in the design or analysis) and provide relevant data and/or references (i.e., for similar conditions) supporting the choice of these parameters.
ii.	A description of construction and installation procedures. Identify how the GCL will be hydrated in the field and provide installation specifications including details regarding: ▪ visual inspection of the suitability of the subgrade; ▪ methods of protecting the GCL during shipping, storage and handling; and ▪ deployment of the GCL at the construction site (include a panel layout plan), seam preparation, seaming methods. Indicate how opening of seams (due to movement as overlaying layers are placed) will be avoided.
iii.	A description of the inspection, sampling and testing methods and frequencies to be employed to assure that the GCL meets the design requirements.
iv.	Demonstrate that there will be adequate shear strength both within the GCL and between the GCL and other components of the liner system so that slippage and sloughing does not occur on the slopes of the facility.

d. Leachate Collection System

If a primary or secondary leachate collection system is proposed, the information in Table 6d is typically discussed in the report:

Table 6d: Leachate Collection System

Item No.	Information
i.	A description of the proposed leachate collection system, including estimated leachate flows, drainage layer design, any pipe network and the leachate removal system.
ii.	Design specifications, calculations and descriptions of design and operational measures that demonstrate that the leachate collection system either meets the requirements of Schedules 1 and 2 or will provide the service life and leachate head control assumed in the assessment of groundwater impact for a site specific design b assessment of groundwater impact for a site specific design by addressing: ▪ the gradation (nominal diameter, uniformity coefficient, silt content), drainage path length, thickness normal to leachate drainage, surface grades of the landfill base, leachate compatibility, biological/chemical clogging potential and hydraulic conductivity of the granular drainage materials; ▪ the long-term transmissivity under final loads, biological/chemical clogging potential and leachate compatibility of any geosynthetic drainage layers; ▪ the geotextile or graded granular filter/separator between the waste and the drainage medium; and ▪ the material, internal diameter, wall thickness, perforation size and location and spacing, flow capacity, structural capacity (wall crushing, pipe deflection, critical buckling pressure), access for cleaning, and the inspection and cleaning schedule of any collection pipes;y addressing.
iii.	A demonstration that the side slopes of the leachate collection system will be stable. Specifically, using design equations, evaluate: ▪ the stability of the granular drainage materials on the underlying soil or geomembrane; ▪ the stability between the components of any geosynthetic drainage layer (geotextiles, geonets) and between the geosynthetic drainage layer and the underlying soil or geomembrane; ▪ the ability of any geosynthetic drainage layer to support its own weight on the side slopes; ▪ the ability of any geosynthetic drainage layer to withstand down-drag during and after waste placement; ▪ the suitability of the anchorage configuration for the geosynthetic drainage layer; and ▪ the stability of any filter/separator layer above the geosynthetic drainage layer.
iv.	Installation specifications, including details regarding: ▪ equipment used in granular drainage layer placement; ▪ methods to control granular drainage layer thickness; ▪ bedding depth for any collection pipes; ▪ method of joining collection pipes; ▪ method of placement and seaming, if any, of geosynthetic drainage layers; and ▪ method of placement of any filter/separator layer above the drainage layer.

e. Construction Quality Control and Assurance

The report typically includes a discussion on the quality assurance plan that addresses both construction material quality control (CQC) and construction quality assurance (CQA), as they pertain to (as applicable) the information discussed in table 6e below.

Table 6e: Construction Quality Control and Assurance

Item No.	Information
i.	the foundation
ii.	compacted clayey liners
iii.	geosynthetic clay liners
iv.	avoiding desiccation of the compacted clayey liner prior to placement of waste over each part of the liner system
v.	geomembrane liners
vi.	protection layers for geomembrane liners
vii	leachate collection systems
viii.	filter/separator layers for leachate collection systems

This plan may include a discussion on the specification of the test methods to be adopted, the frequency of sampling, the use of blind samples, the acceptable range of data and the procedures to be adopted in the event that the data does not satisfy the specifications. A discussion on the rationale behind the plan is typically included in the report.
The CQC/CQA plan typically describes in detail the responsibilities of the construction quality control officer as they pertain to the information identified in Table 6f:

Table 6f: Quality Control Officer Responsibilities

Item No.	Information
i.	Communicating with the contractor.
ii.	Interpreting and clarifying project drawings and specifications with the designer, owner and contractor.
iii.	Recommending acceptance or rejection by the owner/operator of work completed by the construction contractor.
iv.	Submitting blind samples (e.g., duplicates) for analysis by the quality control laboratory and one or more independent laboratories.
v.	Notifying the owner/operator of construction quality problems not resolved on-site in a timely manner.
vi.	Observing the testing equipment, personnel and procedures used by the

	construction contractor to check for detrimentally significant changes over time.
vii	Monitoring compliance with the procedures necessary to avoid desiccation of the compacted clayey liner prior to placement of waste over each part of the liner system.
viii.	Reviewing the quality control records, maintenance summary, and interpretation of test data for accuracy and appropriateness.
ix.	Reporting to the owner/operator on monitoring results.

4.7 Leachate Disposal

Where a site has been designed to collect leachate, the collected leachate must be managed and disposed of in an appropriate manner as required in Regulation 232/98. Typically, leachate disposal would involve discharge to an existing sewage works, either by discharge to a sewer or by hauling it to the sewage treatment plant, or would involve on-site treatment and discharge of the treated effluent to a surface water body. Pre-treatment of leachate may be necessary for discharge to an existing sewage works. As described in Subsection 4.7.1, Regulation 232/98 includes a basic requirement that a report be prepared on the management and disposal of any collected leachate. A more detailed description of the issues to be addressed and the type of information typically provided is included in the approval guidelines given in Subsection 4.7.2.

4.7.1 Regulatory Requirements

Regulation 232/98 requires that a report be prepared describing the procedures for disposal of any leachate collected at a landfilling site. This requirement is given in Section 11 of the Regulation and is as follows:

Leachate Disposal

11. A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report containing plans, specifications and descriptions for the management and disposal of any leachate collected at the site has been prepared.

4.7.2 Approval Guidelines

Where a site has been designed to collect leachate, the leachate management and disposal plans for the site typically include discussions on the information listed in Table 7:

Table 7: Leachate Disposal

Item No.	Information
a.	The handling, treatment and discharge of leachate directly to a waterbody such that the plans, specifications and descriptions provide a level of detail sufficient to demonstrate the feasibility of obtaining approval under the *Ontario Water Resources Act*; or

b.	the handling, treatment and discharge of leachate into an existing sanitary sewer, sewage works or system approved under the *Ontario Water Resources Act*, including: (i) the location and owner of the sanitary sewer, if any, and the sewage works; (ii) the transportation or piping of leachate to the sanitary sewer or sewage works; (iii) the acceptance criteria for discharge to the sanitary sewer, if any, and the sewage works; (iv) an assessment of the impact on the sanitary sewer, if any, the sewage works, the effluent discharge and sewage residue from the sewage works, and the receiving waterbody based on the expected quality and quantity of leachate to be discharged; (v) any treatment required prior to acceptance of the leachate; and (vi) the written agreement of the owner of the sanitary sewer, if any, and the sewage works for acceptance of the leachate.

4.8 Leachate Contingency Plans

A contingency plan is an organized set of procedures for identifying and reacting to an unexpected, but possible, occurrence. The development of a leachate contingency plan is particularly important in landfill design because of the potential for long term leachate impacts on groundwater and surface water. A leachate contingency plan includes the establishment of a predictive monitoring program, the setting of trigger levels for investigation and response activities, and the description of the contingency measures to be carried out. In developing the contingency plan, a sufficient level of detail as described in Regulation 232/98 must be provided to demonstrate its feasibility and practicality, particularly the ability to adequately monitor and predict potential impacts, and to implement effective remedial actions. For a leachate contingency plan, a good understanding of the hydrogeologic setting of the site is therefore a necessity.

As part of the contingency plan, trigger criteria for investigative activities as required by Section 12 of Regulation 232/98 should be established to identify contaminant increases above background, above any predicted impacts (considering temporal and spatial variations), and above the maximum allowable concentrations at property boundary (i.e. the Reasonable Use limits). Where there is a contaminant increase above a predicted concentration (or the maximum allowable concentration), the contingency plan should be reviewed and the necessary implementation procedures should be described as detailed in Regulation 232/98. Should continued monitoring and investigation indicate the Reasonable Use limits will be exceeded at the property boundary, the contingency measures would have to be implemented.

In the case of a landfilling site designed to protect groundwater in accordance with a generic design, the standard allows the landfill owner to delay establishing a full predictive monitoring program (i.e. contaminant attenuation modelling, setting predictive triggers, etc.) until such time as the monitoring devices located near the waste fill area indicate the site has had an impact on background groundwater concentrations. Once background concentrations have been impacted, contaminant modelling and a full predictive monitoring program would have to be established.

The regulatory requirement to develop a leachate contingency plan is included in Subsection 4.8.1 of this Guideline. The approval guidelines given in Subsection 4.8.2 identify the types of contingency measures and issues which should be considered when developing the plan.

4.8.1 Regulatory Requirements

Regulation 232/98 requires that a leachate contingency plan be developed for a landfilling site and identifies the issues to be addressed. These requirements are given in Sections 12 and 27 of the Regulation and are as follows:

Leachate Contingency Plans

12. (1) A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report containing plans, specifications and descriptions for a leachate contingency plan for the site has been prepared in accordance with this section.

(2) The report must contain the following:

1. A description of the contingency measures, including the collection of leachate that would be carried out, if necessary, if a liner or leachate collection system fails or if leachate otherwise leaves the waste fill zone in a quantity greater than expected or with a quality worse than expected.

2. A statement of the maximum allowable concentrations for contaminants in the ground water at any point on any adjacent property and in any surface water feature on the site.

3. A description of the ground water monitoring stations to be used to identify potential increases in contaminant concentrations in the ground water beneath the site and predict potential increases at the property boundary and in any surface water feature on the site before any increases occur.

4. A discussion of the basis on which the monitoring stations referred to in paragraph 3 will be brought into service, indicating that stations near the waste fill area will be brought into service not later than the date that placement of the waste begins.

5. A description of the trigger criteria for initiating investigative activities into the cause of an increase in contaminant concentrations in ground water and in any surface water feature on the site, indicating that the criteria relate to the magnitude of the increase in contaminant concentrations or the magnitude of the rate of increase in contaminant concentrations.

Leachate Contingencies

27. (1) The owner and the operator of the landfilling site shall ensure that investigative activities are carried out with respect to the cause of an increase in contaminant concentrations if any of the trigger criteria described under paragraph 5 of subsection 12 (2), as they may have been modified under paragraph 2 of subsection (3) of this section, is exceeded for any single monitoring event.

(2) The owner and the operator of the landfilling site shall ensure that the steps described in subsection (3) are taken if the investigative activities required by subsection (1) indicate that,

(a) the potential exists for a liner or leachate collection system to fail or for leachate to otherwise leave the waste fill zone in a quantity greater than expected or with a quality worse than expected;

(b) the potential exists to exceed any maximum allowable contaminant concentration described under paragraph 2 of subsection 12 (2);

(c) an expected contaminant level predicted by studies and modelling previously carried out under paragraph 4 of subsection (3) has been exceeded; or

(d) the highest previous observation of the background concentration of a contaminant in the ground water of the receptor aquifer has been exceeded, if studies and modelling have not previously been carried out under paragraph 4 of subsection (3).

(3) The steps referred to in subsection (2) are the following:

1. *Previously identified contingency measures must be reviewed and any necessary or desirable modifications made.*
2. *Previously identified trigger criteria must be reviewed and any necessary or desirable modifications made.*
3. *The monitoring programs for ground water, surface water and leachate must be reviewed and any necessary or desirable modifications made.*
4. *If they have not previously been carried out, studies and modelling that meet the following conditions must be carried out:*
   - *i. The studies and modelling must provide predictions of expected contaminant concentrations at least annually for the contaminating life span of the site.*
   - *ii. The studies and modelling must include predictions related to potential increases in contaminant concentrations in the ground water at the property boundary and in any surface water feature on the site, as well as at any ground water monitoring stations.*
5. *If studies and modelling described in paragraph 4 have previously been carried out, they must be reviewed and any necessary or desirable modifications made.*
6. *Implementation criteria for implementation of the contingency measures must be identified and the related activities and timing must be described.*

(4) If the monitoring results, investigative activities and implementation criteria indicate the need to implement contingency measures, the owner and the operator of a landfilling site shall ensure that the following steps are taken:

1. *The Director must be notified of the need to implement contingency measures.*
2. *Detailed plans, specifications and descriptions for the design, operation and maintenance of the contingency measures must be prepared.*
3. *The contingency measures must be implemented.*

4.8.2 Approval Guidelines

Regulation 232/98 requires that a leachate contingency plan be prepared for a landfilling site. The plans and specifications for the leachate contingency plan typically include discussions on the assessment of the following contingency measures listed in Table 8:

Table 8: Leachate Contingencies

Items No.	Contingency Measure
a.	The construction of purge wells or other system into the waste or within the buffer area to collect leachate or contaminated groundwater, such that the impact on adjacent properties will be in accordance with the Ministry's Reasonable Use Guideline (1994), or to control leachate mounding within the site. The handling, treatment and disposal of the collected leachate or groundwater should be described. Where purge wells are the method of leachate removal, the contingency plan should provide calculations of the number of wells likely to be required, the expected well spacing, the level of leachate mound control that can be realistically expected, and the potential impact on groundwater levels and uses. For leachate removal from within the waste, and in the absence of data, the hydraulic conductivity of the waste should be based on k = 1 x 10-6 m/s for waste depths of 10 m or less, k = 1 x 10-7 m/s for waste depths of 10 - 30 m, and k = 1 x 10-8 m/s for waste depths of 30 - 50 m. The landfill proponent should develop and support values for waste depths exceeding 50 m.
b.	The provision of an alternative water supply to adjacent and any other properties in the vicinity of the site that may be affected by the release of leachate into the groundwater in an amount in excess of the amount defined for the site in accordance with the Ministry's Reasonable Use Guideline (1994) or by the contingency plan (e.g. reduction in groundwater levels).
c.	Any other works or activities to protect human health and the environment that may be appropriate based on the design and hydrogeologic setting of the site.

4.9 Surface Water Control

Surface water control at a landfilling site is necessary to ensure drainage onto or leaving the site does not adversely affect site operations, on-site surface water or surface water in the vicinity of the site. As required by Section 13 of Regulation, where there is a potential for on-site surface drainage to become contaminated, measures should be taken to collect, test, and if necessary, treat the collected drainage.

Regulation 232/98 requires that a landfilling site be designed to protect surface water and specifies performance standards which are to be met. The regulatory requirements are included in Subsection 4.9.1 of this Guideline. A more detailed description of the issues to be addressed and level of protection to be provided is included as approval guidelines in Subsection 4.9.2. The approval guidelines deal with matters such as:

- a site drainage plan showing existing natural conditions, and conditions during and following site operation,
- the conveyance and separation of off-site surface water, clean on-site runoff, and potentially contaminated on-site runoff,
- the design of any sedimentation ponds, and

- the design of any temporary or permanent erosion control measures.

4.9.1 Regulatory Requirements

Regulation 232/98 requires that landfilling sites be designed to control surface water impacts and sets out the performance criteria for this control. These requirements are given in Section 13 of the Regulation and are as follows:

Surface Water Control

13. (1) A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report containing plans, specifications and descriptions for the control, treatment and discharge of surface water at the site during construction, site operation and following closure has been prepared in accordance with this section.

(2) The plans, specifications and descriptions must ensure that:

(a) the concentration of any contaminant in surface water being discharged from the site to a waterbody is in accordance with Ministry of Environment and Energy Guideline B-1, Water Management, dated July 1994, and Ministry of Environment and Energy Procedure B-1-1, Water Management, dated July 1994, as they may be amended from time to time; and

(b) the background levels for dissolved oxygen, turbidity, and temperature, and the hydrologic cycle of any on-site, adjacent or receiving surface water features, are not adversely affected by the site.

4.9.2 Approval Guidelines

The objectives of the surface water control system for a landfilling site are to: divert or control surface water coming onto the site; control runoff discharging from the site; and control erosion, sedimentation and flooding. The following guidelines provide a more detailed description of the issue and the level of protection which are typically discussed in a surface water control report.

The design for surface water control and management at a landfilling site typically include the information listed in Table 9:

Table 9: Surface Water Control

Item No.	Information
a.	A site drainage plan showing the drainage of surface water at the site before the site is established, during operation of the site, and following site closure.
b.	Plans, specifications and descriptions of the design features, control facilities and operational procedures to isolate, contain, convey, control and/or treat the surface water on and off site prior to its discharge to the receiving watercourse(s). The plans, specifications and descriptions should consider the following surface water flows: (i) Clean Surface Water: off-site surface water flows that have been separated from landfilling site operations by means of diversions, berms,

	interceptor channels, etc.; (ii) Non-Contaminated Storm Water: on-site runoff originating from non-operating areas, that does not contact landfill waste, leachate or wastewater, but may originate from parking and loading areas, buildings, stockpiles, etc.; and (iii) Potentially Contaminated Storm Water: on-site runoff originating from landfilling areas, material and waste storage areas, and areas designed for the collection, storage or treatment of leachate;
c.	The design and location of any surface water control facilities, such as berms, swales, ditches, control ponds or other facilities for the control of the quality and quantity of surface water from the site. The design should be in accordance with the following: i. the design of surface water control facilities should be based on accepted methodologies, calculations and analytical tools including, where appropriate, hydrologic modelling (single event and/or continuous simulation), hydraulic modelling and water quality modelling using accepted computer models; ii. the design of external diversion channels, ditches and conveyance structures should be sized to accommodate the peak flow generated from the higher of the 100-year design storm or the prevailing Regional Storm Event (e.g., Hurricane Hazel, Timmins or other historically observed maximum event); iii. the design of all internal drainage ditches, storm sewers and conveyance structures should be sized to accommodate the peak flow generated from a 25-year design storm. In addition, a continuous overland flow route and/or ditch drainage system should be provided and sized to convey the peak flow generated from the higher of the 100-year design storm or the prevailing Regional Storm Event.
d.	The design and location of any sedimentation ponds to remove sediment from any surface water control facilities constructed at the site. The design should be in accordance with the following: (i) the design of any storm water management facilities for the purpose of surface water quality enhancement (i.e., settling of suspended sediment) of non-contaminated storm water should be designed to temporarily treat/store the runoff volume generated from a 4-hour, 25 mm storm event; (ii) the design of any storm water management facilities for the purpose of surface water quantity control (i.e., peak flow reduction) of non-contaminated storm water should be designed to temporarily store the runoff volume generated from controlling all storm events up to the higher of the 24-hour, 100-year design storm or the prevailing Regional Storm event, at or below the existing condition (i.e., pre-landfill) peak

	flows, such that there is no appreciable change in the potential for flooding and/or erosion in the watercourses receiving surface water discharges from the landfilling site.
e.	The design and location of any temporary or permanent erosion and sediment control facilities or measures for the site, including for any surface water control, treatment and discharge facilities and for any areas in which construction/operation activities are taking place.
f.	The design and location of any overflow control facilities for the site to safely convey storm water flows in excess of the specified design storm; and
g.	a description of the operation, inspection and maintenance requirements for any surface water control, treatment and discharge facilities, including erosion and sediment control facilities..

4.10 Subsurface Migration of Landfill Gas

The natural biodegradation of organic waste in a landfilling site produces a gas that is emitted to the atmosphere through the landfill cover or after migrating for some distance in the soil below ground surface. The major constituents of landfill gas are methane (CH4) and carbon dioxide (CO2). Small amounts of other compounds such as hydrogen sulphide, mercaptans and non-methane organic compounds may also be present.
The methane component of landfill gas is of particular concern as it poses an explosion hazard if it becomes trapped in enclosed spaces at concentrations ranging from 5 to 15 percent by volume. Regulation 232/98 addresses this concern by requiring an assessment of the potential for subsurface migration and by setting concentration limits for methane. The concentration limits specified in the Regulation are:

- less than 2.5 percent methane gas in the subsurface at the property boundary,
- less than 1.0 percent methane in an on-site building, or its foundation, and
- less than 0.05 percent methane (i.e. not present) in a building, or its foundation, which is located off-site.

The regulatory requirements are described in Subsection 4.10.1 of this Guideline. Further details on the assessment, and if necessary, the monitoring and control of landfill gas migration are included as approval guidelines in Subsection 4.10.2.

4.10.1 Regulatory Requirements

Regulation 232/98 requires that the potential for landfill gas migration be assessed, and sets limits for control. The requirements are given in Section 14 of the Regulation and are as follows:

Subsurface Migration of Landfill Gas

14. (1) A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report has been prepared in accordance with this section that contains the following:

1. An assessment of the potential for the migration of landfill gas in the subsurface.

2. *Plans, specifications and descriptions for the monitoring, control, collection, use or discharge of landfill gas at the site if, on the basis of the assessment, any of these actions are necessary.*

(2) *The design of the site and any plans, specifications and descriptions for the control of landfill gas must ensure that the subsurface migration of landfill gas meets the following conditions:*

1. *The concentration of methane gas below the surface of the land at the boundary of the site must be less than 2.5 per cent by volume.*
2. *The concentration of methane gas must be less than 1.0 per cent by volume in any on-site building or enclosed structure, and in the area immediately outside the foundation or basement floor of the building or structure, if the building or structure is accessible to any person or contains electrical equipment or a potential source of ignition.*
3. *Paragraph 2 does not apply to a leachate collection, storage or treatment facility or a landfill gas collection or treatment facility for which specific health and safety measures and procedures are in place relating to the risk of asphyxiation and the risk of explosion.*
4. *The concentration of methane gas from the site must be less than 0.05 per cent by volume in any off-site building or enclosed structure, and in the area immediately outside the foundation or basement floor of the building or structure, if the building or structure is accessible to any person or contains electrical equipment or a potential source of ignition.*

4.10.2 Approval Guidelines

The following guideline provides further details on the assessment of the subsurface migration of landfill gas and, if necessary, any measures for monitoring and control. The assessment and design of the landfilling site for landfill gas control typically includes a discussion on the information in Table 10:

Table 10: Landfill Gas

Item No.	Information
a.	An assessment of the potential for landfill gas migration below land surface, including: (i) background concentrations of methane gas and any existing potential sources of methane gas generation other than the waste; (ii) the potential for generation of methane gas by the waste; (iii) the potential for migration of landfill gas below land surface to adjacent or other off-site properties, or into buildings or enclosed structures located on-site or off-site; and (iv) the potential for migration of landfill gas into and within any buried utility or service lines.

b.	Monitoring of landfill gas migration is not normally required where the assessment shows that there is no significant potential for methane gas to migrate below land surface to adjacent or other off-site properties, or into buildings or enclosed structures located on-site or off-site, in concentrations in excess of those specified in Subsection (2) of the Regulation.
c.	Where methane gas is expected to be generated at the site, the report should include the following for any buildings or enclosed structures which may be impacted by the methane gas: (i) the provision of methane gas monitoring devices, with detection alarms, for any occupied building located on site and confined space entry protocols for other buildings or enclosed structures that are accessible by any person; and (ii) a general description of the safety precautions to be taken for methane gas for any building or enclosed structure located on site which contains electrical equipment or any potential source of ignition.
d.	Where monitoring of landfill gas migration is to be carried out, the report should include, at a minimum, the design of the monitoring devices, the monitoring locations, frequency and period of monitoring, and the parameters to be analyzed, including the concentration of methane gas and the gas pressure within the monitoring devices.
e.	A contingency plan to control landfill gas migration below land surface to be implemented in the event methane gas migrates from the waste fill area at concentrations in excess of those specified in Subsection (2) of the Regulation including: (i) a conceptual design of the control facilities; (ii) an impact response plan describing the activities and timing of activities to be carried out in the event of an increase in methane gas concentrations within the buffer area, off site, or within buildings or enclosed structures which may be in excess of those specified in Subsection (2) of the Regulation; and (iii) where the monitoring program indicates the contingency plan needs to be implemented, the owner must notify the Director of the need to implement the contingency plan, prepare detailed plans, specifications and descriptions for the design, operation and maintenance of the contingency plan, and implement the contingency plan.

4.11 Atmospheric Emissions of Landfill Gas

Landfill gas is produced by the natural biodegradation of organic waste in a landfill. In addition to the major constituents, methane (CH_4) and carbon dioxide (CO_2), small

amounts of other compounds such as hydrogen sulphide, mercaptans and non-methane organic compounds may also be present. These trace components may create nuisance odours and affect local air quality. Methane gas, and to a lesser extent carbon dioxide, are "greenhouse" gases which contribute to global warming. The methane component of landfill gas is also a potential source of energy.

Regulation 232/98 requires the mandatory collection of landfill gas for new or expanding sites with a total waste disposal capacity greater than 1.5 million cubic metres. This volume equates to approximately 2.5 million tonnes of waste. Although the precise quantities and nature of air emissions from each landfill varies somewhat, air emissions control for larger sites is considered good environmental practice.

For sites smaller than the mandatory trigger, air emissions control may be required in some cases. For example, factors such as waste type, site location near a populated area, and operational practices (such as enhanced infiltration to promote waste stabilization) may indicate that air emissions control is appropriate even though the site is smaller than 1.5 million cubic meters. On the other hand, there may be situations where air emissions control is not needed for a site larger than the 1.5 million cubic meters trigger and the Regulation allows a landfill owner to show if this is the case. For example, a landfill which receives primarily construction and demolition debris may not need air emissions control. In the case of woodwaste sites associated with the forest products industry, the mandatory requirement does not apply at all as these sites do not pose a significant concern with respect to the emission of trace compounds and are typically located in more remote areas.

The regulatory requirement for air emissions control is described in Subsection 4.11.1 of this Guideline. Further information on the types of issues to be addressed in the design of air emissions control works is included in the approval guidelines given in Subsection 4.11.2.

4.11.1 Regulatory Requirements

Regulation 232/98 requires mandatory air emissions control for landfilling sites larger than 3.0 million cubic metres. This requirement does not apply to landfills associated with forest products operations or to sites which do not have significant air emissions. The requirements for air emissions control are given in Section 15 of the Regulation and are as follows:

Atmospheric Emissions of Landfill Gas

15. (1) A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report has been prepared respecting the design of facilities for the collection, and for the burning or use, of landfill gas generated by the site during site operation and following site closure.

(2) Subsection (1) applies only if a new landfilling site is being established with a total waste disposal volume of more than 1.5 million cubic metres or the total waste disposal volume of an existing landfilling site is being increased to more than 3.0 million cubic metres.

(3) Subsection (1) does not apply to a landfilling site if a written report is prepared showing that the nature and quantity of landfill gas generated at the site is not likely to be of significant concern to the Director, based on the following factors:

1. The characteristics of the site.

2. The type of waste to be deposited.

3. The rate at which waste is deposited at the site.

(3.1) Subsection (1) does not apply to a landfilling site if the only waste to be landfilled at the site is coal ash.

(4) Subsection (1) does not apply to a landfilling site associated with forest products operations, such as the operations of a lumber mill, sawmill, pulp mill or similar facility, if the waste to be deposited at the site is produced by the forest products operations and is predominantly solid, non-hazardous process waste, such as woodwaste, effluent treatment solids, hog fired boiler ash, recycling process rejects, lime mud, grits or dregs.

4.11.2 Approval Guidelines

The following guidelines describe the types of issues which are typically discussed in the design of air emissions control works:

When designing the air emissions control system for a landfilling site, a number of factors related to the overall site design and operation are considered. These factors may affect the type and layout of the gas collection system (e.g. horizontal trenches or vertical collection wells), the rate and quantity of gas generated, and the timing of system installation and operation. These factors typically include those listed in Table 11:

Table 11: Factors Affecting Atmospheric and Landfill Gas

Item No.	Factors
i.	The presence of low permeability soil or a bottom liner system preventing lateral migration of landfill gas.
ii.	Leachate levels within the landfill.
iii.	Site configuration (e.g. landfill slopes, vertical configuration relative to surrounding ground surface, and landfill surface area relative to volume of waste.
iv.	Final cover characteristics and limitations (e.g. for groundwater protection and site end use) affecting moisture within the site and potential air intrusion.
v.	Phasing of landfilling and closure operations for each area of the site.
vi.	The type and procedures for daily or intermediate cover affecting hydraulic and landfill gas movement within the landfill.
vii.	Any activities to control or alter the moisture content within the landfill, such as leachate recirculation.

Taking these factors into consideration, the plans, specifications and descriptions for the design of the landfill gas collection and control system typically include a discussion on the information listed in Table 12:

Table 12: Landfill Gas Collection System

Item No.	Information
a.	Plans, specifications and descriptions of the design of the landfill gas collection system, including: (i) spatial design of the collection system including collector orientation (i.e. vertical wells or horizontal trenches), layout and spacing, depth(s) of placement within the landfill and radius of capture zone; (ii) design of the collection pipes including size, material, perforations, granular bedding/envelope, and provisions for stress relief and settlement; (iii) design of header and transmission pipes including size, material, slope, valving, access chambers, condensate control, seepage protection, protection from freezing, bedding and provisions for stress relief and settlement; and (iv) condensate drainage, storage and disposal.
b.	Plans, specifications and descriptions of the design of the facilities for landfill gas burning, treatment or utilization, including: (i) a description of the landfill gas extraction equipment (i.e. blower) and the design of any moisture removal and gas treatment system; (ii) the design, performance characteristics and operational controls for any flare system including: ▪ the type and design of the flare device; ▪ design combustion temperature and residence time; ▪ the destruction efficiency of volatile organic compounds; ▪ operational control systems such as temperature and combustion air control, flame failure detection, automatic ignition system and flame arrester; (iii) a description of any utilization system for collected landfill gas.
c.	Plans, specifications and descriptions of the operation, monitoring and maintenance procedures for the landfill gas system, including; (i) phasing/timing of system installation, start up and operation -- particularly with respect to integration with overall landfill operation and maximizing landfill gas control; (ii) inspection frequencies and maintenance/replacement procedures for system equipment; (iii) monitoring of landfill gas flow rates and concentrations; and (iv) contingency provisions in the event of unexpected component failures.

In addition to obtaining a waste management approval for the landfill gas collection system under Part V of the *Environmental Protection Act*, approval for the discharge from the control works is also required.

4.12 Design Criteria for Engineered Facilities

Requirements for the design of various engineered facilities for a landfilling site are included in Regulation 232/98. These standards are described separately in Chapter 4.0 of this Guideline. An important design consideration for these facilities or works is that they be able to function effectively for as long as necessary to control contaminants or impacts. For a landfilling site, this means the engineered facilities must be durable enough or be capable of being repaired or replaced for the contaminating life of the site with respect to the contaminants or impacts of concern.

The concept of service life is not just an environmental issue or one limited to landfill design. It is a general concept or principle of all good engineering design. It has been included in the landfill standards as an approval guideline to emphasize its importance and complement the other landfill design standards.

4.12.1 Regulatory Requirements

Design criteria for specific engineered facilities are included as separate requirements in Regulation 232/98 and are described separately in Chapter 4.0 of this Guideline. Service life is a important consideration in engineering design and has been included in the landfill standards as an approval guideline. There are no separate regulatory requirements for this standard in the Regulation.

4.12.2 Approval Guidelines

Good engineering design requires that engineered facilities at a landfilling site be able to function effectively for as long as they are needed to control contaminants or impacts. Common engineered facilities include: liners, covers, berms, leachate collection systems, leachate treatment facilities, monitoring wells and equipment, landfill gas control equipment, and surface water control works.

An engineered facility which is to be constructed at a landfilling site for purposes of controlling leachate, groundwater, surface water or landfill gas should be designed such that:

(a) the service life of the engineered facility exceeds the period of time during which contaminants may be generated by the site and need to be controlled by the engineered facility to prevent an unacceptable impact; or

(b) the engineered facility can be replaced, or an alternative engineered facility can be constructed, as necessary to enable the combined service lives of the engineered facilities to exceed the period of time during which contaminants may be generated by the site and need to be controlled by the engineered facility to prevent an unacceptable impact.

For groundwater, an unacceptable impact is considered to be an increase in contaminant concentrations in excess of the maximum allowable concentrations defined in accordance with the Ministry's Reasonable Use Guideline (refer to Section 4.5 of this Guideline).

For surface water, an unacceptable impact is considered to be an impact on a surface water feature in excess of the standards described in Section 4.9 of this Guideline.

For landfill gas migration below surface, an unacceptable impact is considered to be the migration of landfill gas at concentrations in excess of the allowable methane concentrations defined in Section 4.10 of this Guideline.

4.13 Design Criteria for Noise

Noise sources associated with the operation of landfilling sites fall into three categories: construction equipment carrying out the landfilling operation, including on-site movement of waste trucks and vehicles; ancillary facilities such as waste receiving and recycling facilities; and off-site movement of waste trucks and vehicles. The landfill design report required by Regulation 232/98 (refer to Section 4.1 of this Guideline) must include an assessment of potential noise impacts and the need for control measures. Information on the design criteria to be used for the noise assessment is included in the approval guidelines given in Subsection 4.13.2.

4.13.1 Regulatory Requirements

The regulatory requirement to assess potential noise sources and the need for noise control measures is included in the standard on Design Specifications described in Section 4.1 of this Guideline. There is no separate regulatory requirement for this standard in Regulation 232/98.

4.13.2 Approval Guidelines

Information on noise considerations for landfilling sites is provided in the Ministry publication “Noise Guidelines for Landfill Sites”. The following is a summary of those guidelines:

Noise Guidelines for Landfill Sites

In landfill design, the potential noise effects from three components of the operation of the landfilling site should be considered: the landfilling operation itself (including construction equipment and on-site movement of waste trucks and other vehicles); ancillary facilities (such as waste reception and recycling); and off-site movement of waste trucks and other site vehicles.

a. Landfilling Operation - Sound Level Limits

The limits for sound levels due to the landfilling site operation at a Point of Reception are 45 dBA in any hour of the night, 7:00 p.m. - 7:00 a.m., and 55 dBA in any hour of the day, 7:00 a.m. - 7:00 p.m. These levels are expressed in terms of the One Hour Equivalent Sound Level (Leq).

Should the environment be dominated by noise sources from human activity, such as industry, commerce or road transportation, which produce sound in excess of the above limits, the higher sound levels may be used as the limit, provided noise abatement is not required for these other sources.

For impulsive sound, other than quasi-steady impulsive sound, from a pest control device employed to deter birds from the landfilling site, the applicable sound level limit at a Point of Reception expressed in terms of the Logarithmic Mean Impulse Sound Level (LLM) is 70 dBAI.

For quasi-steady impulsive sound, but not including other impulsive sound from a pest control device employed to deter birds from the landfilling site, the applicable sound level limit at a Point of Reception expressed in terms of the One Hour Equivalent Sound Level (Leq) is 60 dBA.

b. Ancillary Facilities - Sound Level Limits

Facilities or equipment being used at the site, other than construction equipment or on-site vehicles, are considered to be stationary noise sources. The applicable sound level limits are those established for the assessment of stationary sources of sound given in the Ministry publications NPC-205 and NPC-232.

c. Off-Site Source Vehicles

For a landfilling site employing off-site source vehicles (i.e. vehicles hauling waste or cover material to the site) that constitute a predominant component of the background noise, an access route should be selected which will result in a minimum noise impact. The selection process should be based on a detailed quantitative assessment of noise impact on individual receptors and the number of affected receptors along the alternative routes.

4.14 Operation and Maintenance Procedures

Good operation and maintenance procedures at a landfilling site is a component of the overall design to ensure the environmental control and monitoring works continue to function as designed and for as long as they are needed. Good operational procedures are also important for minimizing potential nuisance impacts such as litter, noise, odour and dust.

Regulation 232/98 requires that the landfill owner prepare a report describing the operation and maintenance procedures to be followed at the site. The regulatory requirement is included in Subsection 4.14.1 of this Guideline and further details on the issues to be addressed are included as approval guidelines in Subsection 4.14.2. The guidelines identify operations matters typically discussed in the report:

- a waste control program to identify unacceptable wastes and ensure hazardous wastes are not accepted,
- site supervision and security,
- cover material type, source and stockpiling,
- operation and maintenance procedures for environmental control and monitoring facilities,
- procedures to control noise, odour and dust,
- any procedures, such as promoting infiltration, intended to shorten the contaminating life span of the site, and
- a complaint response plan to address any public concerns with site operations.

In addition to the requirement to prepare an operation and maintenance report, there are a number of other separate landfill standards dealing with specific aspects of landfill operations. These other standards deal with issues such as daily cover, groundwater and surface water monitoring, record keeping and reporting. These standards are described separately in Chapter 6.0 of this Guideline.

4.14.1 Regulatory Requirements

Regulation 232/98 requires that an operation and maintenance report be prepared for a landfilling site. This requirement is given in Section 16 of the Regulation and is as follows:

Operation and Maintenance Procedures

16. *A person shall not establish a new landfilling site or increase the total waste disposal volume of an existing landfilling site unless a written report has been prepared containing plans, specifications and descriptions of the operation, maintenance, monitoring, closure and post-closure care of the site including matters related to record-keeping, reporting and financial assurance.*

4.14.2 Approval Guidelines

Table 4.14.2 provides guidelines on additional information, details on the issues that are typically discussed in the operation and maintenance for a landfilling site:

Table 13: Operation and Maintenance Procedures

Item No.	Information
a.	Acceptable and unacceptable waste types, estimated annual quantities, maximum daily rate of fill, operating days per week and hours of operation.
b.	Signage posted at site entrance indicating hours and days of operation, acceptable and unacceptable wastes, operating authority, Ministry approval number, telephone number for emergencies and additional information.
c.	Site supervision and security.
d.	Procedures for acceptance of incoming waste, including identification of waste requiring special handling or unacceptable waste.
e.	Cover material to be used, sources of cover material, the procedures for acceptance of imported cover material, the procedures for the stockpiling of cover material prior to use, the location and maximum size of any stockpiles, and the minimum number of days supply of cover material to be maintained.
f.	Waste disposal equipment and procedures for waste handling, deposit, compaction and covering.
g.	Coordination and phasing of site development and operation.
h.	Procedures during site development for the protection of site vegetation that is to be preserved.
i.	Operation, inspection and maintenance of any control, treatment and disposal facilities for leachate, groundwater, surface water and landfill gas.

j.	Operation, inspection and maintenance of any monitoring facilities for leachate, groundwater, surface water and landfill gas.
k.	Management, treatment and disposal procedures for any collected leachate, groundwater, surface water and landfill gas.
l.	Procedures to protect any liner system from damage during waste disposal operations.
m.	Procedures to protect any control facilities for leachate, groundwater, surface water and landfill gas from damage during waste disposal operations.
n.	Procedures to protect any monitoring facilities for leachate, groundwater, surface water and landfill gas from damage during waste disposal operations.
o.	Any procedures intended to alter or control the contaminating life span of the site.
p.	Procedures intended to maintain or extend the service life of any engineered facility.
q.	Procedures to minimize, including potential remedial measures for, noise, odour, dust, leachate seeps, vehicle mud tracking off-site, litter, birds, vectors and vermin.
r.	A response plan for fire and other emergencies.
s.	A complaint response plan describing actions to be taken in response to complaints from the public or others concerning site activities, including the actions to be taken to identify the activity causing the complaint and minimize future occurrences.
t.	Record keeping and reporting.
u.	A public communications plan.
v.	Trigger criteria and procedures to implement, operate and maintain the contingency plans for leachate and landfill gas in the event the primary design of the site is inadequate.
w.	Site closure procedures.
x.	Post-closure maintenance, monitoring and reporting; and
y.	Financial assurance provisions for a privately owned site.

5.0 FINANCIAL ASSURANCE

5.1 Financial Assurance - Contingency Plans

Financial assurance is required for the closure and post-closure costs for private sector landfilling sites (refer to Section 5.2 of this Guideline). An additional amount of financial assurance is required for these sites to ensure funds are available for contingencies such as the leachate and landfill gas contingency plans.

Contingency plans involve unexpected events, both with respect to if and when something may occur, as well as the nature and extent of the event. To simplify the financial assurance requirements for contingency plans, Regulation 232/98 specifies that the contingency amount be based on fifty (50) cents per tonne of waste deposited in the site. Also, since the 50 cents per tonne amount is based on 1997 dollars, the amount provided must be adjusted to account for inflation.

At the time of site closure, the total amount of financial assurance required for a site would be:

Financial Assurance for Contingency Plans = [$0.50 per tonne] x [total tonnage capacity] x [inflation adjustment from 1997 to date of site closure]

This amount would have to be adjusted annually thereafter to take into account inflation during the post-closure period.

The amount of contingency plan financial assurance required to be in place at the end of each operating year would be determined in a similar manner -- i.e. -- [$0.50/tonne] x [total tonnage deposited to date] x [inflation adjustment from 1997 to date].

While this approach to calculating financial assurance is consistent from site to site, it also recognizes that the amount of financial assurance should reflect the size of the landfill (i.e. a larger site generates a larger amount of financial assurance). The types of financial assurance that may be provided are identified in Part XII of the *Environmental Protection Act* and include a cash deposit, letter of credit, surety bond and other securities acceptable to the Ministry.

Financial assurance is not required for a site owned by a municipality.

As an alternative to establishing separate contingency plan financial assurance for each private sector landfill, the Regulation also includes a clause allowing the possibility of a single financial assurance plan to be established for a group of sites. The specific details of such a group plan would have to be acceptable to the Director.

The regulatory requirement to provide financial assurance for contingency plans is included in Subsection 5.1.1 of this Guideline. Additional information on financial assurance calculations is included in the approval guidelines given in Subsection 5.1.2.

5.1.1 Regulatory Requirements

Regulation 232/98 requires that contingency plan financial assurance be provided for private sector landfilling sites. This requirement is given in Section 17 of the Regulation and is as follows:

Contingency Plans

17. (1) The owner and the operator of a landfilling site shall ensure that financial assurance is provided for the contingency plans for the site, including the construction, operation, maintenance and replacement of works required by the contingency plans.

(2) The financial assurance shall be provided in the form of a cash deposit paid to the Director or in such other form, such as a bond, a letter of credit or negotiable securities, as is acceptable to the Director.

(3) Subject to subsection (4), the amount of the financial assurance shall be determined in accordance with the following formula:

$$F = \$0.50 \times W \times (I_2 \div I_1)$$

where,

F = the amount of the financial assurance,

W = the number of tonnes of waste that have been deposited in the landfilling site at the time the amount of financial assurance is calculated,

I_1 = the 1997 Annual Average Non-residential Building Construction Price Index for Toronto, determined with reference to the same base year as is applicable to I2 , as published by Statistics Canada under the authority of the Statistics Act (Canada),

I_2 = the most recent Annual Average Non-residential Building Construction Price Index for Toronto available at the time the amount of the financial assurance is calculated, as published by Statistics Canada under the authority of the Statistics Act (Canada).

(4) The amount of financial assurance provided shall be updated annually or as otherwise required by the Director.

(5) The financial assurance shall remain in place until a written report is prepared that shows that the financial assurance is no longer required.

(6) The financial assurance may be used by the Director to pay for expenses related to any planned or unplanned closure of the site or to the post-closure care of the site, if the owner fails, on the request of the Director, to perform the work or cover the expenses.

(7) The owner and the operator of a landfilling site shall ensure that any amount of financial assurance used by the Director under subsection (6) is replaced within six months after it is used unless the Director directs otherwise.

(8) Subsection (1) does not apply to require site specific financial assurance if financial assurance for the contingency plans is provided by a group financial assurance plan acceptable to the Director.

(9) Subsection (1) does not apply in respect of a landfilling site owned by a municipality or the Crown.

(10) Subsection (1) does not apply to a landfilling site owned by a forest products company if the waste to be deposited at the site is produced by forest products operations, such as the operations of a lumber mill, sawmill, pulp mill or similar facility, and is predominantly solid, non-hazardous process waste, such as woodwaste, effluent treatment solids, hog fired boiler ash, recycling process rejects, lime mud, grits or dregs.

5.1.2 Approval Guidelines

Additional guidance on calculating financial assurance is given in the Ministry Guideline F - 15 “Financial Assurance”, dated April 1994, and the Ministry Procedure F - 15 - 1 “Procedures for Financial Assurance” dated April 1994.

5.2 Financial Assurance - Closure & Post-Closure Care

Financial assurance as stated in Section 18 of Regulation 232/98 is required for private sector landfilling sites to ensure that funds are available to close the landfill and to carry out all expected post-closure care activities. An additional amount of financial assurance is required for contingency plans (refer to Section 5.1 of this Guideline).

Site closure involves completing the final cover, landscaping and construction of site monitoring and control works. Post-closure care activities typically involve site inspection, monitoring and maintenance activities, and the construction or replacement of any monitoring or control works. The types of financial assurance which may be provided are identified in Part XII of the *Environmental Protection Act* and include a cash deposit, letter of credit, surety bond and other securities acceptable to the Ministry. Financial assurance is not required for a site owned by a municipality.

Regulation 232/98 requires that financial assurance be provided for closure and post-closure care of private sector landfilling sites. Where a site is being progressively closed during the operation of the site, financial assurance for site closure would not be necessary. The amount of financial assurance is determined on a case-by-case basis and must be sufficient to cover the contaminating life span of the site (e.g. the time period during which leachate collection is necessary to protect groundwater, or prevent mounding and surface discharge). Should the contaminating life span for a site be estimated at less than 25 years, however, the Regulation requires that a minimum 25 year period be used for post-closure care activities such as groundwater monitoring. The amount of financial assurance for a particular landfill typically depend on factors such as site design, type of waste, level of engineering and environmental setting. The amount of financial assurance as required by conditions in the Environmental Compliance Approval is reviewed periodically to ensure that it is sufficient to cover the estimated costs.

The regulatory requirement for closure and post-closure care financial assurance is included in Subsection 5.2.1 of this Guideline. Additional guidance on financial assurance calculations is included in the approval guidelines given in Subsection 5.2.2.

5.2.1 Regulatory Requirements

Regulation 232/98 requires financial assurance for the closure and post-closure care of private sector landfilling sites. This requirement is given in Section 18 of the Regulation and is as follows:

Closure and Post-Closure Care

18. (1) The owner and the operator of a landfilling site shall ensure that financial assurance for the closure of the site and the post-closure care of the site is provided in accordance with this section.

(2) The financial assurance shall be provided in the form of a cash deposit paid to the Director or in such other form, such as a bond, a letter of credit or negotiable securities, as is acceptable to the Director.

(3) The amount of the financial assurance shall be the present value at the estimated date of closure, in dollars current at that date, of an amount sufficient to cover the estimated costs for,

(a) the planned closure of the largest area that will require final cover at any one time during the operation of the site, including the costs of final cover and landscaping;

(b) care and maintenance of the final cover and landscaping for the contaminating life span of the site; and

(c) all other expected post-closure care activities for the contaminating life span of the site, including monitoring, analysis and reporting, the design, construction, operation, maintenance and replacement of engineered facilities and the disposal of wastes from the facilities, but not including any additional activities in the contingency plans for the site.

(4) Any determination of the amount of the financial assurance shall be carried out in a manner consistent with Ministry of Environment and Energy Guideline F - 15, Financial Assurance, dated April 1994, and Ministry of Environment and Energy Procedure F - 15 - 1, Procedures for Financial Assurance, dated April 1994, as they may be amended from time to time.

(5) Clause (3) (a) does not apply if part of the site is closed at least every five years.

(6) If costs are estimated under subsection (3) for any matter related to leachate from the site, the contaminating life span of the site may not be estimated at less than 25 years from the date waste is last deposited at the site.

(7) The financial assurance may be provided in stages as long as the amount that has been provided is always greater than the minimum amount determined in accordance with the following formula:

$$A = B (C \div D)$$

where,

A = the minimum amount of financial assurance that must have been provided,

B = the total amount of the financial assurance, as estimated under subsection (3),

C = the amount of waste that has already been deposited at the site,

D = the total amount of waste that will be deposited at the site.

(8) The estimation of costs and the amount of financial assurance provided shall be updated annually or as otherwise required by the Director.

(9) The financial assurance shall remain in place until a written report is prepared that shows that the financial assurance is no longer required.

(10) The financial assurance may be used by the Director to pay for expenses related to any planned or unplanned closure of the site if the owner fails, on the request of the Director, to perform the work or cover the expenses.

(11) The owner and the operator of a landfilling site shall ensure that any amount of the financial assurance used by the Director under subsection (10) is replaced within six months after it is used unless the Director directs otherwise.

(12) Subsection (1) does not apply in respect of a landfilling site owned by a municipality or the Crown.

5.2.2 Approval Guidelines

Additional guidance on calculating financial assurance is given in the Ministry Guideline F - 15 “Financial Assurance”, dated June 2011.

6.0 OPERATIONS

6.1 Site Preparation Report

A Site Preparation Report is prepared to confirm that site conditions are as expected, and the site has been prepared and constructed in accordance with the approved design. As described in Subsection 6.1.1 of this Guideline, Regulation 232/98 requires that a site preparation report be prepared. A description of the type of information which typically is discussed in the report is included in the report is included in the approval guidelines given in Subsection 6.1.2.

6.1.1 Regulatory Requirements

Regulation 232/98 requires that a site preparation report be prepared for the landfilling site. This requirement is given in Section 19 of the Regulation and is as follows:

Site Preparation Report

19. A person shall not place any waste in a newly constructed base or base side slope area of a landfilling site until a written report has been prepared documenting all construction, quality assurance and quality control activities and confirming that the site conditions and details of the construction of the new area are in accordance with the design plans and specifications of the landfilling site.

6.1.2 Approval Guidelines

The Site Preparation Report documents that site conditions, construction activities and quality assurance/control procedures are in accordance with the design of the landfill and typically included discussion on the information described in Table 14:

Table 14: Site Preparation Report

Item No.	Information
a.	Hydrogeologic conditions found during excavation or drilling activities carried out for the new waste fill area, and for new control or monitoring facilities.
b.	The construction and testing of any liner system.
c.	The construction of any other new control, treatment, disposal or monitoring facilities for leachate, groundwater, surface water and landfill gas.
d.	The construction of any other works or facilities, including screening, landscaping, on-site roads, fencing and other structures.

6.2 Record Keeping

Daily records of landfill activities are needed to properly assess the effectiveness and efficiency of site design and operation, their effect or relationship to any nuisance and environmental impacts, and the occurrence of any public complaints or concerns. Thorough documentation of site activities is necessary for preparation of the annual operations report and will assist in planning future site activities.

Regulation 232/98 requires operational records to be kept by the landfill owner. The regulatory requirement is described in Subsection 6.2.1 of this Guideline. Further details

on the type of information typically kept are included in the approval guidelines given in Subsection 6.2.2.

6.2.1 Regulatory Requirements

Regulation 232/98 requires that daily records be kept of landfill operations. This requirement is given in Section 20 of the Regulation and is as follows:

Record Keeping

20. The owner and the operator of a landfilling site shall ensure that daily records of site operations are made during the operation of the site and that the records are retained for at least two years after they are made.

6.2.2 Approval Guidelines

Record keeping helps maintain high operational standards, and is needed for the annual operations report and to plan future site activities. Daily records typically are kept for each day waste is received at the site or when other significant activities take place. The daily records typically include information described in Table 15:

Table 15: Record Keeping

Item No.	Information
a.	The type, date and time of arrival, hauler, and quantity (by weight where weigh scales are provided at the site, otherwise by estimated volume as received) of all waste and cover material received at the site.
b.	The area of the site in which waste disposal operations are taking place.
c.	Any complaints from the public received by the owner and a description of the action taken by the owner in response.
d.	A calculation of the total quantity (by weight where weigh scales are provided at the site, otherwise by estimated volume as received) of waste received at the site during each operating day and each operating week.
e.	The amount of any leachate removed, or treated and discharged from the site, for sites with leachate collection.
f.	Record of litter collection activities and the application of dust suppressants.
g.	A record of the inspections of any control, treatment, disposal or monitoring facilities.
h.	A description of any out-of-service period of any control, treatment, disposal or monitoring facilities, the reasons for the loss of service, and action taken to restore and maintain service.

6.3 Annual Operations Report

An annual operations report is typically required as a condition in the landfilling site's Environmental Compliance Approval. The condition typically requires information that provides a discussion that describes the results of site monitoring, the status of site development and capacity usage, upcoming phases of site preparation and development, and any operational concerns. Based on the annual report, and the day-to-day review of site activities, any possible improvements to site design and operations typically are identified. For private sector landfilling sites, the annual report typically has a discussion on an update of the financial assurance required for the site and the amount in place.

Regulation 232/98 requires that an annual report on site operations be prepared. The regulatory requirement is described in Subsection 6.3.1 of this Guideline. The type of information which should be provided in the annual report is included in the approval guidelines given in Subsection 6.3.2.

6.3.1 Regulatory Requirements

Regulation 232/98 requires an annual operations report to be prepared for a landfilling site. This requirement is given in Section 21 of the Regulation and is as follows:

Annual Operations Report

21. The owner and the operator of a landfilling site shall ensure that,

(a) within three months after each anniversary of the date on which waste was first accepted at the site, an annual report is prepared respecting the operation of the landfilling site, including a summary of results from monitoring programs; and

(b) all of the reports are retained until at least two years after the site is closed.

6.3.2 Approval Guidelines

An annual report is an important tool used in reviewing site activities and for determining the effectiveness of site design. The annual operations report typically includes sections in the repost that discusses information described in Table 16:

Table 16: Annual Operations Report

Item No.	Information
a.	The results and an interpretive analysis of the results of all leachate, groundwater, surface water and landfill gas monitoring, including an assessment of the need to amend the monitoring programs.
b.	An assessment of the operation and performance of all engineered facilities, the need to amend the design or operation of the site, and the adequacy of and need to implement the contingency plans.
c.	Site plans showing the existing contours of the site; areas of landfilling operation during the reporting period; areas of intended operation during the next reporting period; areas of excavation during the reporting period; the progress of final cover, vegetative cover, and any intermediate cover application; previously existing site facilities; facilities installed during the reporting period; and site preparations and

	facilities planned for installation during the next reporting period.
d.	Calculations of the volume of waste, daily and intermediate cover, and final cover deposited or placed at the site during the reporting period and a calculation of the total volume of site capacity used during the reporting period.
e.	A calculation of the remaining capacity of the site and an estimate of the remaining site life.
f.	A summary of the quantity of any leachate removed, or treated and discharged, from the site during each operating week, for sites with leachate collection.
g.	A summary of the weekly, maximum daily and total annual quantity (by weight where weigh scales are provided at the site, otherwise by estimated volume as received) of waste received at the site.
h.	A summary of any public complaints received by the owner and the responses made.
i.	A discussion of any operational problems encountered at the site and corrective action taken; and
j.	An update of the cost estimate for financial assurance and the amount which has been provided to the Director, in the case of a privately-owned site.

6.4 Public Liaison Committee

Those persons potentially affected by a landfill may need to be kept informed and be given the opportunity to provide input into activities taking place at the site. Ongoing dialogue with the public and local authorities is important in helping to maintain a commitment to high standards of operation and environmental protection at a site. Although not an express requirement of Regulation 232/98, the landfill owner may provide specific opportunities for public involvement, such as by offering to form a public liaison committee. An invitation to participate on the public liaison committee should be extended to nearby residents, residents along the local access road and to municipal representatives. Copies of reports such as the annual operations report may need to be made available to the committee. The specific details of the terms of reference for the committee should be determined on a case by case basis. Further information on establishing a public liaison committee is included in Subsection 6.4.2 of this Guideline.

6.4.1 Regulatory Requirements

The formation of a public liaison committee is an effective way to obtain public input into ongoing landfill operations and has been included in the standards as approval guidelines rather than as a regulatory requirement in Regulation 232/98.

6.4.2 Approval Guidelines

The landfill owner may be required through a condition in the site's Environmental Compliance Approval to establish a forum for the exchange of information and public dialogue on activities carried out at the site. Open communication with the affected

public and local authorities is important in helping maintain high standards for site operation and environmental protection.
Prior to the receipt of waste at a landfilling site, the owner may be required by a Condition in the site's Environmental Compliance Approval to form a public liaison committee or should establish some other forum (such as regular public meetings) to obtain public input into site activities.
Where a public liaison committee is to be formed, the committee may consider structuring and operating the committee in a manner which addresses information described in Table 17:

Table 17: Public Liaison Committee

Item No.	Information
a.	Notice of the possible formation of a public liaison committee should be provided to all property owners or occupants within 500 m of the site, property owners or occupants adjacent to the local access road to the site (other than a County Road or Provincial Highway), the local municipality and any upper tier municipality in which the site is located.
b.	The owner should offer to host regular meetings of the public liaison committee.
c.	Copies of the annual operations report, including site monitoring, should be provided to the public liaison committee.
d.	Where requested by the public liaison committee, copies of any applications pertaining to the site which have been submitted to the Director should be provided to the committee; and
e.	For an operating site, whenever there has not been a meeting of an existing public liaison committee within the previous twenty-four months, or a public liaison committee has not existed during that period, the owner should again offer to form a public liaison committee.

6.5 Burning
Regulation 232/98 prohibits the open burning of mixed municipal waste at a landfilling site. Open burning is unacceptable because of concerns with air emissions, smoke and other nuisance effects, and the potential fire hazard. The controlled burning of small quantities of clean wood and brush, however, may be permitted in some cases -- for example, at smaller more remote sites.
The regulatory requirements on burning at landfilling sites are included in Subsection 6.5.1 of this Guideline. Additional guidance on the burning of clean woodwaste at landfilling sites is available from the Ministry, as indicated in Subsection 6.5.2

6.5.1 Regulatory Requirements
Regulation 232/98 prohibits open burning of mixed municipal waste landfilling sites. This requirement is given in Section 22 of the Regulation and is as follows:

Burning

22. (1) The owner and the operator of a landfilling site shall ensure that no municipal waste is burned at the site as part of the landfilling operation.

(2) Subsection (1) does not apply to clean wood and brush that is burned during daylight hours under controlled and supervised conditions in a segregated portion of the site.

6.5.2 Approval Guidelines

The burning of municipal waste at a landfilling site is prohibited except for the controlled burning of small quantities of clean wood and brush at some sites. Further information on burning at landfilling sites is provided in Ministry Guideline C-7 “Burning at Landfill Sites”.

6.6 Scavenging

Scavenging is the uncontrolled removal of material from waste at a landfilling site and is prohibited in Regulation 232/98. Scavenging is not allowed due to safety concerns and the potential for damage to environmental control, monitoring and other works at the landfill.

The prohibition on scavenging is not intended to, and does not, prevent a landfill owner from setting up recycling areas at a landfilling site. The establishment of segregated recycling areas where potentially recyclable material is placed for subsequent pick-up is encouraged by the Ministry.

The regulatory requirement prohibiting scavenging is included in Subsection 6.6.1 of this Guideline. There are no approval guidelines for this standard.

6.6.1 Regulatory Requirements

Regulation 232/98 prohibits scavenging (i.e. the uncontrolled removal of material from waste) at a landfilling site. This requirement is given in Section 23 of the Regulation and is as follows:

Scavenging

23. The owner and the operator of a landfilling site shall ensure that there is no scavenging at the site.

6.6.2 Approval Guidelines

There are no approval guidelines for this standard.

6.7 Surface Water Monitoring

Surface water monitoring is necessary to demonstrate that a landfilling site is performing as designed and to identify any potential impacts on surface water features in the vicinity of the site. The surface water monitoring program typically addresses the discharges from on-site surface water control works and any potential impacts on receiving waters. Based on the results of the surface water assessment (described above in Section 4.4 of this Guideline), biological monitoring (i.e. benthic -- bottom dwelling -- organisms) of nearby surface water features may be considered appropriate in some cases.

Regulation 232/98 requires that a surface water monitoring program be carried out at a landfilling site. The regulatory requirement is included in Subsection 6.7.1 of this Guideline. A more detailed description of the type of information to be obtained and issues to be addressed is included in the approval guidelines given in Subsection 6.7.2. The approval guidelines deal with matters such as:

- semi-annual monitoring for a comprehensive list of inorganic and organic parameters including metals and volatile organics, and characteristics such as flow, temperature and dissolved oxygen content,
- monitoring on two other occasions per year for a reduced list of indicator parameters, and
- biological monitoring, where appropriate.

The monitoring results along with an assessment of the results and recommendations for future monitoring should be included in an annual site monitoring report.

6.7.1 Regulatory Requirements

Regulation 232/98 requires that a surface water monitoring program be carried out for a landfilling site. This requirement is given in Section 24 of the Regulation and is as follows:

Surface Water Monitoring

24. The owner and the operator of a landfilling site shall ensure that a program is carried out for monitoring the quality and quantity of the surface water features on the site and of the surface water features that receive a direct discharge from the site.

6.7.2 Approval Guidelines

The surface water monitoring program described below includes monitoring frequencies and a detailed list of monitoring parameters. The frequency and parameters for monitoring may be amended, however, where site specific conditions indicate this is appropriate. Monitoring locations and the specific details of the monitoring program will be affected by the location and nature of the surface water features, the type of waste to be deposited, and other design and operational factors.
The program for monitoring surface water quality and quantity typically involves the information described in Table 18:

Table 18: Surface Water Monitoring

Task No.	Information
a.	Representative samples of surface water being discharged from the site and of any receiving surface water features, including upstream control locations, should be: (i) obtained semi-annually in spring and fall and be analyzed for the parameters listed in column 3 of Schedule 5 and for other parameters of concern identified in the surface water assessment; and (ii) obtained on two other occasions per year and be analyzed for the parameters listed in column 4 of Schedule 5.
b.	Where appropriate based on the surface water assessment, monitoring to assess the composition and any changes to the benthic community present in any surface water features receiving a discharge from the site.
c.	The results and assessment of the results of the surface water monitoring should be included in an annual report.
d.	The results and assessment referred to in Subsection (c) should include: (i) an assessment of the sampling results relative to the predicted results and

	expected impacts on surface water at the site and on any waterbody that may be affected by leachate or sediment from the site; (ii) an assessment of the need to amend the frequency or location of sampling and analytical parameters; and (iii) an assessment of the need to amend the design or operational procedures for the site, or to implement the leachate contingency plan.
e.	The parameters and frequency for monitoring may be amended where the owner prepares a report showing alternative provisions are appropriate based on conditions such as geographic location, climatic conditions and the type of waste to be deposited at the site.

6.8 Groundwater Monitoring

Regular monitoring of groundwater is necessary to demonstrate that a landfilling site is performing as designed and the impacts on the environment are acceptable. Regular monitoring allows for the analysis of trends over time and ensures there is an early warning of potential problems.

Regulation 232/98 requires that a groundwater monitoring program be carried out at a landfilling site. The regulatory requirement is included in Subsection 6.8.1 of this Guideline. A more detailed description of the type of information to be obtained and issues to be addressed is included in the approval guidelines given in Subsection 6.8.2. The approval guidelines deal with matters such as:

- annual monitoring for a comprehensive list of inorganic and organic parameters including metals and volatile organics,
- monitoring on two other occasions per year for a reduced list of indicator parameters, and
- where requested by nearby property owners, annual monitoring of domestic wells.

The monitoring results along with an assessment of the results and recommendations for future monitoring should be included in an annual site monitoring report.

6.8.1 Regulatory Requirements

Regulation 232/98 requires that a groundwater monitoring program be carried out for a landfilling site. This requirement is given in Section 25 of the Regulation and is as follows:

Ground Water Monitoring

25. The owner and the operator of a landfilling site shall ensure that a program is carried out for monitoring ground water quality and quantity.

6.8.2 Approval Guidelines

The groundwater monitoring program described below includes monitoring frequencies and a detailed list of monitoring parameters. The frequency and parameters for monitoring may be amended, however, where site specific conditions indicate this is appropriate. Monitoring locations and the specific details of the monitoring program will be based on factors such as site size, hydrogeologic setting, the type of waste to be deposited and the design of the site.

The program for monitoring groundwater quality and quantity for a landfilling site typically includes the information described in Table 19:

Table 19: Ground Water Monitoring

Item No.	Information
a.	Representative samples of groundwater within the site should be: (i) obtained annually from groundwater monitoring facilities and be analyzed for the parameters listed in column 1 of Schedule 5; and (ii) obtained on two other occasions per year from groundwater monitoring facilities and be analyzed for the parameters listed in column 2 of Schedule 5.
b.	Water levels (prior to the removal of any water) from the groundwater monitoring facilities referred to in Subsection (a) should be measured and recorded during each monitoring event.
c.	Where requested by property owners or occupants, representative samples of groundwater should be obtained from domestic wells located within 500 m of the waste fill area of the site at a frequency of one sample per well per year and these groundwater samples should be analyzed for the parameters listed in column 2 of Schedule 5.
d.	The results of analysis of a water sample collected under Subsection (c) should be provided to the owner or occupant of the property with the domestic well from which the sample was obtained, within 90 days of obtaining the sample.
e.	The results of analysis of all water samples collected in the groundwater monitoring program, together with an assessment of these results should be included in an annual report.
f.	The results and assessment referred to in Subsection (e) should include: (i) an assessment of the condition of groundwater monitoring facilities; (ii) an assessment of background groundwater levels and chemistry in each of the principal hydrostratigraphic units identified in the hydrogeological assessment and sampled in the course of groundwater monitoring program; (iii) an assessment of the sampling results relative to the predicted results and expected impacts on groundwater at the site and adjacent to the site; (iv) an assessment of the need to amend the frequency or location of sampling and the analytical parameters; and (v) an assessment of the need to amend the design or operational procedures for the site, or to implement the leachate contingency plan.
g.	The parameters and frequency for monitoring may be amended where the owner prepares a report showing alternative provisions are appropriate based on conditions such as geographic location, climatic conditions and the type of waste to be deposited at the site.

6.9 Leachate Monitoring

Leachate monitoring complements the groundwater and surface water monitoring programs, and provides important information for landfill design and performance assessment. Initial leachate (source) concentrations are needed for purposes of landfill design while ongoing leachate monitoring is used to assess current and expected

impacts from the site. Where leachate is collected at a site, information on leachate quality and quantity is needed to develop appropriate leachate management and disposal procedures.
Regulation 232/98 includes a basic requirement that leachate monitoring be carried out at a landfilling site. The regulatory requirement is included in Subsection 6.9.1 of this Guideline. A more detailed description of the type of information to be obtained, including a comprehensive list of monitoring parameters, is included in the approval guidelines given in Subsection 6.9.2. The leachate monitoring results and assessment is typically a requirement of a condition in the site's Environmental Compliance Approval as a component in the annual site monitoring report.

6.9.1 Regulatory Requirements

Regulation 232/98 requires that a leachate monitoring program be carried out at the landfilling site. This requirement is given in Section 26 of the Regulation and is as follows:

Leachate Monitoring

26. The owner and the operator of a landfilling site shall ensure that a program is carried out for monitoring leachate quality and quantity.

6.9.2 Approval Guidelines

The leachate monitoring program described below includes monitoring frequencies and a detailed list of monitoring parameters. The frequency and parameters for monitoring may be amended, however, where site specific conditions indicate this is appropriate. Monitoring locations and the specific details of the monitoring program will depend upon the extent of engineered leachate controls, the type of waste to be deposited, and other design and operational factors.
The program for monitoring leachate quality and quantity should typically involves the information described in Table 20:

Table 20: Leachate Monitoring

Item No.	Information
a.	Representative samples of leachate taken from within the waste or from the primary and/or secondary leachate collection system should be: (i) obtained annually and be analyzed for the parameters listed in column 1 of Schedule 5; and (ii) obtained on two other occasions per year and be analyzed for the parameters listed in column 2 of Schedule 5.
b.	Representative measurements taken on three occasions per year of the depth of leachate mounding in the deposited waste and any leachate collection system.
c.	The results and an assessment of the results of the leachate monitoring should be included in an annual report.
d.	The results and assessment referred to in Subsection (c) should include: (i) an assessment of the results of the leachate quality analyses and determinations of the depth of leachate mounding relative to the predicted results; (ii) an assessment of the need to amend the frequency or location of sampling and analytical parameters, and the frequency, location or procedures for

	determining the depth of leachate mounding; and (iii) an assessment of the need to amend the design or operational procedures for the site, or to implement the leachate contingency plan.
e.	The parameters and frequency for monitoring may be amended where the owner prepares a report showing alternative provisions are appropriate based on conditions such as geographic location, climatic conditions and the type of waste to be deposited at the site.

6.10 Daily Cover

Daily cover is used to control potential nuisance effects such as insects, rodents, birds, litter and odour, to facilitate vehicle access on the site, and to ensure an acceptable site appearance is maintained. Typically, soil is used as daily cover; however, alternative materials such as foundry sand, wood chips and compost may be used provided they meet these performance objectives. Where low permeability cover soils are used for daily or intermediate cover, the owner may need to remove or scarify the soil before placement of additional wastes overtop to promote hydraulic connection throughout the landfill. In some cases, the nature of the waste to be deposited at the site, or the small size and remote location of the site may allow for less frequent covering. For example, in the case of woodwaste landfills associated with the forest products industry, daily cover is normally not required.

Regulation 232/98 includes a requirement that daily cover be used at landfilling sites, but allows for the use of alternative cover materials or procedures. The regulatory requirements are included in Subsection 6.10.1 of this Guideline. The approval guidelines in Subsection 6.10.2 provide additional information on stockpiling of cover material and the issues to be addressed when considering the use of alternative cover materials.

6.10.1 Regulatory Requirements

Regulation 232/98 includes requirements concerning the use of daily cover at landfilling sites. These requirements are given in Section 28 of the Regulation and are as follows:

Daily Cover

28. (1) The owner and the operator of a landfilling site shall ensure that all waste accepted for disposal at the site is disposed of in the waste fill zone and is covered at the end of each working day by daily cover in accordance with this section.

(2) The daily cover shall consist of soil, foundry sand, wood chips, compost or other material.

(3) When tested using the Toxicity Characteristic Leaching Procedure, the daily cover must not produce leachate containing any of the contaminants listed in Schedule 4 to Regulation 347 of the Revised Regulations of Ontario, 1990 (General — Waste Management) made under the Act at a concentration equal to or in excess of the concentration specified in that Schedule for the contaminant.

(4) Subsection (1) does not apply to a landfilling site associated with forest products operations, such as the operations of a lumber mill, sawmill, pulp mill or similar facility, if the waste to be deposited at the site is produced by

the forest products operations and is predominantly solid, non-hazardous process waste, such as woodwaste, effluent treatment solids, hog fired boiler ash, recycling process rejects, lime mud, grits or dregs.

6.10.2 Approval Guidelines

The following guidelines identify the types of issues which may need to be addressed when considering the use of alternative cover materials and provide additional information on the stockpiling of cover material.

As indicated in Section 4.14 of this Guideline, the operation and maintenance report for a landfilling site typically describes the material to be used for daily or intermediate cover, the procedures to be followed when using the material, and any stockpiling of the material. Where the material to be used for cover is something other than soil, foundry sand, woodchips or compost, the description of the covering activities typically includes providing the information described in Table 21:

Table 21: Daily Cover

Item No.	Information
a.	A description of the material.
b.	The quantity to be applied at any one time and the procedures for its application.
c.	An assessment of the benefits and limitations of the cover material in controlling litter, odour, dust, vectors and vermin under the expected range of weather and operational conditions.
d.	The location and maximum quantity of material to be stockpiled on the site at any one time prior to its use as cover material, and
e.	An assessment of any measures necessary to control dust, surface water runoff and leachate from the stockpiling of the material.

Where the cover material is soil or foundry sand, and the quantity of soil or foundry sand accepted and stockpiled at the site for use as cover material exceeds the cover requirements for a 60 day period, and the concentration of contaminants in the soil or foundry sand exceeds the concentrations specified for industrial land (at-depth, potable) in the Ministry document 7382e: Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act ,an assessment should be carried out of any measures necessary for the control of surface water runoff or leachate from the stockpile.

Low permeability daily or intermediate cover soil may hinder the downward flow of leachate to leachate collection systems or result in leachate breakouts at surface.

Where factors such as the nature of the waste to be deposited at the site, or the size and location of the site indicate that covering on a daily basis may not be necessary, the alternative frequency and the basis for this frequency may need be described (refer to Section 4.1 of this Guideline -- Subsection 6(2)(c)(xxiv) of Regulation 232/98).

6.11 Final Cover

The proper closure of a landfilling site requires the application of a final cover which is aesthetically pleasing, controls infiltration, and is suitable for the end use planned for the site. The final cover should also be compatible with any gas control needs for the site. Typically, a simple soil and vegetative cover is used at landfilling sites; however, alternative covers can be considered. The specific characteristics of the final cover will depend on the particular proposal taking into consideration the type of waste and the design objectives for the cover.

A low permeability soil and vegetative cover is typically used for a natural attenuation landfill where a reduced rate of infiltration and leachate generation is normally desirable. For an engineered site with leachate collection, an increased rate of infiltration to promote waste stabilization would normally be desirable to reduce long term maintenance and monitoring requirements, and to reduce the contaminating life span of the site. The generic designs included in Regulation 232/98 (refer to Section 4.5 of this Guideline) in fact specify a minimum infiltration rate for this reason -- to help ensure the service life of the engineered facilities exceeds the contaminating life span.

Subsection 6.11.1 below describes the final cover requirements given in the Regulation. Information on the quality of soil which may be used in the final cover is included in the approval guidelines given in Subsection 6.11.2.

6.11.1 Regulatory Requirements

Regulation 232/98 sets out the performance factors to be addressed in the design of the final cover for a landfilling site. This requirement is given in Section 29 of the Regulation and is as follows:

Final Cover

29. (1) The owner and the operator of a landfilling site shall ensure that the following materials are applied to the waste fill zone as final cover, from bottom to top:

1. *A minimum of 0.6 metres of cover material.*
2. *A minimum of 0.15 metres of topsoil or other material approved by the Director as able to sustain plant growth.*
3. *A vegetative cover consisting of vegetation that is suited to local conditions and that is capable with minimal care of providing vigorous, plentiful cover not later than its third growing season.*

(2) The owner and the operator of a landfilling site shall ensure that the final cover is designed so that,

- *(a) the infiltration rate through the final cover is in accordance with the design for the site respecting ground water protection prepared under section 10;*
- *(b) any existing or anticipated facilities for the control, collection, use or discharge of landfill gas are accommodated; and*
- *(c) the requirements for the end use of the site, as described in the site design report prepared under section 6 and the closure report prepared under section 31, are met.*

6.11.2 Approval Guidelines

Final cover through a condition within the site's Environmental Compliance Approval may be required to be progressively applied to the site as the final waste contours are reached. This will improve the aesthetics of the site and reduce the extent of final closure measures which must be carried out at the end of waste disposal operations.

With respect to contaminant levels in the final cover, the concentrations of substances in the final cover should not exceed the concentrations (surface, non-potable) specified in the Ministry's document 7382e: Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, as amended from time to time for the intended land use of the site upon closure.

6.12 Final Slopes

The final slopes of a landfilling site have an effect on the waste capacity of the site, the performance of the final cover (also refer to Section 6.11 of this Guideline) and site maintenance requirements. Steep slopes promote surface water runoff, but increase erosion potential. More gradual slopes reduce runoff and erosion, but increase infiltration and the potential for ponding of surface water. Each of these factors should be considered in the design of the site and choice of final contours.
Subsection 6.12.1 describes the regulatory requirements for final slope design given in Regulation 232/98. The regulatory requirements specify maximum and minimum slopes that experience has shown can be successfully used in Ontario. The standard, however, allows alternative limits to be used in site design where they can be shown to be appropriate for a particular proposal. Approval guidelines for final slopes are included in Subsection 6.12.2.

6.12.1 Regulatory Requirements

Regulation 232/98 sets limits on maximum and minimum final slopes, but allows alternative designs where appropriate. This requirement is given in Section 30 of the Regulation and is as follows:

Final Slopes

30. (1) The owner and the operator of a landfilling site shall ensure that the final slopes above grade within the waste fill zone at the time of site closure do not exceed one unit vertical to four units horizontal and are not less than one unit vertical to 20 units horizontal.

(2) Subsection (1) does not apply if a written report has been prepared that confirms that an alternative design for the final slopes is acceptable, having regard to the slope stability of the deposited waste and final cover, the potential for erosion of the final cover, the proposed end use of the site and the infiltration requirements for ground water protection.

6.12.2 Approval Guidelines

The final slopes for a landfill should not normally exceed one unit vertical to four units horizontal (1V:4H), or be less than one unit vertical to twenty units horizontal (1V:20H). The final slopes for a particular site, however, should be determined by considering erosion potential and long term maintenance requirements, and may need to be based on meeting the design criteria set out for final cover as described in Section 6.11 of this Guideline.

6.13 Closure Report

Once a landfilling site has reached capacity, final closure of the site must be completed in a manner that is aesthetically pleasing and ensures long term protection of the environment. Site closure activities involve the progressive closure of portions of the fill area as they reach final approved contours. While the closure of some sites, such as a small natural attenuation site, may only require completion of the final soil cover and

limited post-closure monitoring, other sites, such as a large, highly engineered site, likely require a number of constructed works to be completed, and significant ongoing monitoring and maintenance.

The post-closure care period for a landfill depends on the environmental setting, the level of engineering, the required service lives of any engineered works, and the type of waste and remaining contaminant concentrations. The post-closure period may extend from many decades to several hundreds of years. The contaminant concentrations throughout the post-closure period depend on the type of waste deposited in the site and the rate of waste stabilization. Waste stabilization is affected by site design, for example the final cover characteristics, and whether operational procedures such as enhanced infiltration (to promote waste stabilization) have been practiced. For an engineered site, promoting waste stabilization would normally be desirable. For a natural attenuation site, limiting infiltration and leachate production may be more appropriate.

Regulation 232/98 requires that a report be prepared describing site closure activities and post-closure care requirements. The report is to be prepared at least two years before the expected date of closure or by the time 90 percent of the site has been filled. The regulatory requirements are included in Subsection 6.13.1 of this Guideline. A description of the type of information which should be included in a closure report is given as approval guidelines in Subsection 6.13.2. The closure report is intended to update and provide more detail on the closure and post-closure activities described originally in the site design report. The report typically includes a discussion on the include information on:

- notification procedures concerning the upcoming closure of the site,
- completion and ongoing maintenance of the final cover and landscaping,
- the planned end use for the site,
- final construction of any environmental control or monitoring facilities,
- post-closure operation and maintenance requirements including those for any environmental control or monitoring facilities, and
- for private sector landfills, an update of the financial assurance provisions.

6.13.1 Regulatory Requirements

Regulation 232/98 requires that a report on closure and post-closure care be prepared prior to final site closure. This requirement is given in Section 31 of the Regulation and is as follows:

Closure Report

31. The owner and the operator of a landfilling site shall ensure that a written report on activities for the closure of the site, activities for the post-closure care of the site and the proposed end use of the site is prepared not later than the date 90 per cent of the total waste disposal volume is reached or two years before the anticipated date of closure, whichever comes first.

6.13.2 Approval Guidelines

A site closure report must be prepared before a landfill has reached capacity. The report typically includes a discussion that updates and provides further details on the closure and post-closure activities planned for the site. The report typically includes information described in Table 22:

Table 22: Closure Report

Item No.	Information
a.	A plan showing site appearance after closure.
b.	A description of the proposed end use of the site.
c.	Descriptions of the procedures for closure of the site, including: (i) advance notification of the public of the landfill closure; (ii) posting of a sign at the site entrance indicating the landfill is closed and identifying any alternative waste disposal arrangements; (iii) completion, inspection and maintenance of the final cover and landscaping; (iv) site security; (iv) removal of unnecessary structures, buildings and facilities; and (vi) final construction of any control, treatment, disposal and monitoring facilities for leachate, groundwater, surface water and landfill gas.
d.	Descriptions of the procedures for post-closure care of the site, including: (i) operation, inspection and maintenance of the control, treatment, disposal and monitoring facilities for leachate, groundwater, surface water and landfill gas; (ii) record keeping and reporting; and (iii) complaint contact and response procedures.
e.	An assessment of the adequacy of and need to implement the contingency plans for leachate and methane gas.
f.	An updated estimate of the contaminating life span, based on the results of the monitoring to date; and
g.	An update of the cost estimate for financial assurance and the amount which has been provided to the Director, in the case of a privately-owned site.

6.14 Annual Post-Closure Care Report

To help ensure a landfilling site continues to perform as designed, an annual post-closure care report typically is be prepared summarizing the results of site monitoring and maintenance, and the operation of the environmental control works. Post-closure care will be required for as long as contaminants from the site pose a potential concern to the environment. The frequency and period of reporting may be reviewed and adjusted as necessary based on the results of previous post-closure inspection and monitoring.

Regulation 232/98 requires that an annual post-closure care report be prepared. The regulatory requirement is included in Subsection 6.14.1 of this Guideline. A description of the type of information to be included in the report is given in Subsection 6.14.2. These approval guidelines address issues such as:

- the results and assessment of all monitoring programs,

- a discussion of any operational or maintenance problems with any environmental control facilities, and
- for private sector landfills, an update of the financial assurance provisions.

6.14.1 Regulatory Requirements

Regulation 232/98 requires that an annual post-closure care report be prepared following closure of the site. This requirement is given in Section 32 of the Regulation and is as follows:

Annual Post-Closure Care Report

32. The owner and the operator of a landfilling site shall ensure that, within three months after each anniversary of the date on which waste was last placed on the site, an annual report is prepared respecting the post-closure care of the landfilling site, including a summary of results from monitoring programs.

6.14.2 Approval Guidelines

In a similar manner to the annual operations report discussed in Section 6.3 of this Guideline, an annual post-closure report is an important tool used in reviewing post-closure monitoring and maintenance activities, and for helping ensure the site continues to perform as designed. The annual post-closure care report typically includes discussion that include information described in Table 23:

Table 23: Post Closure Report

Task No.	Information
a.	The results and an interpretive analysis of the results of all leachate, groundwater, surface water and landfill gas monitoring, including an assessment of the need to amend the monitoring programs.
b.	An assessment of the adequacy of and need to implement the contingency plans for leachate and methane gas.
c.	An assessment of the operation, maintenance and performance of, and a discussion of any corrective action taken concerning the final cover and any control, treatment, disposal and monitoring facilities for leachate, groundwater, surface water and landfill gas.
d.	A summary of the quantity of any leachate removed, or treated and discharged, from the site, for sites with leachate collection.
e.	An assessment of the need to continue the control, treatment, disposal or monitoring of leachate, groundwater, surface water or landfill gas.
f.	A summary of the public complaints received by the owner and the responses made.
g.	An updated estimate of the contaminating life span, based on the results of the monitoring to date.

h.	An update of the cost estimate for financial assurance and the amount which has been provided to the Director, in the case of a privately-owned site; and
i.	An assessment of the need to amend the frequency and period covered by the post-closure care report.

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SCHEDULES

SCHEDULE 1
Service Lives -- Primary Leachate Collection Systems
(Regulation Sections 6 and 10)

100 Year Service Life

1. *A landfilling site's primary leachate collection system, consisting of perforated collection pipes bedded in a layer of stones with a separating layer above and below the stones, may be assumed to have a service life of 100 years, starting at the earlier of the mid-point of the site's operating life and the tenth anniversary of the first deposit of waste in the waste fill zone, if the following conditions are met:*

    1. *The pipes must be bedded in a continuous layer of stones that extends completely across the base of the waste fill zone and that has a minimum thickness of 0.3 metres on the base side slopes and a minimum thickness of 0.5 metres elsewhere. The stones must have a D_{85} of not less than 37 millimetres, a D_{10} of not less than 19 millimetres, a uniformity coefficient (D_{60}/D_{10}) of less than 2.0, and, when measured by weight, not more than 1.0 per cent of the stones may pass the US #200 sieve.*

    2. *A suitable geotextile or graded granular separator must be installed between the stone layer and the overlying waste and between the stone layer and any underlying soil or liner.*

    3. *The perforated leachate collection pipes must be made of high density polyethylene (HDPE), with a minimum internal diameter of 150 millimetres and with perforations not less than 12 millimetres in diameter located along and around the pipe so that,*

        i. *the hydraulic capacity of the perforations can readily accommodate the expected quantity of leachate,*
        ii. *leachate that enters the pipes can readily flow within the pipes,*
        iii. *blockage by sedimentation is minimized, and*
        iv. *the structural integrity of the pipes is maintained.*

    4. *The perforated leachate collection pipes must be bedded in the stones so that there is at least 250 millimetres of stones above the pipes and at least 50 millimetres of stones below the pipes.*

    5. *The perforated leachate collection pipes must be placed across the base of the waste fill zone, excluding the base side slopes, and spaced so that the drainage path before leachate can potentially intercept a collection pipe is not more than 50 metres in length.*

    6. *The leachate collection pipes must have adequate structural integrity to withstand impacts from waste placement and other site operations and to withstand the weight of the waste, cover material and any structures that may be located over them.*

7. *Leachate collection pipes must be inspected at least annually for the first five years after placement of waste overtop of each pipe and then as often as future inspections indicate to be necessary.*

8. *Leachate collection pipes must be cleaned whenever an inspection indicates that cleaning is necessary.*

9. *Leachate must be removed from the collection system in order to avoid obstructions to leachate flows within the system.*

10. *The base of the waste fill zone must be contoured to provide minimum surface grades of 0.5 per cent toward the leachate collection pipes.*

11. *Sludge must not be deposited in the waste fill zone in a manner that would allow sludge to move into the leachate collection system and promote biological clogging.*

75 Year Service Life

2. *A landfilling site's primary leachate collection system, consisting of perforated collection pipes bedded in a layer of stones with a separating layer above and below the stones, may be assumed to have a service life of 75 years, starting at the earlier of the mid-point of the site's operating life and the tenth anniversary of the first deposit of waste in the waste fill zone, if all of the conditions set out above for a 100 year service life are met with the following changes:*
    1. *The requirement that the layer of stones in which the pipes are bedded have a minimum thickness of 0.5 metres elsewhere than the base side slopes is changed to a requirement that the layer have a minimum thickness of 0.3 metres elsewhere than the base side slopes.*
    2. *The requirement that the perforated leachate collection pipes be bedded in the stones so that there is at least 250 millimetres of stones above the pipes and at least 50 millimetres of stones below the pipes must be met, but local thickening of the layer of stones is acceptable.*
    3. *The requirement that the perforated leachate collection pipes be spaced so that the drainage path before leachate can potentially intercept a collection pipe is not more than 50 metres in length is changed to a requirement that the pipes be spaced so that the drainage path before leachate can potentially intercept a collection pipe is not more than 25 metres in length.*

60 Year Service Life

3. *A landfilling site's primary leachate collection system, consisting of perforated collection pipes bedded in a layer of stones with a separating layer above and below the stones, may be assumed to have a service life of 60 years, starting at the earlier of the mid-point of the site's operating life and the tenth anniversary of the first deposit of waste in the waste fill zone, if all of the conditions set out above for a 100 year service life are met with the following changes:*

    1. *The requirement that the layer of stones in which the pipes are bedded have a minimum thickness of 0.5 metres elsewhere than the base side slopes is changed to a requirement that the layer have a minimum thickness of 0.3 metres elsewhere than the base side slopes.*

2. *The requirement that the perforated leachate collection pipes be bedded in the stones so that there is at least 250 millimetres of stones above the pipes and at least 50 millimetres of stones below the pipes must be met, but local thickening of the layer of stones is acceptable.*

4. *In this Schedule,*
   (a) *D_{85} for stones in a stone layer is the stone diameter such that, when measured by weight, 85 per cent of the stones in the layer have a smaller diameter;*
   (b) *D_{60} for stones in a stone layer is the stone diameter such that, when measured by weight, 60 per cent of the stones in the layer have a smaller diameter; and*
   (c) *D_{10} for stones in a stone layer is the stone diameter such that, when measured by weight, 10 per cent of the stones in the layer have a smaller diameter.*

SCHEDULE 2
Service Lives -- Secondary Leachate Collection Systems
(Regulation Sections 6 and 10)

1000 Year Service Life

1. *A landfilling site's secondary leachate collection system, consisting of perforated collection pipes bedded in a layer of stones with a separating layer above and below the stones, may be assumed to have a service life of 1000 years, starting at the earlier of the mid-point of the site's operating life and the tenth anniversary of the first deposit of waste in the waste fill zone, if the following conditions are met:*

    1. *The pipes must be bedded in a continuous layer of stones that extends completely across the base of the waste fill zone, including the base side slopes, and that has a minimum thickness of 0.3 metres. The stones must have a D_{85} of not less than 37 millimetres, a D_{10} of not less than 19 millimetres, a uniformity coefficient (D_{60}/D_{10}) of less than 2.0, and, when measured by weight, not more than 1.0 per cent of the stones may pass the US #200 sieve.*

    2. *A suitable geotextile or graded granular separator must be installed between the stone layer and any underlying soil or liner and between the stone layer and any overlying material.*

    3. *The perforated leachate collection pipes must be made of high density polyethylene (HDPE), with a minimum internal diameter of 150 millimetres and with perforations not less than 12 millimetres in diameter located along and around the pipe so that,*

        i. *the hydraulic capacity of the perforations can readily accommodate the expected quantity of leachate,*
        ii. *leachate that enters the pipes can readily flow within the pipes,*
        iii. *blockage by sedimentation is minimized, and*
        iv. *the structural integrity of the pipes is maintained.*

    4. *The perforated leachate collection pipes must be bedded in the stones so that there is at least 250 millimetres of stones above the pipes and at least 50 millimetres of stones below the pipes. Local thickening of the layer of stones is acceptable.*

    5. *The perforated leachate collection pipes must be placed across the base of the waste fill zone, excluding the base side slopes, and spaced so that the drainage path before leachate can potentially intercept a collection pipe is not more than 100 metres in length.*

    6. *The leachate collection pipes must have adequate structural integrity to withstand impacts from waste placement and other site operations and to withstand the weight of the waste, cover material and any structures that may be located over them.*

    7. *Leachate collection pipes must be inspected at least annually for the first five years after the initial production of leachate from the secondary leachate*

collection system and then as often as future inspections indicate to be necessary.

8. *Leachate collection pipes must be cleaned whenever an inspection indicates that cleaning is necessary.*

9. *Leachate must be removed from the collection system in order to avoid obstructions to leachate flows within the system.*

10. *The base of the waste fill zone must be contoured to provide minimum surface grades of 0.5 per cent toward the leachate collection pipes.*

2. In this Schedule,

(a) *D_{85} for stones in a stone layer is the stone diameter such that, when measured by weight, 85 per cent of the stones in the layer have a smaller diameter;*

(b) *D_{60} for stones in a stone layer is the stone diameter such that, when measured by weight, 60 per cent of the stones in the layer have a smaller diameter; and*

(c) *D_{10} for stones in a stone layer is the stone diameter such that, when measured by weight, 10 per cent of the stones in the layer have a smaller diameter.*

SCHEDULE 3
Service Lives -- Geomembrane Liners
(Regulation Sections 6 and 10)

Primary Liner -- 150 Year Service Life

1. The geomembrane used as part of a landfilling site's primary liner may be assumed to have a service life of 150 years, starting at the earlier of the mid-point of the site's operating life and the tenth anniversary of the first deposit of waste in the waste fill zone, if the following conditions are met:

    1. The geomembrane must be made of high density polyethylene (HDPE) and must have a thickness of at least 1.5 millimetres.

    2. The oxidative induction time of the geomembrane must exceed,
        i. 100 minutes, as determined by ASTM D3895-95 (American Society for Testing and Materials Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry), as it may be amended from time to time, or
        ii. 250 minutes, as determined by ASTM D5885-95 (American Society for Testing and Materials Standard Test Method for Oxidative-Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry), as it may be amended from time to time.

    3. The oxidative induction time of the geomembrane after oven aging at 85 degrees Celsius for 90 days, as described in ASTM D5721-95 (American Society for Testing and Materials Standard Practice for Air-Oven Aging of Polyolefin Geomembranes), as it may be amended from time to time, must exceed,
        i. 80 per cent of the value for the original geomembrane, as determined by ASTM D3895-95 (American Society for Testing and Materials Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry), as it may be amended from time to time, or
        ii. 80 per cent of the value for the original geomembrane, as determined by ASTM D5885-95 (American Society for Testing and Materials Standard Test Method for Oxidative-Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry), as it may be amended from time to time.

    4. The geomembrane must be installed in direct and uniform contact with a suitable foundation or clayey liner.

    5. The geomembrane must be protected against puncturing and load-induced damage at all times, including during installation.

    6. During installation, care must be taken to,
        i. remove wrinkles in the geomembrane,
        ii. minimize stress concentration,
        iii. ensure high quality seams,
        iv. minimize differential settlement,

v. minimize exposure to ultraviolet light,
vi. prevent damage due to sliding,
vii. prevent damage due to installation in cold conditions, and
viii. prevent damage due to rodents.

Secondary Liner -- 350 Year Service Life

2. The geomembrane used as part of a landfilling site's secondary liner may be assumed to have a service life of 350 years, starting at the earlier of the mid-point of the site's operating life and the tenth anniversary of the first deposit of waste in the waste fill zone, if all of the conditions set out above for a 150 year service life are met with the following change:

    1. The requirement that the geomembrane have a thickness of at least 1.5 millimetres is changed to a requirement that the geomembrane have a thickness of at least 2.0 millimetres.

SCHEDULE 4
Service Lives -- Compacted Clayey Liners
(Regulation Sections 6 and 10)

Unlimited Service Life

1. A landfilling site's compacted clayey liner may be assumed to have an unlimited service life if the following conditions are met:

    1. The liner must be,
        i. at least 0.75 metres thick and compacted in at least five lifts, or
        ii. at least 0.6 metres thick and compacted in at least four lifts, if the liner is not constructed over a leachate collection system and is not used in conjunction with a geomembrane as part of a composite liner.

    2. Each of the lifts in which the liner is compacted must be not more than 0.15 metres in compacted thickness.

    3. Appropriate mineralogical studies or other leachate compatibility studies must indicate that the clayey material is not likely to experience a significant increase in hydraulic conductivity due to interaction with leachate.

    4. During installation, care must be taken to,
        i. control soil properties and water content,
        ii. ensure the breakup of clods,
        iii. control lift thickness and compaction,
        iv. remove stones larger than 100 millimetres,
        v. prevent desiccation of the compacted clayey liner,
        vi. prevent damage to the compacted clayey liner due to freezing,
        vii. prevent damage to the compacted clayey liner from vehicular traffic,
        viii. prevent damage to the compacted clayey liner due to rodents, and
        ix. prevent damage to the compacted clayey liner due to differential settlement.

    5. The report of a suitably qualified geotechnical engineer must confirm that there is no evident cracking in the constructed liner or significant occurrence of clods, stones, branches or other material that could shorten the service life of the constructed liner or significantly increase the hydraulic conductivity.

SCHEDULE 5
Groundwater, Leachate and Surface Water Monitoring Parameters

Parameter Group	Parameter			
	Column 1	Column 2	Column 3	Column 4
	Comprehensive List for Groundwater and Leachate	Indicator List For Groundwater and Leachate	Comprehensive List for Surface Water	Indicator List for Surface Water
Inorganics				
	Alkalinity	Alkalinity	Alkalinity	Alkalinity
	Ammonia	Ammonia	Ammonia	Ammonia
	Arsenic		Arsenic	
	Barium	Barium	Barium	
	Boron	Boron	Boron	
	Cadmium		Cadmium	
	Calcium	Calcium		
	Chloride	Chloride	Chloride	Chloride
	Chromium		Chromium	
	Conductivity	Conductivity	Conductivity	Conductivity
	Copper		Copper	
	Iron	Iron	Iron	Iron
	Lead		Lead	
	Magnesium	Magnesium		
	Manganese			
	Mercury		Mercury	
	Nitrate	Nitrate	Nitrate	Nitrate
	Nitrite		Nitrite	Nitrite
	Total Kjeldahl Nitrogen		Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen
	pH	pH	pH	pH
	Tota lPhosphorus		Tota Phosphorus	Total Phosphorus
	Potassium			
	Sodium	Sodium		
	Suspended Solids (Leachate Only)	Suspended Solids (Leachate Only)	Suspended Solids	Suspended Solids
	Total Dissolved Solids	Total Dissolved Solids	Total Dissolved Solids	Total Dissolved Solids
	Sulphate	Sulphate	Sulphate	Sulphate

	Zinc		Zinc	
Volatile Organics				
	Benzene			
	1,4 Dichlorobenzene			
	Dichloromethane			
	Toluene			
	Vinyl Chloride			
Other Organics				
	Biochemical Oxygen Demand (BOD_5) (Leachate Only)	Biochemical Oxygen Demand (BOD_5) (Leachate Only)	Biochemical Oxygen Demand (BOD_5)	Biochemical Oxygen Demand (BOD_5)
	Chemical Oxygen Demand	Chemical Oxygen Demand	Chemical Oxygen Demand	Chemical Oxygen Demand
	Dissolved Organic Carbon	Dissolved Organic Carbon		
	Phenol		Phenol	Phenol
Field Parameters				
			Temperature	Temperature
	pH	pH	pH	pH
	Conductivity	Conductivity	Conductivity	Conductivity
			Dissolved Oxygen	Dissolved Oxygen
			Flow	Flow

DEFINITIONS

REGULATORY DEFINITIONS

The definitions of terms used in Regulation 232/98 are given in Section 1 of the Regulation and are as follows:

1. (1) In this Regulation,
"base side slope" means any portion of the base of the waste fill zone extending from ground surface downward at an angle steeper than one unit vertical to four units horizontal;
"buffer area" means that part of a landfilling site that is not waste fill area;

"contaminant attenuation zone" means a three-dimensional zone that,

a. is located on land adjacent to a landfilling site,
b. is in the subsurface or extends into the subsurface, and
c. is used or is intended to be used for the attenuation of contaminants from the landfilling site to levels that will not have an unacceptable impact beyond the boundary of the zone;

"contaminating life span" means,

(a) in respect of a landfilling site, the period of time during which the site will produce contaminants at concentrations that could have an unacceptable impact if they were to be discharged from the site, and
(b) in respect of a landfilling site and a contaminant or group of contaminants, the period of time during which the site will produce the contaminant or a contaminant in the group at concentrations that could have an unacceptable impact if they were to be discharged from the site;

"engineered facility" means anything affixed to or made part of land that is intended to be a functional element or feature of a landfilling site for more than five years and that is created or put in place by human activity;

"maximum waste loading" means, for a landfilling site, the total waste disposal volume divided by the area of the waste fill area;

"primary leachate collection system" means the uppermost leachate collection system below the waste fill zone;

"primary liner" means the uppermost liner below the waste fill zone;
"secondary leachate collection system" means a leachate collection system located below the primary leachate collection system;

"secondary liner" means a liner located below the primary liner;

"service life" means the period of time during which a properly maintained engineered facility will function in accordance with the performance specifications for its design;

"total waste disposal volume" means, for a landfilling site, the maximum volume of waste, including the volume of any daily or intermediate cover, to be deposited at the site in the space extending from the base of the waste fill zone or the top of any engineered facilities located on the base of the site to the bottom of the final cover;

"unacceptable impact" means interference with existing or potential reasonable uses of,

(a) land,
(b) ground water in or under land, or
(c) surface water on land;

"waste fill area" means the area on the surface of the landfilling site beneath which or above which waste is disposed of by landfilling;

"waste fill zone" means the three-dimensional zone in which waste is disposed of by landfilling.

(2) The definitions in section 1 of Regulation 347 of the Revised Regulations of Ontario, 1990 also apply to this Regulation.

(3) For the purpose of better understanding the definition of "engineered facility" in subsection (1), the following things are examples of common engineered facilities, if they are intended to be functional elements or features of a landfilling site for more than five years:

1. Berms.
2. Drainage ditches.
3. Liners.
4. Covers.
5. Pumps.
6. Facilities to detect, monitor, control, collect, redirect or treat leachate, surface water or ground water.
7. Facilities to detect, monitor, control, collect, redirect, treat, utilize or vent landfill gas.