Supporting Document 4

Facility Characteristics Report

Waste Management of Canada Corporation

West Carleton Environmental Centre Landfill Footprint Expansion

FACILITY CHARACTERISTICS REPORT

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1. Introduction

1.1 Background

Waste Management of Canada Corporation (WM) is undertaking an Environmental Assessment (EA) for a proposed undertaking consisting of the provision of a new landfill footprint at the existing Ottawa Waste Management Facility (Ottawa WMF). The new landfill footprint will be one component of the proposed West Carleton Environmental Centre (WCEC). The existing Ottawa WMF is located on Lots 3 and 4, Concession 3 in the former Township of Huntley, formerly in the Township of West Carleton, now the City of Ottawa near the intersection of Carp Road and Highway 417.

To date WM has undertaken and received approval of a Terms of Reference (ToR) for identification and assessment of a new landfill footprint as part of the WCEC. The study area considered in the ToR are lands within the area bounded by Highway 417, Carp Road and Richardson Sideroad, as shown in Figure FCR-01. WM presently owns or has agreements to purchase lands within this area. Two distinct landfill development envelopes were presented in the ToR and these were identified by applying the following constraints within the study area:

- Ownership of land by WM or the option to purchase land;
- Existing natural environment features;
- Land use constraints; and,
- Perimeter buffer zones.

The development envelopes are referred to by their proximity to the Ottawa WMF, namely to the west of William Mooney Road (West Envelope) and to the north of the Ottawa WMF (North Envelope). The West and North Envelopes have been identified as the areas within which the Alternative Methods for Carrying out the Undertaking will be analyzed in the EA.

A *Conceptual Design Report* (CDR) was prepared which presented information on four footprint options within the development envelopes initially identified in the ToR. The information provided for each option included:

- location within the development envelopes including buffer zones to property boundaries and sensitive environmental features;
- configuration of side slopes and height;
- estimated traffic levels;
- leachate generation rate; and,
- other design and operational assumptions.

Comparative analyses of footprint options presented in the CDR were carried out by the technical disciplines which are part of the project team. The analyses led to the selection of Option 2 as the preferred footprint. Option 2 is located within the central part of the north envelope and north of the existing landfill as shown in Figure FCR-02.

Option 2 was the basis of further design development which is presented in this *Facility Characteristics Report (FCR).* The landfill design concept presented in the FCR is the subject of a detailed impact assessment by the technical disciplines which will determine the net effects that will be caused, or that might reasonably be caused, on the environment (i.e., the advantages and disadvantages to the environment). The detailed impact assessment includes consideration of any mitigation that might be necessary to reduce or eliminate impacts, and the appropriate monitoring, contingency and impact management plans.

1.2 Objectives of Document

The FCR presents preliminary design and operations information for the preferred new landfill footprint, defined as Option 2 in the CDR. This FCR provides information on all main aspects of landfill design and operations including:

- site layout design;
- surface water management
- leachate management;
- gas management; and,
- landfill development sequence and daily operations.

The FCR also provides estimates of parameters relevant to the detailed impact assessment including estimates of leachate generation, contaminant flux through the liner system, landfill gas generation, and traffic levels associated with waste and construction materials haulage.

2. Existing Site Characteristics

2.1 Existing Setting

The Ottawa WMF is located on Lots 3 and 4, Concession 3 in the former Township of Huntley, formerly in the Township of West Carleton, now the City of Ottawa near the intersection of Carp Road and Highway 417. The landfill at the Ottawa WMF occupies 35 hectares (ha) within a 104 ha site bordered by City of Ottawa Road 5 (Carp Road) to the east, Highway 417 to the south, William Mooney Road to the west, and private lands and Richardson Side Road to the north as shown in Figure FCR-01.

Land uses surrounding the site include agriculture, aggregate extraction and processing, concrete production, commercial, and residential. The lands immediately to the east of Carp Road contain a quarry and aggregate processing plant and two concrete batch plant operations. A small industrial operation, Laurysen Kitchens, exists immediately north of the existing landfill on the west side of Carp Road.

2.2 Existing Operations

The existing conditions at the Ottawa WMF are shown in Figure FCR-02. The landfill operates under Provisional Certificate of Approval No. A461002 and is licensed to receive domestic, commercial and non-hazardous solid industrial wastes from within the Province of Ontario. Communities utilizing the landfill have included the City of Ottawa as well as the Town of Smith Falls and the Townships of Beckwith, Carleton Place, Montague and Mississippi Mills (also referred to as the “Good Neighbour Zone”). As of the preparation of this report the landfill has reached its approved capacity. The closed south cell is a former landfill (historically known as the ‘Rump Dump’) which is separate from and situated south of the existing landfill, shown on Figure FCR-02.

Current activities at the Ottawa WMF include the following:

- Landfill and waste processing operations;
- Public recycling drop-off facility (including electronics recycling);
- Drop-off facility for used construction and renovation materials (a partnership with Habitat for Humanity);
- Leachate management operations (discussed further in Section 2.4);
- Landfill gas management operations (discussed further in Section 2.5); and
- Monitoring and site management activities (discussed further in Section 2.6).

The majority of site traffic is from the south (417 and northbound Carp Road).

2.3 Stormwater Management

The Ottawa WMF falls within the Huntley Creek subwatershed, which drains into the Carp River located approximately 4 km to the northeast of the site. Currently there is no direct surface discharge to this subwatershed from the existing landfill and its associated operations. The site is underlain by relatively permeable soils and surface water infiltrates to the shallow water table via three defined recharge areas, two of which have sedimentation forebays. These are identified in Figure FCR-02 as SWMF #1/Depression #3; SWMF #2/Depression #1; and Depression #2.

Depressions #4 and #5 are located to the north of the existing landfill adjacent to Carp Road. These are the result of historic aggregate extraction operations and function as groundwater recharge areas similar to the other noted ponds/depressions but do not accept drainage from the existing landfill.

2.4 Leachate Management

The approximate eastern third of the existing landfill was constructed with a geosynthetic liner and leachate collection system. The western two-thirds of the landfill is unlined, and few records exist regarding historical excavation depths, previous landfilling practices, and the base which existed beneath the unlined portion of the mound. The unlined portion of landfill has resulted in an eastward-migrating leachate plume. Groundwater impacts are being addressed through the operation of a series of groundwater purge wells located along the eastern perimeter of the site. Collected leachate and impacted groundwater are being discharged to the City of Ottawa's sanitary sewer system.

Other leachate control measures in place at the site include:

- Final cover has been applied to the landfill. The final cover consists of an engineered soil cover over most of the waste with a portion covered by geomembrane cap (termed the 'beanie cap').
- Poplar tree plantations are maintained in an area south of the landfill. These plantations are irrigated with a mixture of surface pond water and leachate.
- Approval was recently received from the MOE for a sequencing-batch reactor (SBR) system to pre-treat leachate from the landfill prior to discharge to the City sewer system.

2.5 Gas Management

Landfill gas is collected by an active extraction system which includes over 180 vertical wells and 1,600 m of horizontal piping installed within and adjacent to the landfill. The geomembrane 'beanie' cap contributes to the collection of landfill gas by reducing the venting of gas to the atmosphere.

Collected gas is piped to a Gas-to-Energy Plant which can generate up to 6.4 MW of energy under current gas generation rates, as well as to a flaring facility which includes enclosed and candlestick flares.

In addition to the gas extraction system, an air barrier system has been installed along the eastern boundary of the site in response to the detection of subsurface migration of landfill gas from the existing landfill at this location. The air barrier system injects clean air into the subsurface via a series of wells to create a pressure barrier limiting the subsurface migration of gas.

2.6 Monitoring and Site Management Activities

Monitoring and site management activities currently undertaken by WM include the following:

- Operational monitoring and maintenance of Engineered Facilities including:
  - Purge Well System:
    - Quality and volume of water discharged to sewer;
    - Water levels in purge wells;
    - Regular preventative maintenance of pumps, controls and related components.
  - Landfill Gas Extraction System
    - Daily operational monitoring;
    - Weekly system balancing;
    - Regular preventative maintenance on collection and blower systems;
    - Quarterly reporting to MOE.
- Environmental monitoring including:
  - Groundwater monitoring including measurement of groundwater elevation (monthly or annually, depending on monitor location), and sampling/ analysis for various indicator parameters (once or twice annually, depending on monitor location).
  - Surface water monitoring in various ponds and ditches around the site, including measurement of surface water elevations (monthly or annually, depending on location), and sampling/analysis for various indicator parameters (once or twice annually, depending on location).

  - Landfill gas monitoring on a monthly basis using a hand-held multi-gas monitoring instrument in on-site gas monitoring wells.
  - Annual reporting/interpretation of monitoring results.
- Regular visual inspections of the landfill cover, as well as surface air emissions surveys to determine where gas extraction vacuum needs to be increased.
- General site housekeeping inspections including dust, litter, and cleanliness of site roadways.
- Response to odour complaints received from site neighbours.

As a condition of the ECA for the existing landfill, monitoring and site management activities are outlined in an EMP. The annual monitoring and site management activities undertaken at the existing landfill are documented in an annual report. A copy of previous annual reports is available at http://wcec.wm.com/. For the development and operation of the new landfill footprint these monitoring and site management activities will evolve as necessary to include the new landfill in compliance with good management practices and regulatory requirements.

3. Proposed Design

3.1 Waste Stream

3.1.1 Service Area

An Ontario-wide service area is being requested for the new landfill. It is intended that the landfill will largely receive residual wastes from generators within the City of Ottawa with smaller volumes from neighbouring municipalities.

3.1.2 Waste Capacity Requirements

The new landfill capacity is based on WM's assessment that there is a sustainable market opportunity to receive up to 400,000 tonnes per year of waste over an approximate 10 year planning period. The landfill airspace requirement corresponding to this opportunity is estimated at 6.5 million m^3 which includes daily cover material. The airspace requirement is based on the following:

a) 400,000 T/yr over a 10 year period equates to a total waste tonnage of 4,000,000 T.

b) In-place waste density has been estimated as 0.725 T/m^3. Waste density is influenced by numerous factors including waste type and operating methods, although this value is considered reasonable for a large, modern landfilling facility. At this density 4,000,000 T corresponds to a waste volume of 5,517,000 m^3.

c) A waste to daily cover ratio of 6:1 (approximately 15%) based on WM operating experience which provides a balance between the efficient use of cover material and management of nuisance effects. At this ratio the total volume of daily cover soil would be 920,000 m^3.

d) The total volume of waste and daily cover based on these parameters is 6,437,000 m^3. For planning purposes the required airspace requirement is approximated as 6,500,000 m^3.

e) The volume occupied by the final cover used to close the landfill site is not included in the noted airspace requirement.

3.1.3 Waste Quantities and Characteristics

WM anticipates receiving an average of 400,000 T/yr of waste over a 10 year period, consisting primarily of institutional, commercial, and industrial waste, as well as residential waste and

'Special' waste. 'Special' waste consists primarily of impacted soils that may be used for daily or interim cover.

The composition of the waste stream is expected to vary based on actual waste sources.

3.2 Landfill Design

3.2.1 General Considerations

The new landfill will be designed in compliance with the requirements of Ontario Regulation 232/98. The regulation allows two approaches for designing a landfill to protect groundwater quality – a site specific design, or a generic design. The site specific approach allows a proponent to design the leachate controls (e.g., base liner, leachate collection system, final cover) to suit the site setting provided that the Reasonable Use limits for groundwater quality are met. The generic approach allows the proponent to select one of two generic designs which have been developed such that the Reasonable Use limits are met within a broad range of hydrogeologic settings. WM intends to design the site with the Generic II – Double Liner system as specified in the regulation, or MOE-approved equivalent.

3.2.2 Footprint Location and Buffers

The layout of the new footprint is shown in Figure FCR-03 and is described as follows:

- The southern half of the footprint is on WM-owned lands and the northern half is on lands that WM has options to purchase.
- A 100 m buffer is maintained between the north limit of the footprint and the private lands to the north (e.g., lands which front onto Richardson Side Road) in accordance with Ontario Regulation 232/98.
- An approximate 350 m buffer is maintained between the east limit of the footprint and Carp Road.
- A light industrial building (e.g., the Laurysen building) is situated in the eastern portion of WM optioned lands. WM anticipates using the Laurysen building for equipment storage/maintenance or waste diversion activities in the future.
- An approximate 45 to 50 m buffer is maintained between the toe of slope of the existing and new landfills. This allows sufficient area for a new waste haul road to the new footprint and for maintenance and monitoring access.

- The location of the west limit of the footprint was determined by maintaining the noted buffers and providing the required 6,500,000 m^3 capacity while maintaining landfill elevation below 158 mASL (as reported in the CDR) and maintaining side slopes required by Ontario Regulation 232/98 (e.g., varying from 4H to 1V to 5%.). This results in an approximate 146 m buffer between the west limit of the footprint and William Mooney Road. This buffer preserves a portion of the existing woodlot within the west part of the WM-owned lands.

3.2.3 Final Contours

The final contours of the landfill are shown in Figure FCR-03 and reflect a rectangular landform with a maximum elevation (top of final cover) of 155.7 mASL. This elevation is approximately 30.7 m above the surrounding existing grade. By comparison, the maximum elevation of the existing Ottawa WMF landfill is approximately 172 mASL or approximately 47 m above the surrounding existing grade. The contours reflect maximum side slopes of 4H to 1V, and a minimum slope of 5%. The total footprint area of the new landfill is 37.8 ha.

3.2.4 Base Grades

The base grades for the landfill have been developed such that the base of the landfill liner system will be at or above the predicted maximum shallow groundwater level. The approximate elevation contours for the base of the liner system are shown in Figure FCR-04.

The design and layout of the new landfill liner and leachate collection system are discussed in Section 5.1.1.

3.2.5 Seismic Slope Stability Analysis

Slope stability analyses were performed to assess the potential effect of ground motion due to seismic activity on the slope stability of the landfill and liner system.

Unlike plate boundary regions where the rate and size of seismic activity is directly correlated with plate interaction, eastern Canada is part of the stable interior of the North American Plate. The damage potential of an earthquake is determined by how the ground moves. Expected ground motion can be calculated on the basis of probability, and the expected ground motions are referred to as ‘seismic hazard’. Ground motion probability values are given in terms of probable exceedance, that is, the likelihood of a given horizontal acceleration or velocity being exceeded during a particular period. The probability used in the 2010 National Building Code of Canada is 0.000404 per annum, equivalent to a 2-per-cent probability of exceedance over 50 years.

Seismic slope stability analyses using the pseudo-static factor of safety approach was used. In this method, a seismic coefficient is specified to represent the effect of the inertial forces imposed by the earthquake upon the potential failure mass. A factor of safety is defined in the conventional manner as the ratio of the ultimate shear strength of the slope elements to the maximum shear stresses induced in those elements by seismic and static loadings. The peak ground acceleration at the site was determined using the 2010 National Building Code Seismic Hazard Calculator of Natural Resources Canada. The National Building Code peak ground acceleration at the site is 0.31 g.

With the selection of appropriate liner materials, the seismic slope stability analyses results suggested that the slope stability of the landfill and liner system can have an adequate factor of safety under seismic condition with the peak ground acceleration. Detailed assessment of stability of the landfill and liner system will be carried out using updated input parameters during the detailed design of the landfill to confirm that appropriate materials are selected and to ensure that adequate factor of safety is achieved.

Details of the analyses and results are presented in Appendix A.

3.2.6 Site Entrance and Roads

The site entrance for the new landfill will be located off Carp Road approximately 640 m south of Richardson Side Road as shown on Figure FCR-03. The entrance to the existing Ottawa WMF was deemed not ideal due to poor sight lines along Carp Road to the north, and close proximity to entrances of industrial operations on the east side of Carp Road. The proposed entrance location improves sight lines to the north, maintains adequate separation from the intersection of Richardson Side Road and Carp Road, and increases distance from the intersection of Carp Road and Highway 417.

The layout of site roads is shown in Figure FCR-03 and is summarized as follows:

- The main site entrance off Carp Road will accommodate waste haulage and construction traffic, as well as traffic related to public waste drop-off facility users (see Section 3.2.9).
- The length of the entrance roadway leading to the scale facility is approximately 400 m and will incorporate several inbound lanes. This configuration will provide ample truck queuing thus eliminating potential for queuing on Carp Road.
- The main waste haul road follows the east and south perimeters of the new footprint. The haul road will be developed progressively as required by landfill development. The entire length of entrance and haul roads outside the landfill footprint will be paved.
- A granular-surfaced maintenance/service road will be constructed progressively around the entire landfill perimeter.

3.2.7 Scale Facility

A new scale facility will be constructed immediately east of the new footprint. This is expected to incorporate two scale decks for inbound/outbound waste trucks. The scale operator will be located in scale house situated between the scale decks. By-pass lanes will be situated on both sides of the facility.

3.2.8 Office and Equipment Maintenance Facility

WM anticipates utilizing two existing structures on the Laurysen property as the new landfill office and equipment maintenance facility. The Laurysen office building can be converted into the new landfill office and its location provides good sightlines to the site entrance and east perimeter of the landfill.

3.2.9 Other WCEC Facilities

WM anticipates that the public recycling drop-off facility (including electronics recycling) and drop-off facility for used construction and renovation materials (a partnership with Habitat for Humanity) will continue to operate. A decision has not yet been taken whether these operations will continue in their existing location (e.g., near the existing landfill entrance) or whether new facilities will be constructed as part of the new footprint.

It is feasible to locate a new drop off facility in the lands between Carp Road and the eastern limit of the new landfill, and a concept for a grade-separated drop-off facility that would accommodate roll-off bins is shown in Figure FCR-03. Positive features of this concept include:

- Diversion activities are in clear sight of Carp Road which helps promote waste diversion to the public;
- The facility can be readily monitored by site staff given its close proximity to the proposed site office (Laurysen office);
- The capacity can be expanded southward if space for additional bins is required.

WM also intends to continue other diversion operations in the southwest corner of the WM property. The specifics of these operations have not yet been determined, but it is anticipated that these will be accessed via an extension of the new landfill waste haul road. A potential location for some of these operations is shown in Figure FCR-07.

4. Stormwater Management

Stormwater management for the expanded site will be achieved through integration of an existing and proposed system of ditches, culverts, storm sewers and ponds that have been designed to mitigate the impacts of stormwater runoff on water quantity and water quality before discharge. Relevant stormwater management criteria, as identified by MOE in Ontario Regulation 232/98 and related Landfill Standards Guidelines (1998), include:

- Ditching designed to accommodate runoff from a 1:25 year rainfall event;
- Detention of runoff from a 4-hour 25 mm rainfall event; and,
- Attenuation of peak flows to pre-development levels for all rainfall events up to and including the 1:100 year Return Period event.

The stormwater management system for the new landfill will be designed in a manner similar to the existing system reflecting that surface water runoff from the landfill footprint and immediately adjacent areas (e.g., final cover, haul roads) recharges to groundwater and does not directly discharge off-site. The proposed system is shown in Figure FCR-03 and is summarized as follows:

- A new stormwater management (SWM) pond will be situated within Depression #5 located near the northeast corner of the new footprint and will accommodate flow from the new landfill (once capped) and the perimeter maintenance/ service road.
- Two new SWM ponds will be situated within Depression #4 located near the southeast corner of the new footprint. The pond within the western portion of Depression #4 will accommodate flow from the new Waste Haul Road, and the pond in the eastern portion of Depression #4 will replace existing SWMF #1 and Depression #3 (which will be displaced by the new landfill).
- Each of the three new SWM ponds will be designed as two-stage facilities with flow control between the two stages.
- SWMF #2/Depression #1 and Depression #2 will continue to function as at present and are not influenced by drainage from the new landfill.

In each of the new ponds the first stage will be lined and will function not only as a sedimentation pond but also as a containment pond where runoff can be stored in the case of a spill or other emergency. The first stage pond will be designed to retain runoff from the 1:100 Year rainfall.

The second stage of each pond will be unlined to permit recharge to groundwater and will also be sized to accommodate the 1:100 Year runoff. Other design features are anticipated to include:

- The invert of the first stage will be higher than the invert of the second stage and higher than the design water level, to ensure positive drainage.
- The design water level will be for the 1:100 year rainfall event since the SWMF would have no natural positive outlet given the adjacent topography.
- The design water levels would not be higher than adjacent service roads.
- Emergency overflow routes will be defined during detailed design. With no positive outflow, the recharge rate governs the rate of water level reduction and available capacity for the next rainfall event, and it is possible that overflow conditions may be encountered.

Current estimates of runoff flows and volumes for the new SWM facilities are found in Table 4-1.

Table 4-1: New SWM Facilities – Flow and Volume Estimates

Location	Drainage Area (ha)	Q Peak-SCS24hr (m^3/s)		Volume (m^3)
		1:25 yr (84 mm)	1:100 yr (107 mm)	1:100 yr
New Landfill – North SWMF	40.9	1.140	1.597	15663
Access Road – Southwest SWMF	3.3	0.770	1.026	2712
SWMF 1 (1+4) – Southeast SWMF	21.1	0.910	1.290	8073

Estimates of the volume of water that will infiltrate through the second stage (unlined portion) of each pond are provided in Table 4-2.

Table 4-2: New SWM Facilities – Infiltration Estimates from Second Stage of SWM Ponds

Location	Ratio of Runoff to Total Precipitation	Contributing Drainage Area (ha)	Annual Runoff Volume (m^3)	Area of Base of Second Stage (unlined) WM Pond (m^2)	Annual Infiltration per Unit Area (mm/yr)
New Landfill – North SWMF	0.2	40.9	76,048	6,000	12,675
Access Road – Southwest SWMF	0.7	3.3	21,903	1,200	18,253
SWMF 1 (1+4) – Southeast SWMF	0.2	21.1	39,232	3,580	10,959

Fill or excavation will be carried out as required to control drainage and achieve positive grades to appropriate outlets and culverts/storm sewers will be installed, where needed, to convey flows under travelled sections of the site. During detailed design consideration will be given to combining the unlined ponds in Depression #4.

5. Leachate Management

5.1 Proposed Leachate Management System

5.1.1 Leachate Containment and Collection

WM intends to design the leachate control system for the site with the Generic II – Double Liner System as specified in Ontario Regulation 232/98, or MOE-approved equivalent. The Generic II system consists of following components (from top down):

- 0.3 m thick granular/perforated pipe primary leachate collection system (lcs);
- Minimum 0.75 m thick geomembrane/engineered clay composite primary liner;
- 0.3 m thick granular/perforated pipe secondary lcs;
- 0.75 m thick geomembrane/engineered clay composite secondary liner; and
- 1 m thick natural or constructed soil attenuation layer.

The Generic II design also includes suitable separator layers (geotextile or layer of graded granular material) between the waste and underlying primary lcs, and between granular layers and soil or liners.

For planning purposes it has been assumed that the landfill liner system would be developed in approximately eight stages with an area of 47,250 m^2 each. The size of liner development stages may be varied during more detailed design work. The layout of the liner stages is shown in Figure FCR-03 and a typical cross-section through the liner system is shown in Figure FCR-11.

The base grades for the landfill will be sloped to the northeast toward a single low point in the northeast corner of the footprint. The surface of the primary liner will be contoured as a 'washboard' surface oriented north-south. Piping for the primary lcs will be located in valleys between the washboard ridges and will convey leachate to a header pipe located along the north perimeter of the footprint, which will convey leachate to a pumping station in the northeast corner.

The secondary liner surface will also be sloped to the northeast, although the liner surface will be a smooth plane with no washboard contour. A pumping station for the secondary lcs will be located in the northeast corner.

Design contingencies such as a leachate recirculation system, double leachate header pipes and contingency pumping stations will be considered during detailed design.

The layout of the leachate collection systems is shown in Figures FCR-05 and FCR-06. A cross-section through the collection systems is shown in Figure FCR-11.

5.1.2 Final Cover

The final cover is part of the landfill's leachate control system and serves several functions including:

- Physical barrier between landfilled waste and the environment;
- Reduce infiltration into the landfill;
- Reduce the release of landfill gas to the atmosphere thus facilitating gas collection; and,
- Provide a platform for end use implementation.

Ontario Regulation 232/98 requires that landfills following the generic design approach incorporate a final cover which permits a minimum of 150 mm of infiltration annually. The proposed final cover consists of 0.6 m of compacted soil overlain by 0.15 m of vegetated soil and will be designed to permit a minimum of 150 mm of infiltration annually.

5.1.3 Leachate Treatment

<u>Preferred Method</u>

The preferred leachate treatment system for the new landfill consists of leachate pretreatment utilizing an SBR followed by disposal of leachate through discharge to the City of Ottawa sanitary sewer system. On a seasonal basis, pretreated leachate would also be disposed through irrigation of trees on-site.

The collected leachate is pretreated, as required, in order to meet the City of Ottawa Sewer Use By-law. The leachate effluent would then be discharged to an existing forcemain at Carp Road and Highway 417. The effluent would be further treated at the City's Robert O. Pickard Environmental Centre (ROPEC) facility.

Leachate would also be disposed on a seasonal basis through irrigation of poplar and/or willow trees on-site. The leachate may require partial or full on-site treatment using chemical and/or biological processes prior to irrigation. The treated leachate will be discharged to the tree plantation during days with suitable weather conditions. No liquid effluent would leave the WCEC site.

The implementation of sewer disposal and tree irrigation in tandem would allow for maximum operational flexibility at the WCEC. This leachate treatment system would provide for a standing contingency plan, should discharge to the City's sanitary sewer be interrupted for any reason; it would have no limitations with respect to seasonality; and the area required for the tree stand and associated storage pond would be much smaller than that required if tree irrigation was the only disposal method.

Contingency Method

As a contingency evaporator technology could be utilized to dispose of leachate. Leachate from the landfill would be pumped to an equalization tank that will provide storage to handle peaks in leachate generation. The leachate would then be fed to the evaporator for processing. The evaporator system may utilize landfill gas as the energy source to evaporate the leachate or waste heat from the landfill gas co-generation facility. Depending upon the strength of the leachate and the resulting air quality emissions, the leachate may have to be pretreated using a chemical and/or biological process prior to evaporation. These units have been widely used in the U.S. for a number of years for leachate disposal.

Emergency Method

In an emergency (e.g., if the preferred method were unavailable for a period of time) leachate could be trucked to one or more wastewater treatment plants (public or private) outside Ottawa for disposal. The collected leachate may require pretreatment using chemical and/or biological processes if required to meet the quality parameters of the receiving wastewater treatment plant(s). The specific location of such facilities will be subject to agreements and identified as part of the ECA process.

Potential locations for a leachate pretreatment system, tree plantation, as well as for the contingency evaporation system are shown on Figure FCR-07.

5.2 Estimated Leachate Generation Rates

Leachate generation rate is an important parameter used in assessing the operational and environmental performance of a landfill site. It will vary over the operational and post-closure period of the facility and is influenced by factors including precipitation, degree of landfill development, final cover design and state of construction, and other factors. Two cases were considered: a maximum generation rate during the operating period, and the generation rate after closure.

Leachate generation rates were estimated in two steps:

- Infiltration was estimated using the Hydrologic Evaluation of Landfill Performance (HELP) for a range of scenarios that will exist during the operating and post-closure period. For the purposes of this assessment changes in moisture storage within the landfill were assumed to be zero, and the estimated infiltration rate was considered representative of the leachate generation rate (e.g., infiltration = total precipitation – runoff – evapotranspiration = leachate generation rate).
- The generation rate was then estimated by applying the infiltration rate to the areas of the landfill that correspond to these scenarios.

The scenarios considered were as follows:

Newly Constructed Liner Stage

- Represents a newly-constructed liner stage prior to placement of any waste.
- Reflects that the primary leachate collection stone layer is exposed.
- All infiltration into the leachate collection layer is collected as leachate.

Daily Cover

- Represents waste covered by daily cover 0.15 m thick.
- Two soil types modelled to represent a range of soil that might be used for daily cover, with soil properties taken from the HELP model database:
  - sand, effective saturated $k = 5.8 \times 10^{-3}$ cm/s;
  - moderately compacted silty clay, effective saturated $k = 1.2 \times 10^{-6}$ cm/s.
- Both cases modelled as bare soil with no vegetation.
- No runoff is permitted off the covered surface, which is consistent with WM's practice of utilizing impacted soils from the waste stream for daily cover.

Interim Cover

- Represents waste covered by an interim cover 0.30 m thick.
- Two soil types modelled with the same material properties as modelled for daily cover (sand, and moderately compacted silty clay).
- Both cases modelled with a fair stand of grass.
- Two cases modelled for each soil type:
  - no runoff is permitted off the covered surface;
  - runoff permitted from a cover constructed from clean soil, 4H to 1V exterior slope.

Final Cover

- Represents waste following application of final cover.
- Two cases considered representing reasonable minimum/maximum infiltration rates:
  - a minimum infiltration rate of 150 mm/year as specified for the Generic II design in Ontario Regulation 232/98,
  - a reasonable maximum infiltration rate, reflecting a cover as follows:
    - 0.15 m thick vegetated soil layer, effective saturated $k = 5.2 \times 10^{-4}$ cm/s taken from the HELP model database;
    - a barrier layer constructed from gravelly sands that exist on site, measured saturated $k = 3.8 \times 10^{-2}$ cm/s.
    - Assumes that runoff occurs from the cover sloped at 5%.

The estimated infiltration rates for these scenarios are summarized in Table 5-1.

Table 5-1: Leachate Generation for Various Landfill Operating Conditions

Condition	Newly Constructed	Daily Cover		Interim Cover				Final Cover	
Description	No waste placed, LCS exposed.	Sand cover 0.15 m thick, no runoff.	Silty clay cover (mod. Comp.) 0.15 m thick, no runoff.	Sand cover 0.3 m thick, **no runoff.**	Silty clay cover (mod. comp.) 0.3 m thick, **no runoff**.	Sand cover 0.3 m thick, **w/ runoff from 4H to 1V ext. slope**.	Silty clay cover (mod. comp.) 0.3 m thick, **w/ runoff from 4H to 1V ext. slope**.	Gravely sandy soil (local).	Minimum infiltration permitted through the final cover for an Ont. Reg. 232/98 generic design.
Average Annual Leachate Generation (mm)	**546**	**448**	**332**	**474**	**334**	**237**	**21**	**218**	**150**

The approximate maximum leachate generation rate during the landfill operating period is estimated to be 5.1 L/s (annual average) based on the following:

1. Liner stages 1 through 7 have been landfilled to an elevation of approximately 141.5 m (e.g., approaching end of Phase I operations as shown in Figure FCR-08) and covered with interim cover. To be conservative it was assumed that the cover was constructed from sand rather than compacted silty clay.
2. The infiltration rate for 'interim sand cover, 0.3 m thick, no runoff', was applied to the interior 'flat' area of Stages 1-7, estimated to be 237,000 m^2.
3. The infiltration rate for 'interim sand cover, 0.3 m thick, w/ runoff from external 4H to 1V slopes' was applied to the area of the external slopes of Stages 1-7, estimated to be 94,000 m^2.
4. The infiltration rate for 'no waste, lcs exposed' was applied to the area of Stage 8 (approximately 47,000 m^2), reflecting landfilling has just commenced in Stage 8, but essentially entire Stage 8 lcs is exposed.

The maximum leachate generation rate was estimated using conservative assumptions. WM will manage landfill operations to minimize leachate generation. WM will also implement leachate treatment capacity, as required, to manage the leachate generated.

The long-term leachate generation rate reflecting that final cover has been applied to the entire site is estimated to range from 1.8 L/s to 2.7 L/s (annual average). This corresponds to a final cover that permits 150 mm infiltration (e.g., Ontario Regulation 232/98 generic minimum) or 226 mm infiltration (gravely sand final cover) respectively.

Additional information on the HELP modelling, including model input/output summaries for the scenarios examined is presented in Appendix B.

5.3 Assessment of Potential Contaminant Flux through Base Liner System

The detailed hydrogeologic impact assessment will examine potential groundwater quality impacts from the entire WCEC site which includes the new landfill as well as the partially-lined existing landfill. To support the hydrogeologic impact assessment an estimation of potential contaminant migration through the base liner system of the new landfill was prepared and is presented herein.

Numerical analysis was carried out using POLLUTE Version 7.14 to estimate the contaminant concentration at the base of the liner system over time. The POLLUTE model is a well-tested contaminant migration analysis program, and scenarios that can be considered range from simple systems on a natural clayey aquitard to landfill designs with composite liners, multiple barriers, and multiple aquifers.

The model was set up reflecting that the new landfill will incorporate an Ontario Regulation 232/98 G II design. As required by the regulation, the service life of the liner and lcs was considered in the assessment. The primary leachate collection system, and the geomembrane layer of the primary and secondary composite liners were assumed to fail to function at the end of their service lives which are reflected in the Regulation as being 100 years, 150 years and 350 years, respectively.

The leachate parameters used in the model were the same as those selected as the indicator parameters for the hydrogeological impact assessment. Average concentrations of leachate samples collected at the existing Ottawa WMF landfill up to May 2011 were used as shown in Table 5-2.

Table 5-2: Leachate Concentrations Used As Input to the POLLUTE Model

Indicator Parameters	Average Concentrations (mg/L)
Ammonia	1,408
Chloride	2,911
Potassium	1,078
Sodium	2,800
Trichloroethylene	0.003

Note: Concentrations of Trichloroethylene in the samples were reported to be below the detection limit. The average concentration was based on at half of the detection limits.

The model was used to calculate the migration of leachate through the landfill liner system based on infiltration through the final cover after closure using the Hydrologic Evaluation of Landfill Performance (HELP) model. The details of the estimation of the infiltration by the HELP model are described in Section 5.2 of this report. The final cover was assumed to be the more permeable of the two final cover cases considered (e.g., gravelly sand, average annual infiltration of 218 mm).

The maximum concentration at the base of the liner system for each indicator parameter was calculated by the POLLUTE model for two cases: no leachate recirculation, or with recirculation reflecting that collected leachate is added back to the waste mass to provide moisture to enhance biodegradation but without saturating the waste. For the Leachate Recirculation Case, a recirculation rate of 100 mm/a for 50 years was assumed. The model results for both cases model are summarized in Table 5-3.

Table 5-3: Results of the POLLUTE Model

Indicator Parameters	Maximum Concentrations at the Base of the Liner System, mg/L (No Recirculation)	Maximum Concentrations at the Base of the Liner System, mg/L (Leachate Recirculation)
Ammonia	0.046	0.057
Chloride	114	165
Potassium	3.1	5.2
Sodium	79	114
Trichloroethylene	3×10^{-5}	3×10^{-5}

Additional discussion of the results as well as sensitivity analyses are presented in Appendix C.

6. Gas Management

6.1 Proposed Landfill Gas Controls

In accordance with Ontario Regulation 232/98, the new landfill will incorporate an active gas collection system. The design of the system will be developed during EPA–level work, and is anticipated to consist of the following features:

- Active gas collection will start within several years of commencement of waste placement to ensure that landfill odour is controlled. Perforated horizontal collectors will be installed in the landfill as filling progresses.
- Horizontal collector spacing will be determined as filling progresses. Typical spacing may consist of the following:
  - 2 levels of horizontal collectors; one level at approximately 8 m from the landfill base, and the second approximately 16 m from the base;
  - Horizontal spacing between collectors may be approximately 20-30 m;
  - Spacing (vertical or horizontal) would be adjusted as required based on site conditions.
- Leachate collection system piping may be used as additional gas collection points, if required.
- Vertical wells will be installed once the fill thickness is sufficient. Typical well to well spacing may be 60 m but will be adjusted as required based on actual site conditions.
- WM wishes to maximize the beneficial use of the landfill gas. Collected gas will be piped to the existing power generation facility or the flaring facility as required. These facilities would be modified as required to accommodate actual gas flows from the new footprint.

6.2 Assessment of Landfill Gas Generation

Landfill gas is generated when organic matter in the waste decomposes. The rate of landfill gas generation will depend on the amount of waste deposited in the landfill and properties of the waste including moisture content, pH, temperature, type and composition, and nutrients for micro-organisms that break down the waste.

The U.S. EPA Landfill Gas Emissions Model (LandGEM), Version 3.02, was used to estimate generation rates for the new landfill. The model is based on a first-order decomposition rate equation for estimating emissions from the decomposition of landfilled waste in municipal solid waste landfills.

Landfill gas generation rates were estimated based on an annual waste disposal rate of 400,000 tonnes over 10 years.

Two key input parameters in LandGEM are the Methane Generation Rate (k) and the Potential Methane Generation Capacity (Lo). LandGEM provides default values of k and Lo of 0.04 $year^{-1}$ and 100 m^3/Mg respectively for *Conventional* landfills. Default values are also available for *Arid* type landfills (e.g., sites located in areas that receive less than 635 mm (25 inches) of rainfall per year) but are not considered representative for the WM site. The United States *Clean Air Act* (*CAA*) also identifies default k and Lo values of 0.05 $year^{-1}$ and 170 m^3/Mg respectively.

The *LandGEM Conventional* and *CAA* default values were both used to model landfill gas generation rates. The results indicate estimated peak total landfill gas generation rates of 26 million m^3/year (1,800 cfm) and 54 million m^3/year (3,600 cfm) based on the *LandGEM Conventional* and *CAA* default k and Lo values respectively. The model results also indicate that the peak generation rates will occur in one to two years after the end of landfilling. For impact assessment purposes these estimates are considered to define a reasonable range for the new landfill based on the following:

- 635 mm annual precipitation is used by LandGEM to differentiate between *Conventional* and *Arid* landfill types. The annual precipitation at the WM site is more than 900 mm which suggests that using LandGEM *Conventional* default values may underestimate gas generation for the WM site.
- *CAA* default values have been found to over-estimate gas generation rates for typical MSW landfills in eastern Canada and northeastern United States and thus are considered be an upper limit for the WM site.

Additional information related to the landfill gas generation assessment is provided in Appendix D.

7. Development and Operations

7.1 Sequence of Landfill Development

The anticipated landfill development sequence is shown in Figures FCR-08, FCR-09, and FCR-10, and can be summarized as follows:

- Liner Stages 1 and 2 as well as the new site entrance and roads, scale facility, and SWM ponds would be constructed prior to commencement of waste receipt.
- Liner Stages 3 through 8 will be constructed as required by waste receipts. Waste placement will generally occur in two Phases. Phase 1 reflects filling sequentially from Stages 1 to 8 in an overall east to west direction to an elevation of approximately 141.5 mASL. This elevation provides a minimum working surface of approximately 1 ha over the first liner stage, which WM requires for landfill operations. Depending on site specific conditions during operations, WM may periodically choose to fill above elevation 141.5 mASL in Phase 1 (e.g., co-ordination of filling with progress of liner construction).
- In Stage 2, filling will progress east to west between elevation 141.5 mASL and final design contours.
- Final cover construction would commence after waste filling has reached final design contours.

7.2 Site Materials Balance

The new landfill construction will utilize both on-site and imported materials. The soils balance relating to preparatory earthworks is summarized in Table 7-1.

Table 7-1: Earthworks Balance

Earthworks (base grading, perimeter berms, roads, SWM Ponds), All Stages	Volume (m^3)
Base Grading Cut	340,000
Base Grading Fill	55,000
Base Grading Surplus	285,000
Fill Required for Perimeter Berms, Roads, and SWM Ponds	570,000
Granular and Asphalt for Surfacing of Roads	48,000
Net Imported Fill	**333,000**

The base liner, leachate collection system, and final cover will be constructed from imported materials as summarized in Table 7-2.

Table 7-2: Base Liner, Leachate Collection System, and Final Cover Volumes

Component	Volume (m^3)
Attenuation Layer (1 m)	378,000 m^3
Secondary Clay Liner (0.75 m)	284,000 m^3
Secondary Leachate Collection System (0.3 m)	113,000 m^3
Primary Clay Liner (variable thickness to create washboard contour, min 0.75 m)	364,000 m^3
Primary Leachate Collection System (0.3 m)	113,000 m^3
Final Cover (barrier layer 0.6 m)	227,000 m^3
Vegetated Soil (0.15 m)	57,000 m^3
Total	**1,536,000 m^3**

Soils received as part of the waste stream that will be used as daily cover are not reflected in Table 7-1 or 7-2. The daily cover requirement has been estimated at approximately 920,000 m^3 (see Section 3.1.2).

7.3 Traffic Associated with Landfill Construction and Operation

Truck traffic associated with the landfill operation includes trucks hauling waste to the site as well as haulage of construction materials for base grading earthworks, liner, leachate collection system and final cover construction.

WM conducted a traffic analysis for 2005 operating conditions at the existing Ottawa WMF. Landfill operations in 2005 reflected peak activity at the site and is viewed as being conservative relative to the proposed landfill operation. The traffic analysis reflected:

- Between 180 to 230 waste loads per day;
- 25 to 35 trips per AM peak hour;
- 25 to 50 trips per PM peak hour; and,
- One load corresponds to two trips: load in, empty out.

It is recognized that there will be traffic associated with ancillary WCEC facilities including the public waste drop off facilities and waste diversion operations. Estimated traffic movements for these operations are presented under separate cover.

Traffic will also be generated by importing construction materials. Imported material volumes were converted to trips per hour based on a truck capacity equivalent to 10 m^3 of soil/granular in situ, and haulage occurring over a construction season lasting 9 months, 25 working days per month and 10 hours per day.

The proposed site development sequence results in the traffic scenarios as presented in Table 7-3.

Table 7-3: Traffic Scenarios Based on Proposed Development Sequence

1.	**Site Preparation Prior to Landfilling** • Construction of preparatory earthworks (roads, perimeter berm, SWM ponds), and Stage 1 & 2 base liner and lcs (45 trips per hour); • Waste haulage has not commenced.	**Up to 45 trips/hour**
2.	**Routine Phase 1 Operations** • Landfilling in progress (assume max observed during 2005 WMF operations, 50 trips/hour); • Construction of any one of Stages 3 to 8 (range of 14 to 23 trips/hour, assume max of 23 trips/hour); • No final cover construction.	**Up to 73 trips/hour**
3.	**Routine Phase 2 Operations** • All liner stages have been constructed; • Landfilling in progress (assume max observed during 2005 WMF operations, 50 trips/hour); • Final cover construction has not yet commenced.	**Up to 50 trips/hour**
4.	**Phase 2 Operations Approaching Closure** • Landfilling in progress (assume max observed during 2005 WMF operations, 50 trips/hour); • Final cover construction over half of site footprint (13 trips/hour).	**Up to 63 trips/hour**

Appendix E presents the basis of the predicted traffic levels associated with construction activities.

7.4 Operational Characteristics

7.4.1 Landfill Operations

Ontario Regulation 232/98 requires the landfill be designed and operated to ensure that nuisance impacts are minimized, and the regulation requires that the proponent prepare a report describing all aspects of the operation as well as maintenance procedures that will be followed. The detailed Design and Operating Plan will be prepared as part of EPA-level work.

Daily operations will be planned such that:

- The size of the working face is kept to a minimum in order to minimize the area of exposed waste;
- Working face location is adjusted as required and seasonally to provide shelter from prevailing winds;
- Berms are constructed as required to attenuate visual and noise impacts;
- Portable litter fences are routinely used around the working face to capture blowing litter;

- Waste compaction commences immediately after placement and spreading;
- Cover material is readily available and the working face is fully covered at the end of each operating day; and,
- A comprehensive monitoring and maintenance program is implemented which addresses all aspects of the landfill operation. This includes a routine waste inspection program and monitoring for landfill odour.

7.4.2 Site Staffing

The operation of the new landfill is anticipated to require the following staff roles:

- District Management;
- Scale House attendants;
- administrative staff;
- labourers;
- heavy and light equipment operators.

7.4.3 Equipment

The operation of the new landfill is anticipated to require the following equipment:

- 2 x Cat 836 compactors;
- 2 x Cat D7 dozers;
- 1 x Cat D6 dozer;
- 2 x Cat 300 rock trucks;
- 2 x Cat 330 excavators;
- 1 x Grader;
- 1 x pickup truck; and,
- 1 x New Holland Loader (watering for dust control, sweeping, snow removal).

Equipment may consist of either the noted make/model or equivalent from different manufacturers.

8. Site Closure and End Use

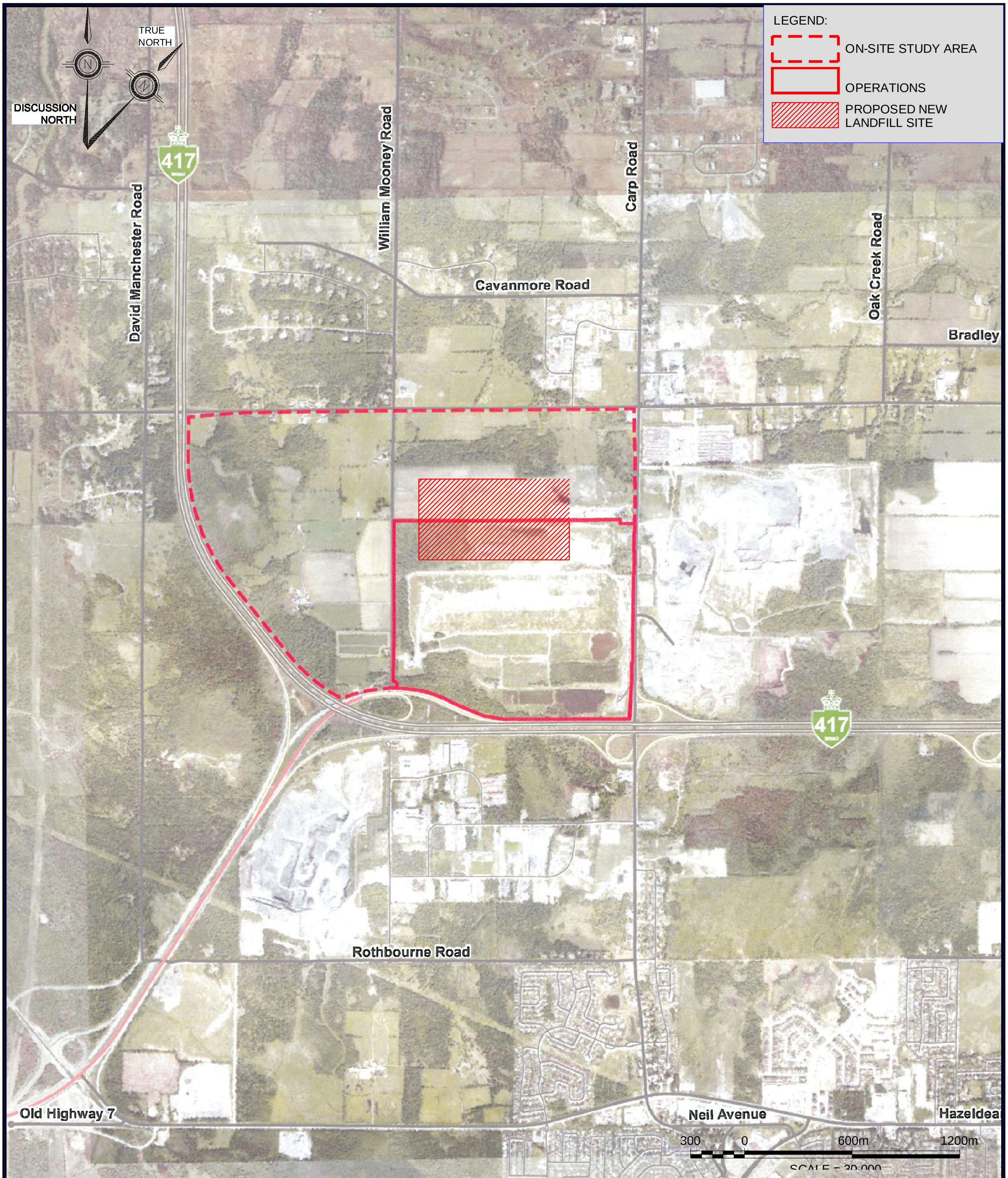
Site closure will follow the completion of the landfill to the approved final contours. Closure activities include final cover construction, removal of roads and waste receipt facilities that are not required in the post closure period, and implementation of a long-term monitoring and maintenance program. The closure plan will be developed as part of EPA-level work.

Site end use will be determined by WM in consultation with the local community and other stakeholders through the EPA approvals process. Potential end uses may include public open space (e.g., park) that could accommodate various passive or active recreational activities, or a restricted access open space.

Ongoing landfill monitoring and maintenance requirements will need to be incorporated into End Use planning. Specific considerations will include but are not limited to:

- Access to leachate and gas control systems for ongoing operations, maintenance and monitoring;
- Access to environmental monitoring locations;
- Prevention of public access to operational or monitoring areas; and,
- Impact of potential end use activities on the site's leachate, gas, or surface water controls.

Figures



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SITE LOCATION PLAN

PROJECT NUMBER
60191228

DATE
January 2012

FIGURE NUMBER
FCR-01

A SIZE 8.5" x 11" (215.9mm x 279.4mm)

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BY:----

FILE NAME: 60191228-FIG-01-SITE-LOACTION-PLAN.DWG

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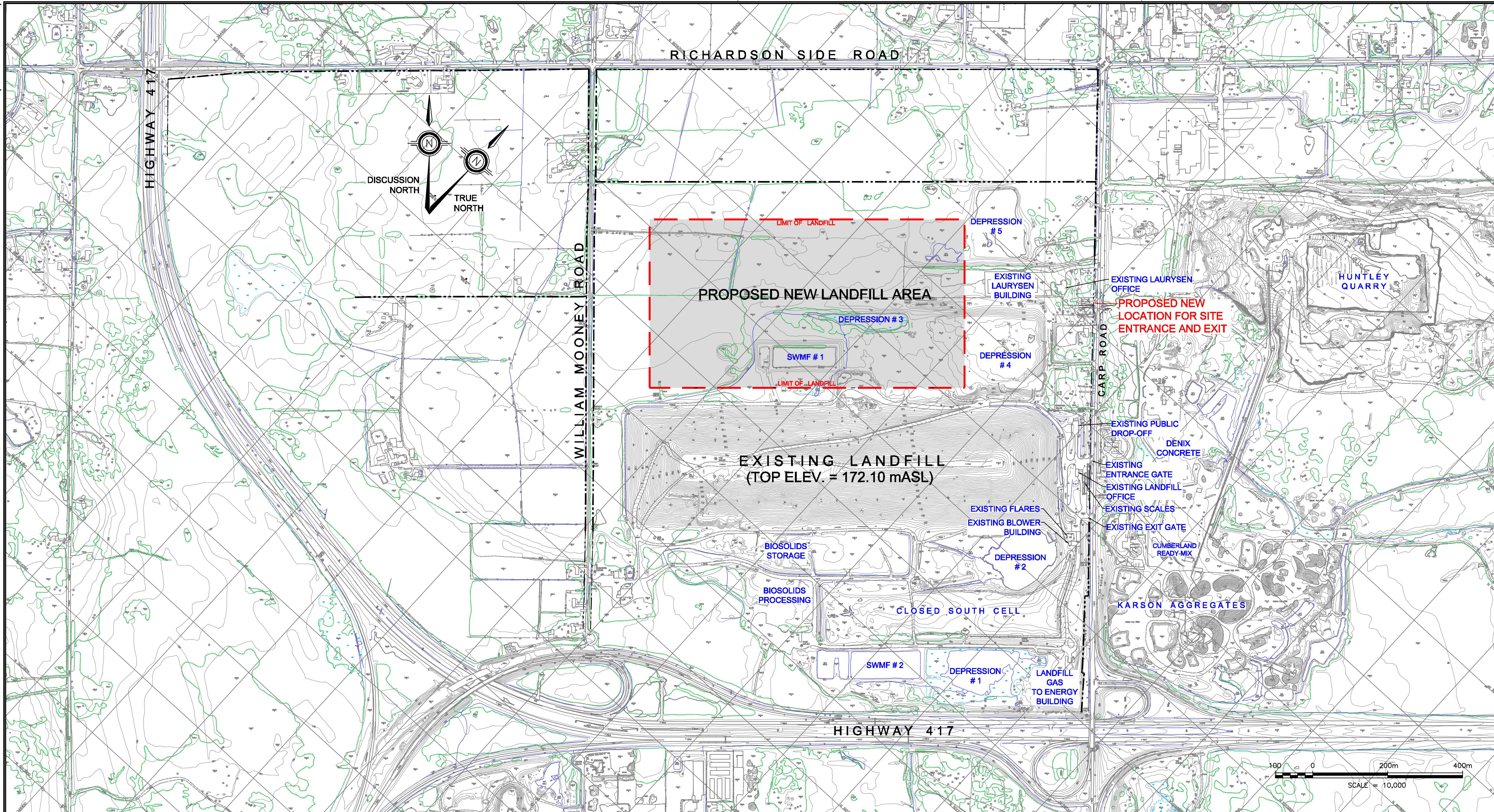
FILE NAME: 60191228-FIG-02-EXISTING-CONDITIONS.DWG BY:---- PLOT: 8/31/2012 9:54:33 AM B SIZE 11" x 17" (279.4mm x 431.8mm)



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LEGEND:

PROPERTY BOUNDARY

LIMIT OF PROPOSED NEW LANDFILL

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EXISTING CONDITIONS

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
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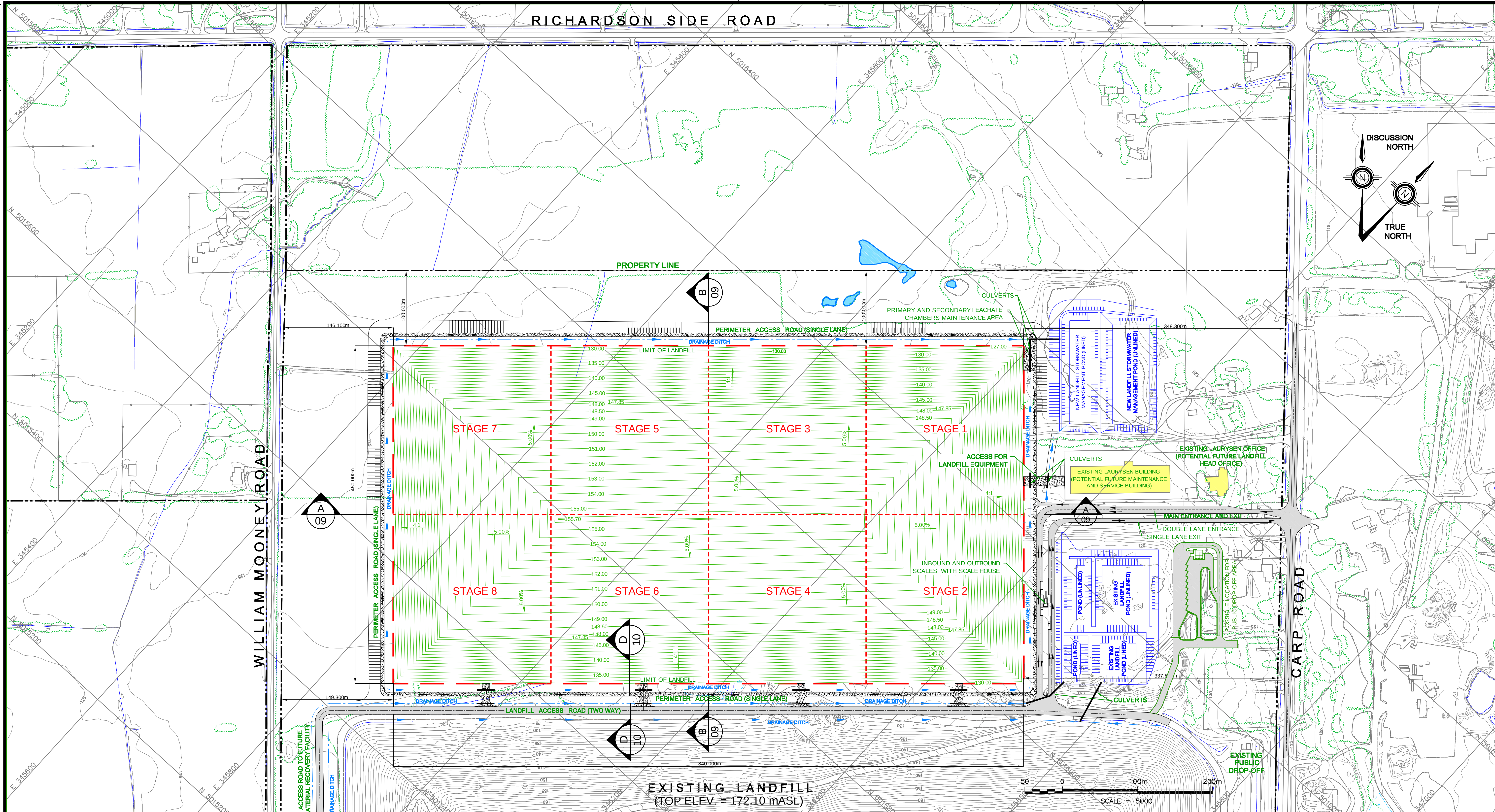

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LEGEND:

- PROPERTY BOUNDARY
- LIMIT OF LANDFILL
- LIMIT OF LINER CONSTRUCTION (STAGES 1 TO 8)
- 5.00% DIRECTION OF SLOPE AND GRADE
- 145.00 TOP OF FINAL COVER CONTOUR AND ELEVATION
- SURFACE DRAINAGE DITCH AND FLOW DIRECTION
- PAVED ROAD
- GRAVEL ROAD

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FACILITY LAYOUT

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-03	.

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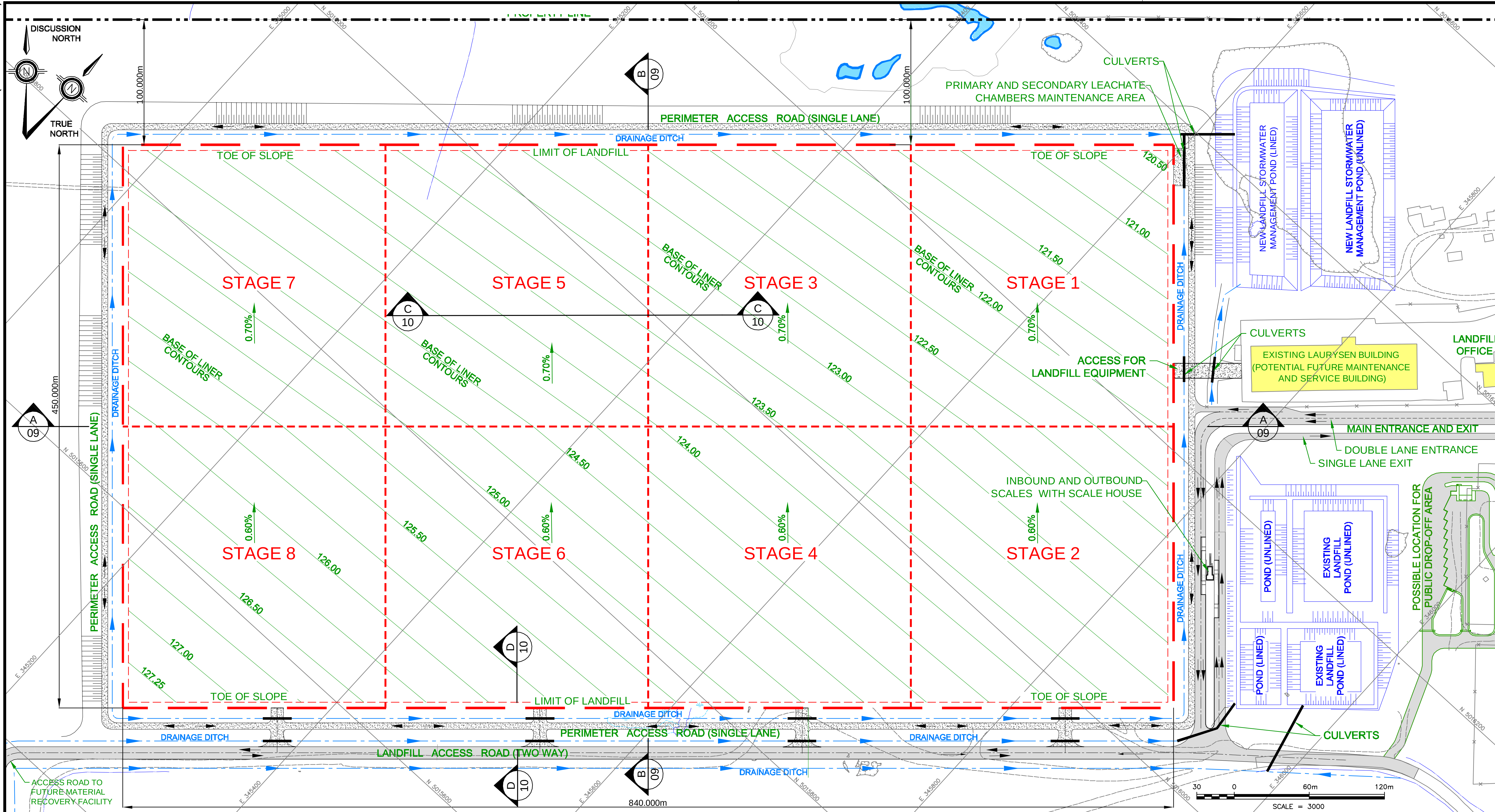

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LEGEND:

- PROPERTY BOUNDARY
- LIMIT OF LANDFILL
- LIMIT OF LINER CONSTRUCTION (STAGES 1 TO 8)
- 0.50% — DIRECTION OF SLOPE AND GRADE
- 125.50 — BOTTOM OF LINER CONTOURS AND ELEVATION
- SURFACE DRAINAGE DITCH AND FLOW DIRECTION
- PAVED ROAD
- GRAVEL ROAD

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BOTTOM OF LINER SYSTEM CONTOURS

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-04	.

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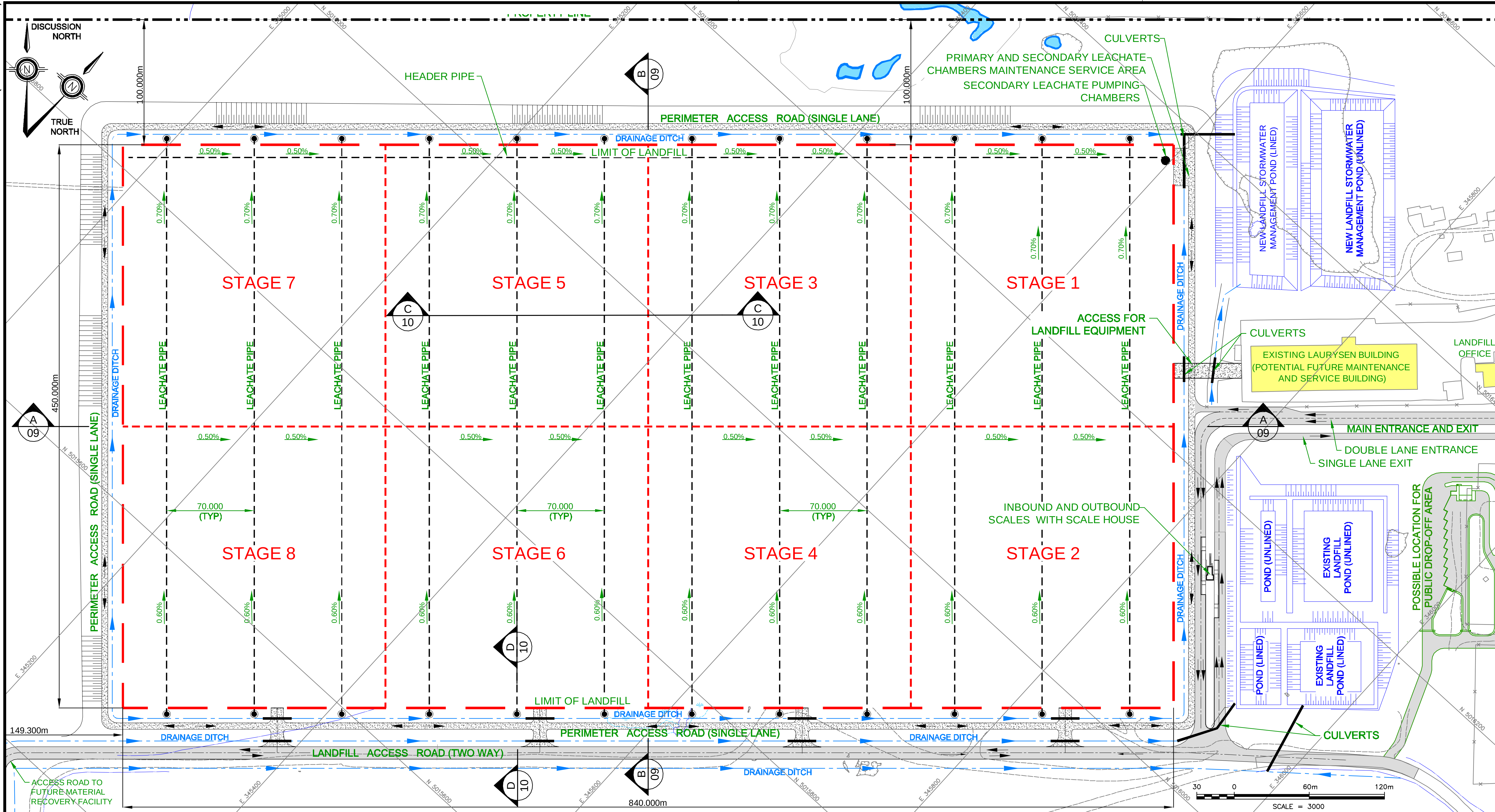

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LEGEND:

- PROPERTY BOUNDARY
- LIMIT OF LANDFILL
- LIMIT OF LINER CONSTRUCTION (STAGES 1 TO 8)
- SECONDARY LEACHATE COLLECTION PIPE
- SECONDARY LEACHATE PIPE CLEANOUT ACCESS
- 0.70% DIRECTION OF SLOPE AND GRADE
- PAVED ROAD
- GRAVEL ROAD

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SECONDARY LEACHATE COLLECTION SYSTEM LAYOUT

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
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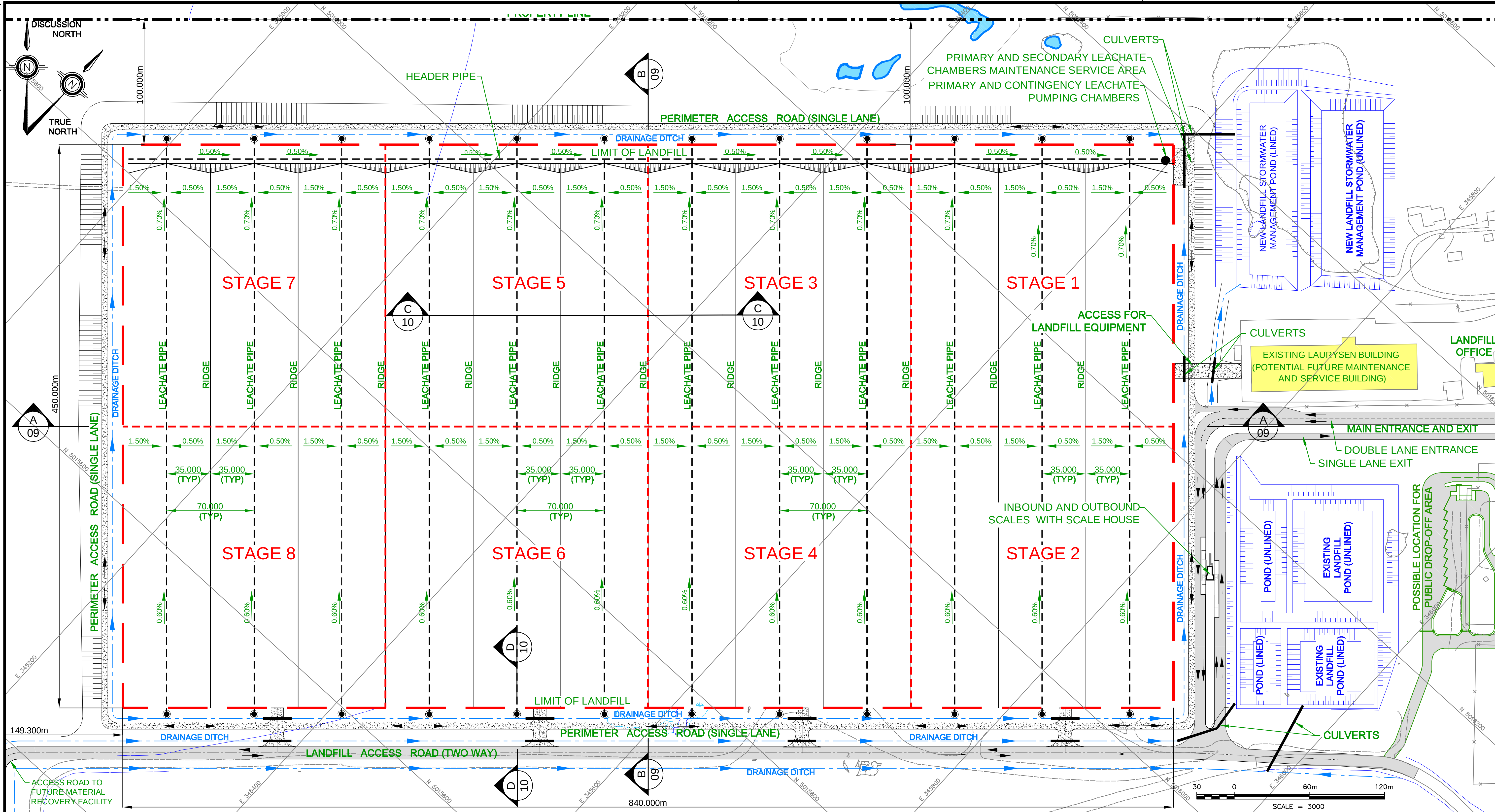

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LEGEND:

- PROPERTY BOUNDARY
- LIMIT OF LANDFILL
- LIMIT OF LINER CONSTRUCTION (STAGES 1 TO 8)
- PRIMARY LEACHATE COLLECTION PIPE
- PRIMARY LEACHATE PIPE CLEANOUT ACCESS
- 0.75% DIRECTION OF SLOPE AND GRADE
- PAVED ROAD
- GRAVEL ROAD

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PRIMARY LEACHATE COLLECTION SYSTEM LAYOUT

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-06	.

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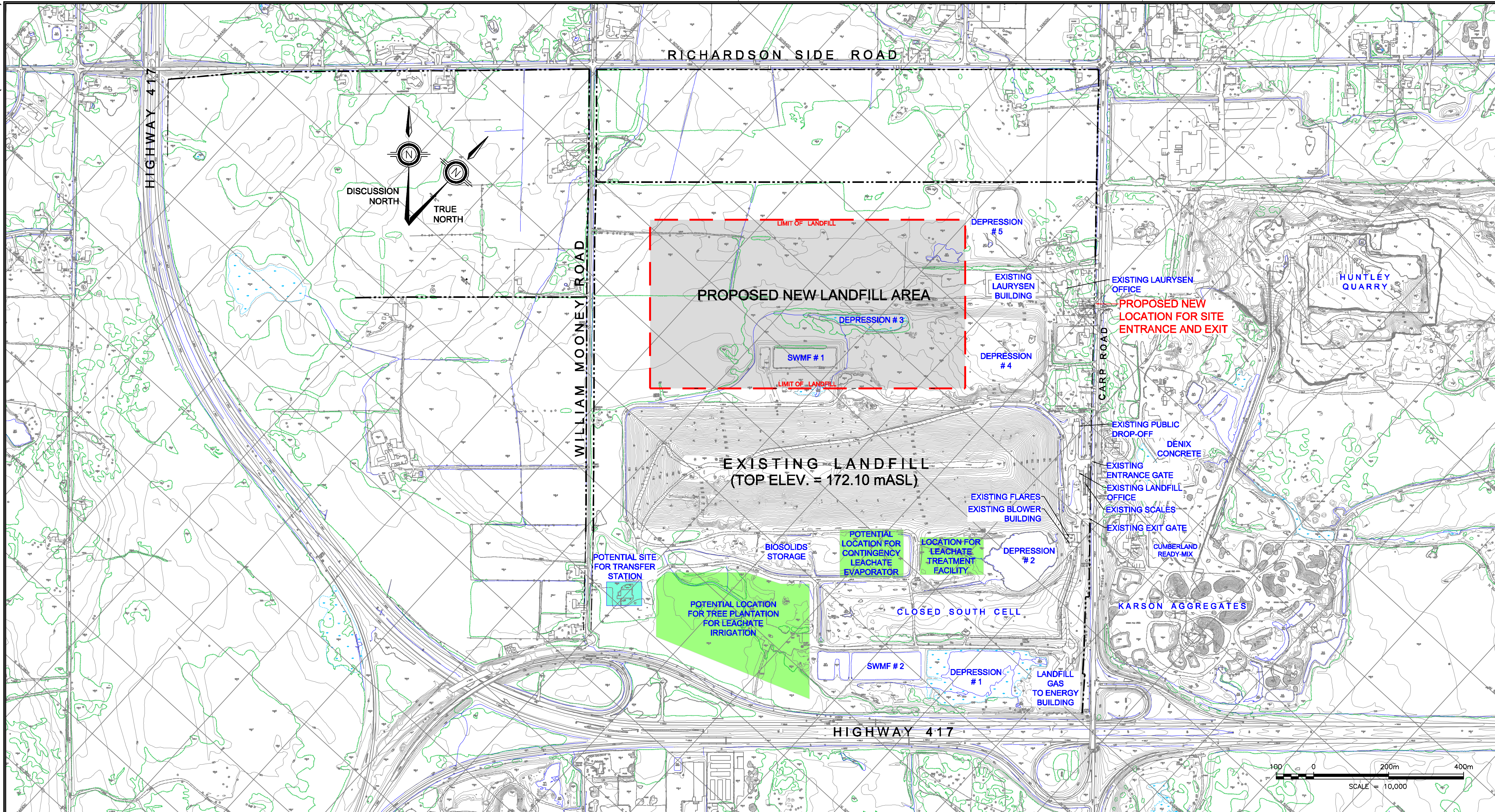

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LEGEND:

PROPERTY BOUNDARY

LIMIT OF PROPOSED NEW LANDFILL

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POTENTIAL LOCATIONS FOR FUTURE ANCILLARY FACILITIES

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
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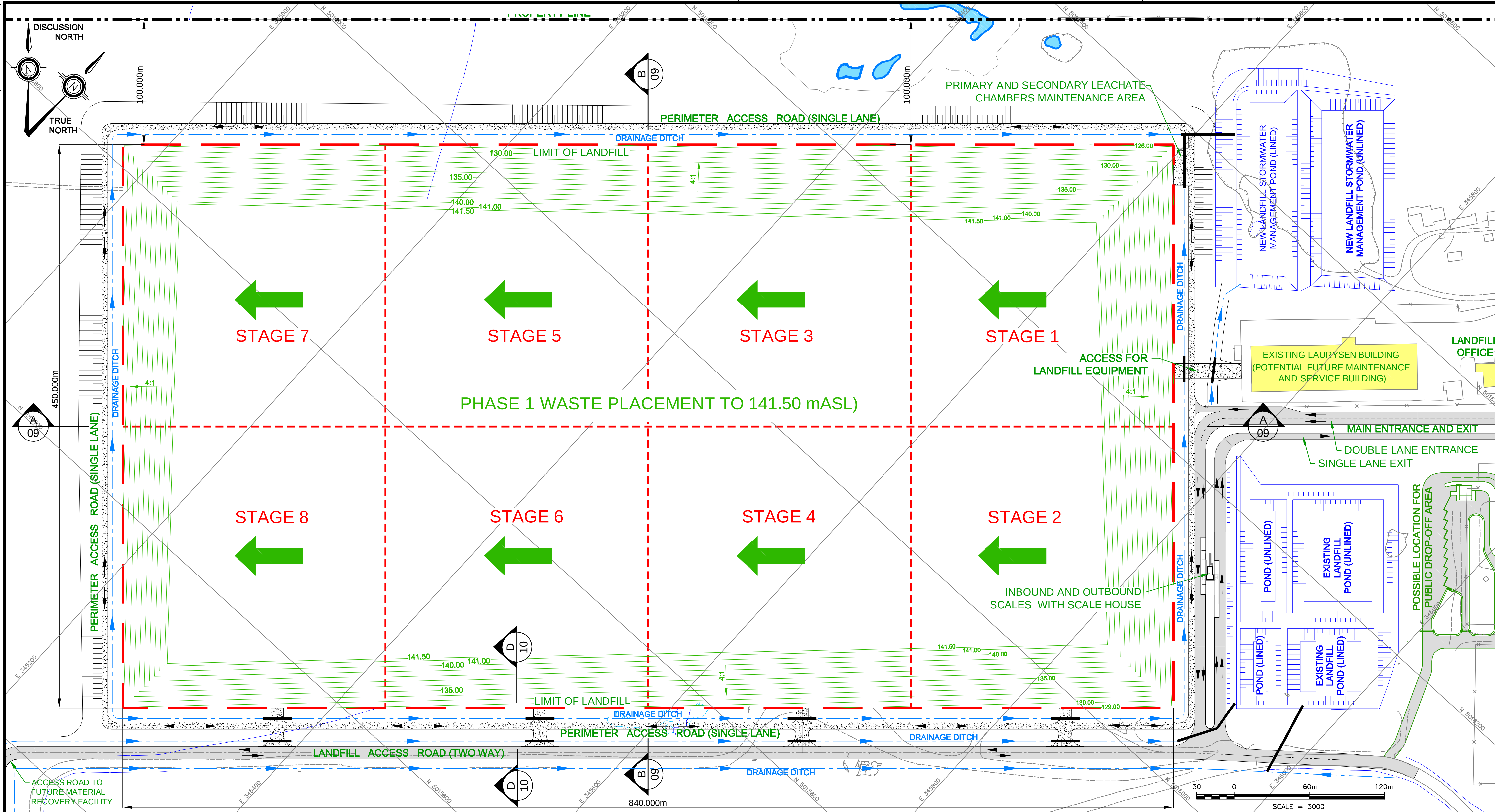

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LEGEND:

- PROPERTY BOUNDARY
- LIMIT OF LANDFILL
- LIMIT OF LINER CONSTRUCTION (STAGES 1 TO 8)
- 5.00% DIRECTION OF SLOPE AND GRADE
- 145.00 TOP OF WASTE CONTOURS (BELOW ELEVATION 141.50)
- PROGRESSION OF WASTE PLACEMENT

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PROGRESSION OF LINER CONSTRUCTION AND WASTE PLACEMENT - PHASE 1

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
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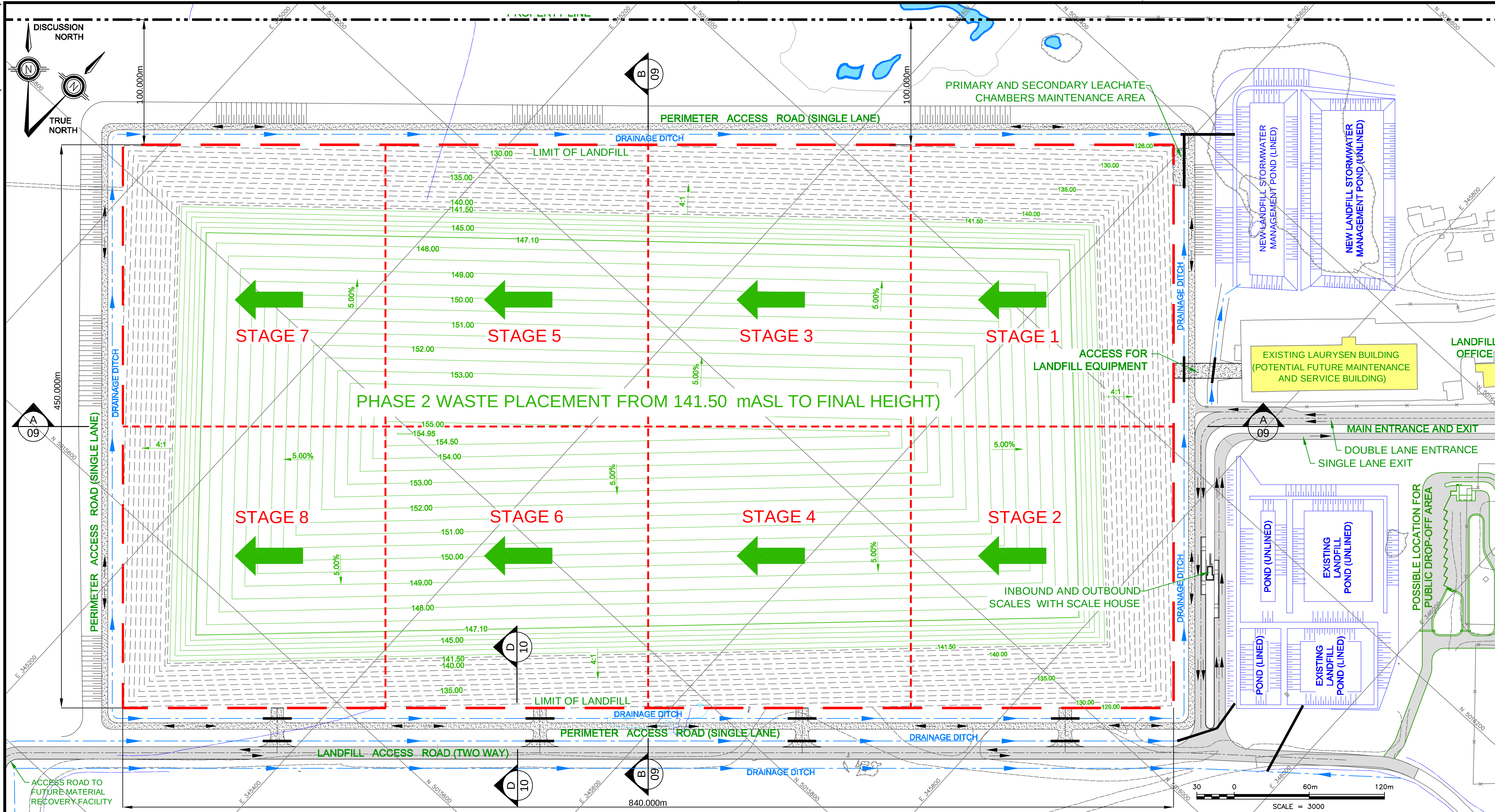

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

LEGEND:

	PROPERTY BOUNDARY
	LIMIT OF LANDFILL
	LIMIT OF LINER CONSTRUCTION (STAGES 1 TO 8)
5.00%	DIRECTION OF SLOPE AND GRADE
145.00	TOP OF WASTE CONTOURS (ABOVE ELEVATION 141.50)
145.00	TOP OF WASTE CONTOURS (BELOW ELEVATION 141.50)
	PROGRESSION OF WASTE PLACEMENT

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PROGRESSION OF WASTE PLACEMENT - PHASE 2

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
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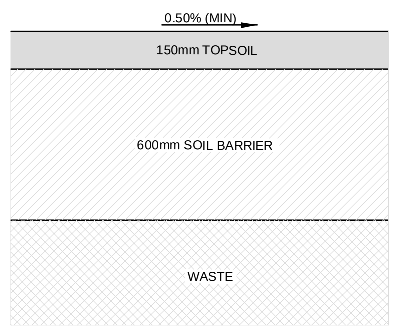
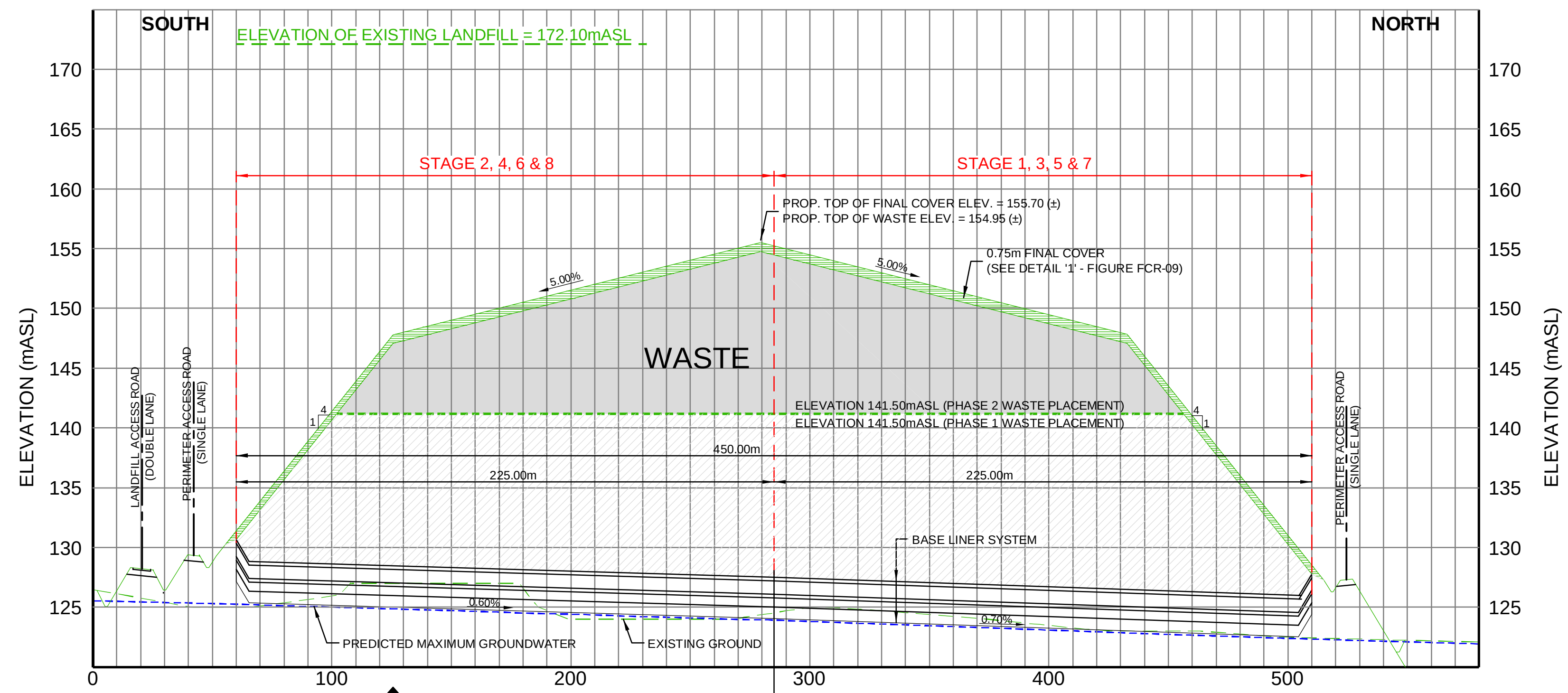


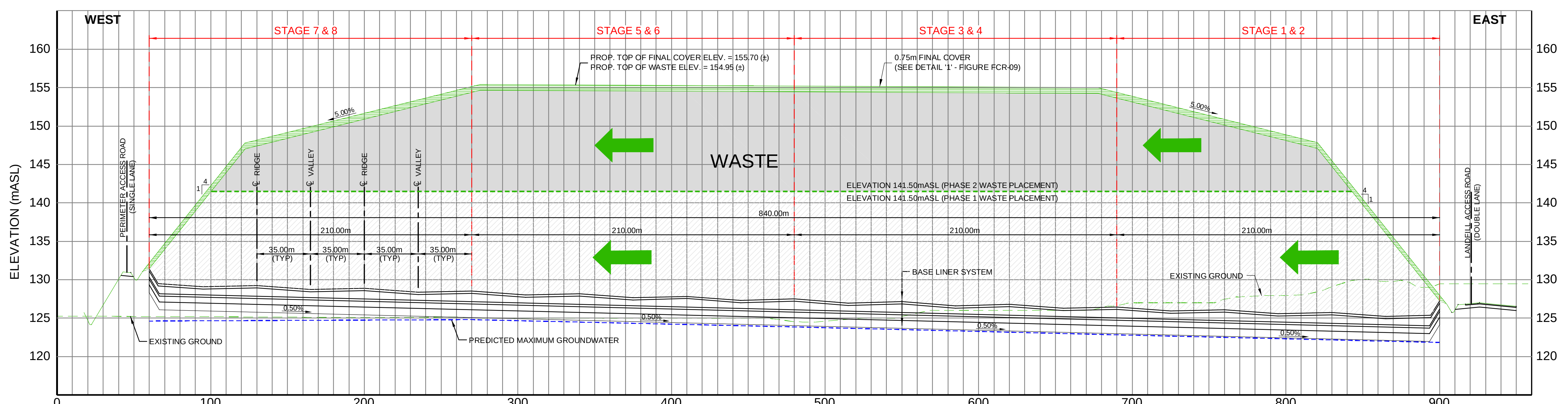
DETAIL 1/9
TYPICAL CONFIGURATION
THROUGH FINAL COVER SYSTEM
SCALE = 1:10



CROSS SECTION B/09
SCALE = 1:3000 (Horizontal)
SCALE = 1:600 (Vertical)

PHASE 2 WASTE PLACEMENT ABOVE ELEVATION 141.50mASL

PHASE 1 WASTE PLACEMENT BELOW ELEVATION 141.50mASL



CROSS SECTION A/09
SCALE = 1:3000 (Horizontal)
SCALE = 1:600 (Vertical)

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

LEGEND:

PHASE 1 WASTE PLACEMENT

PHASE 2 WASTE PLACEMENT

PROGRESSION OF WASTE PLACEMENT

AECOM

Waste Management of Canada Corporation
West Carleton Environmental Centre

Preferred Concept
CROSS SECTIONS 'A' AND 'B'
AND FINAL COVER DETAIL

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-10	.

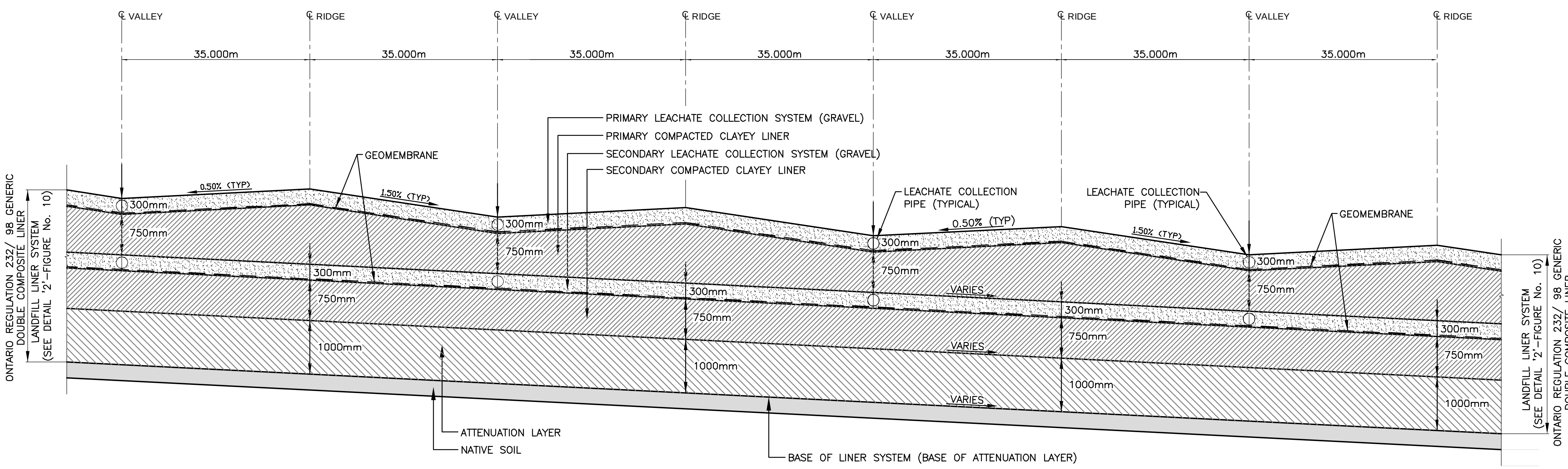
P:\60191228\000-CADD\040 CADD-BIM WIP\FCR_EA-FINAL-SUB-AUGUST-2012\60191228-FIG-10-Sections.dwg Layout:Facility-layout Plotted: Aug 31, 2012 @ 9:39am by Lefebvrej

B SIZE 11" x 17" (279.4mm x 431.8mm)

PLOT: 8/31/2012 9:18:01 AM

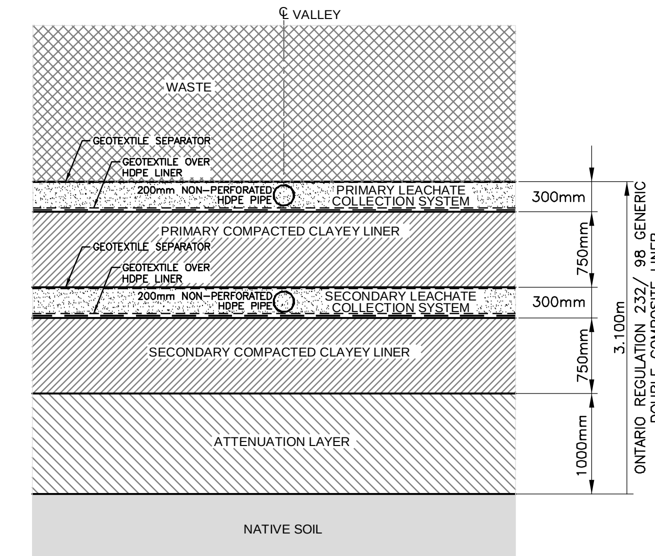
BY:----

FILE NAME: 60191228-FIG-11-SECTIONS.DWG



CROSS SECTION C / 10

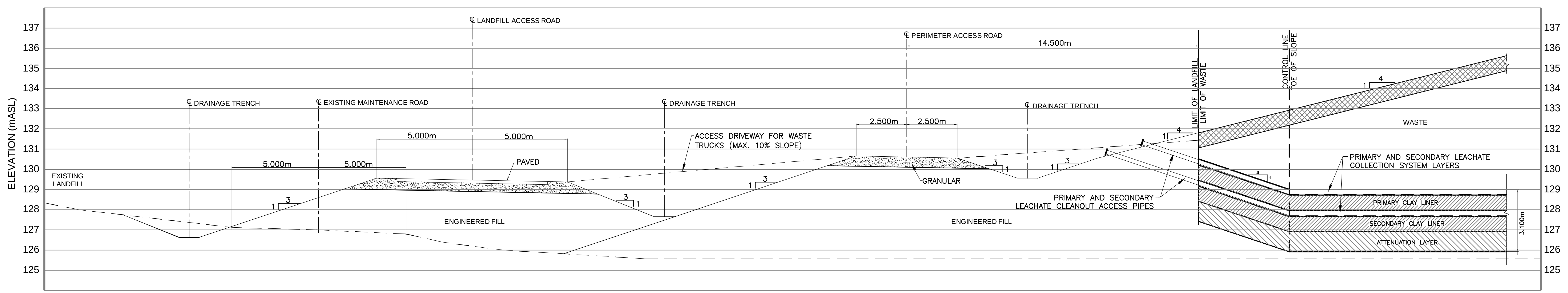
SCALE = 1:1000 (HORIZ)
= 1:100 (VERT)



DETAIL 2 / 10

TYPICAL CONFIGURATION THROUGH LINER SYSTEM

SCALE = 1:75



CROSS SECTION D / 10

SCALE = 1:200

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

LEGEND:

AECOM

Waste Management of Canada Corporation
West Carleton Environmental Centre

Preferred Concept
CROSS SECTIONS 'C' AND 'D'
AND BASE LINER SYSTEM DETAIL

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-11	.

Appendix A

Seismic Slope Stability Analysis

Appendix A. Seismic Slope Stability Analysis

1. Purpose

The purpose of the slope stability analyses presented in this appendix is to assess the potential effect of ground motion due to seismic activity on the slope stability of the landfill and liner system of the proposed new landfill at the West Carlton Environmental Centre (WCEC). The site is located on Lots 3 and 4, Concession 3 in the former Township of Huntley, formerly in the Township of West Carleton, now the City of Ottawa near the intersection of Carp Road and Highway 417.

2. Background

Unlike plate boundary regions where the rate and size of seismic activity is directly correlated with plate interaction, eastern Canada is part of the stable interior of the North American Plate. Seismic activity in areas like these seems to be related to the regional stress fields, with the earthquakes concentrated in regions of crustal weakness. In the Western Quebec Seismic Zone, pattern of historical seismic activity recorded by the Canadian seismograph network since the beginning of the century shows the earthquakes concentrating in two sub-zones: one along the Ottawa River and a second along a more active Montreal-Maniwaki axis. (Natural Resources Canada, 2011a)

The damage potential of an earthquake is determined by how the ground moves. Expected ground motion can be calculated on the basis of probability, and the expected ground motions are referred to as seismic hazard. The seismic hazard at a given site is determined from numerous factors. Canada has been divided into earthquake source regions based on past earthquake activity and tectonic structure. The relationship between earthquake magnitude and the average rate of occurrence for each region is weighed, along with variations in the attenuation of ground motion with distance. In calculating seismic hazard, scientists consider all earthquake source regions within a relevant distance of the proposed site (Natural Resources Canada, 2011b).

Ground motion probability values are given in terms of probable exceedance, that is the likelihood of a given horizontal acceleration or velocity being exceeded during a particular period. The probability used in the 2010 National Building Code of Canada is 0.000404 per annum, equivalent to a 2-per-cent probability of exceedance over 50 years. This means that over a 50-year period there is a 2-per-cent chance of an earthquake causing ground motion greater than the given expected value.

3. Methodology

A conventional method to evaluate the slope stability of municipal solid waste landfill is the pseudo-static factor of safety approach (US EAP, 1995). In this method, a seismic coefficient is specified to represent the effect of the inertial forces imposed by the earthquake upon the potential failure mass and a factor of safety is defined in the conventional manner as the ratio of the ultimate shear strength of the slope elements to the maximum shear stresses induced in those elements by seismic and static loadings.

The computer software SLOPE/W (version 2007), developed by GEO-SLOPE International, was used to perform the slope stability assessment. GEO-SLOPE software is used in more than 100 countries. SLOPE/W, in one form, or another has been used since 1977. SLOPE/W was the very first geotechnical software product available commercially for analyzing slope stability. The initial code was developed by Professor D.G. Fredlund at the University of Saskatchewan. Currently, thousands of professionals both in education and in practice used the software (GEO-SLOPE, 2007).

4. Model Input Parameters

The peak ground acceleration at the site was determined using the 2010 National Building Code Seismic Hazard Calculator of Natural Resources Canada. The National Building Code peak ground acceleration at the site is 0.31 g. To examine the effect of seismic hazard on the slope stability of the landfill the peak ground acceleration was used in the SLOPE/W pseudo-static analysis.

The geometry of the landfill in the slope stability analyses was according to the Figures FCR-3 and FCR-10 in the Facility Characteristics Report. The slope of the landfill at the northeast corner adjacent to the proposed surface water ponds is the highest and was used in the analysis.

The typical configuration of the landfill liner system is shown in Figure FCR-11 in the Facility Characteristics Report. There are many layers and interfaces of adjacent layers. The shear of the weakest interface may govern the stability of the slope. The strength of the layers and interfaces depend on the specific materials selected for each of the components. Published data was used in this preliminary slope stability analysis and the input parameters are presented in the attached Table SS1. In the detailed design of the landfill, the stability assessment will be based on properties and strength of the materials selected for the liner system.

If the composite liner has a smooth geomembrane, the shear strength of its interface is generally lowest and is the critical interface on slope stability. The liner system is modelled in the slope stability analyses as two layers. The top layer represents the primary leachate collection system plus the geotextile and geomembrane directly beneath. The strength of this layer is assumed to be controlled by the critical interface. The rest of the liner system below is modelled as another layer.

The key input parameters to SLOPE/W are presented in Table SS1. For a liner system with a smooth geomembrane, the critical interface shear strength is assumed to be 8 degrees based on published data. Sensitivity analyses were carried assuming the strength is increased by 50% to 12 degrees which also corresponds to published specific value from a manufacturer. The strength of the waste was based on values established by Sukhmander, Singh, and Murphy using results of laboratory testing, back-calculations from field load test and performance records, and in situ testing (Singh and Murphy, 1990). The effect of variation on the waste strength on the results was examined in sensitivity analyses for the smooth geomembrane cases. Slope stability analyses were performed with and without seismic condition.

Slope stability analyses, with and without seismic condition, were also performed for a liner system with a textured geomembrane instead of a smooth membrane. Textured geomembrane generally has a significantly higher interface shear strength than smooth geomembrane. The critical interface friction angle that gave a slope stability factor of safety greater than 1.0 under seismic condition was determined by back-calculations. In the above cases, the critical slip surface was determined by SLOPE/W as a composite slip surface. Additional cases were analyzed for the critical slip surface being circular as in conventional rotational analyses.

5. Results of Slope Stability Analyses

The results of SLOPE/W are summarised in the attached Table SS2, figures showing the critical slip surface and the corresponding calculated factor of safety for each case, and the plots of results of the sensitivity analyses.

The results showed that the factor of safety on slope stability is lower when the effect of seismic hazard is considered (see attached Table SS2). The seismic condition is based on the peak ground acceleration at the site according to the 2010 National Building Code. For a smooth geomembrane the calculated factors of safety under seismic condition were generally less than half of the corresponding results without seismic loading (Cases PD2A and PD2B versus Case PD1). Similar differences were found for the cases with a textured geomembrane as shown in Table SS2 (Case PD4B versus Case PD3, and Case PS2Bversus Case PS1).

With a smooth geomembrane, the calculated factors of safety under seismic condition were all well below 1.0 for the ranges of input parameters considered. These pseudo-static analyses results suggested that the calculated factor of safety on slope stability under the seismic condition for a liner system with a smooth geomembrane at the critical slip surface is inadequate. The results are summarized in Cases PD2A and PD2B in Table SS2 and in the plots of the sensitivity analyses results.

For the scenarios considered, Cases PD4A, PD4B, PS2A and PS2B, the back-calculations suggested that under seismic condition, the critical interface shear strength has to be approximately 25 degrees or greater for a calculated factor of safety above 1.0.

6. Discussion and Conclusions

Published generalized friction angle of texture HDPE geomembrane with non-woven, needle-punched or heat-bonded, geotextile showed values between 28 to 32 degrees (Koerner, 2005). The data by Koerner also suggested that the interface fraction between a texture HDPE geomembrane and soil could also be over 25 degrees. Furthermore, the use of peak ground acceleration with a pseudo-static factor of safety of 1.0 has been shown to give conservative assessments of slope performance in earthquakes (US EPA, 1995). With the selection of appropriate liner materials, the seismic slope stability analyses results suggested that the slope stability of the landfill and liner system can have adequate factor of safety under seismic condition with peak ground acceleration up to 0.31 g. This value of 0.31 g corresponds to the peak ground acceleration at the site for an earthquake with probability of exceedance of 2-per-cent over 50 years according to the 2010 National Building Code.

Detailed assessment of stability of the landfill and liner system shall be carried out using updated input parameters in the detailed design of the landfill to confirm that appropriate materials are selected and ensure that adequate factor of safety is achieved.

7. References

GEO-SLOPE International Ltd., 2007:
Stability Modelling with SLOPE/W 200, An Engineering Methodology, 2nd Edition, May 2007.

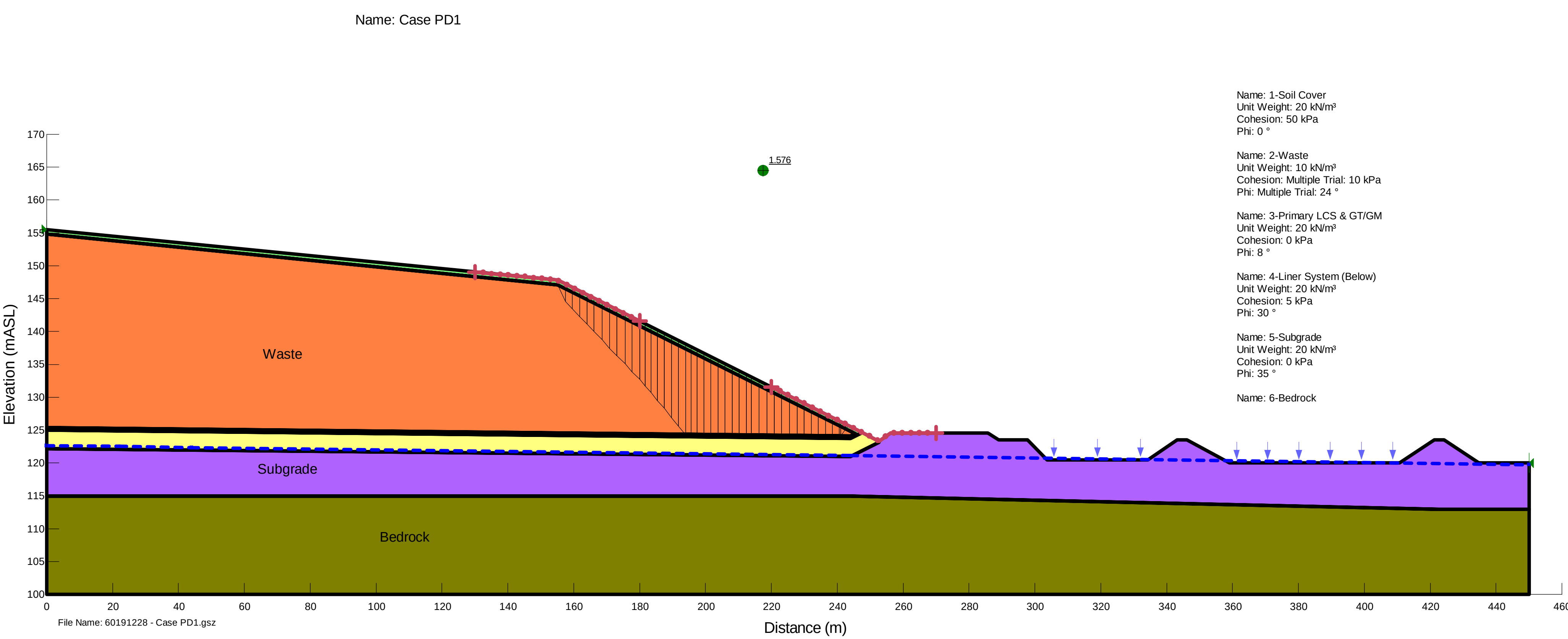
Koerner, R.M, 2005:
Designing with Geosynthetics, 5th Edition, Pearson Prentice Hall.

Natural Resources Canada, 2011a:
Earthquake Zones in Eastern Canada, Date Modified 2011-11-07
http://earthquakescanada.nrcan.gc.ca/zones/eastcan-eng.php#WQSZ

Natural Resources Canada, 2011b:
Seismic hazard Calculations, Date Modified 2011-11-07
http://earthquakescanada.nrcan.gc.ca/hazard-alea/zoning-zonage/haz-eng.php

Singh, S. and Murphy. B.J., 1990:
Evaluation of the Stability of Sanitary Landfills in “Geotechnical of Waste Fills – Theory and Practice”, ASTM STP 1070, ASTM.

United Stated Environmental Protection Agency (US EAP), 1995:
RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities. EPA/600/R-95/051 April 1995.


Name: Case PD1
1.576
Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: Multiple Trial: 10 kPa
Phi: Multiple Trial: 24 °
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 8 °
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °
Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: 6-Bedrock
Waste
Subgrade
Bedrock
Elevation (mASL)
Distance (m)
File Name: 60191228 - Case PD1.gsz

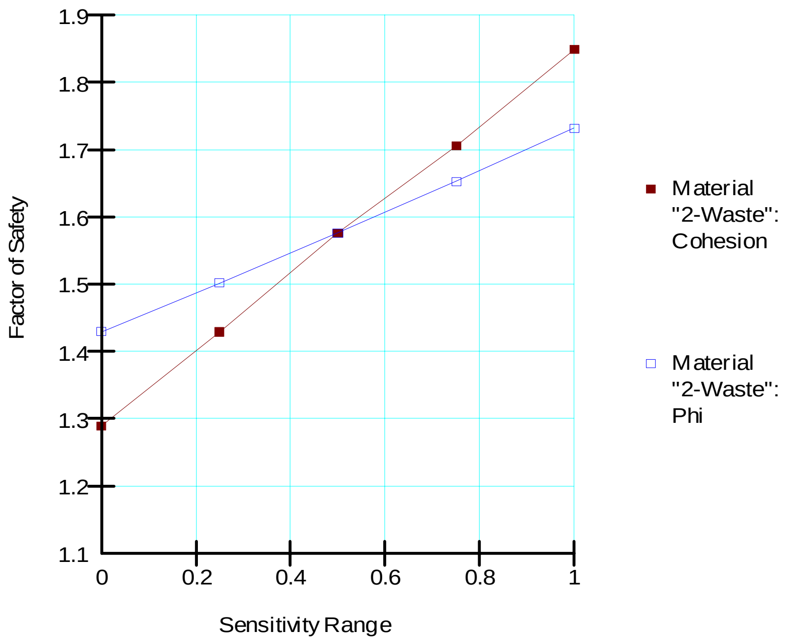
Project Name: West Carleton Environmental Centre
Project No.: 60242342
Task: Preliminary Seismic Slope Stability Analysis
Date: Jan-2012

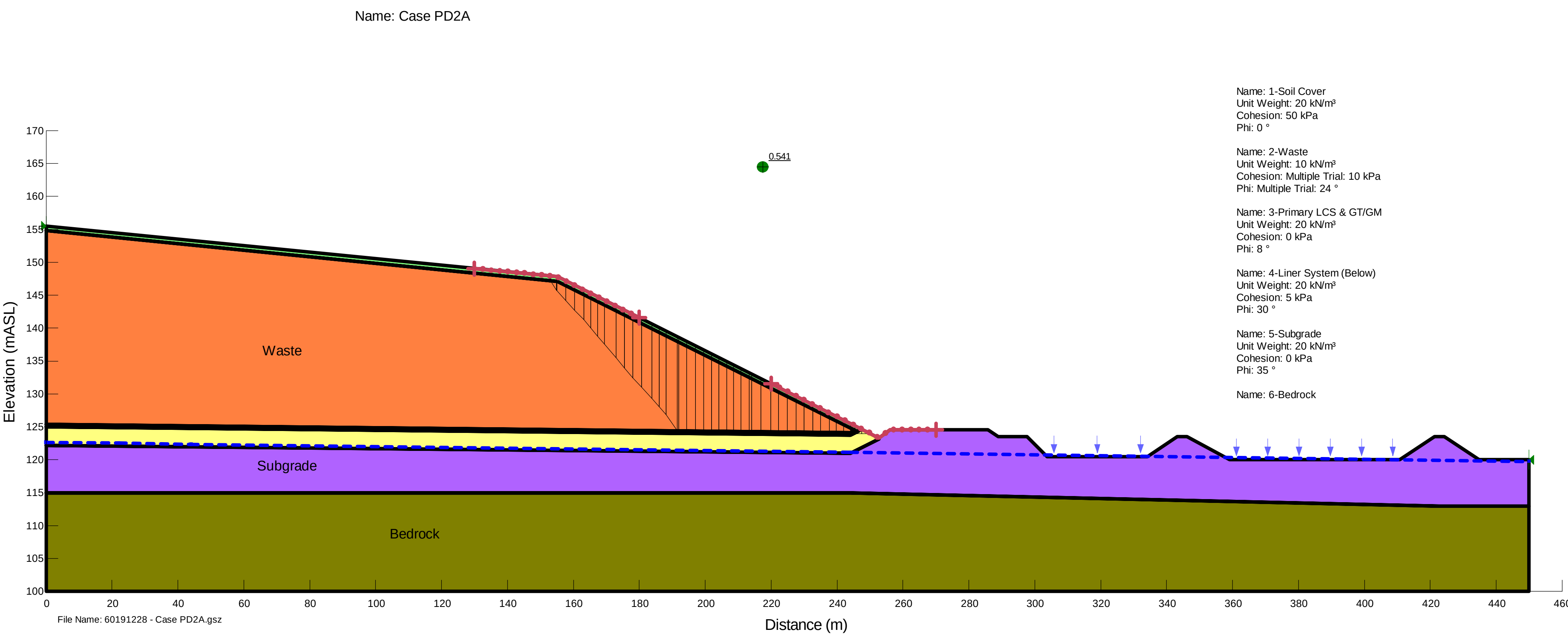
Sensitivity Analysis

Case PD1

(Critical Interface Friction Angle ϕ: 8 Degree)

Input Data		
Sensitivity Range	Corresponding "2-Waste" Cohension Value (kPa)	Corresponding "2-Waste" Phi Value (Degree)
0	0	20
0.25	5	22
0.5	10	24
0.75	15	26
1	20	28





Name: Case PD2A
Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: Multiple Trial: 10 kPa
Phi: Multiple Trial: 24 °
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 8 °
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °
Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: 6-Bedrock
0.541
Waste
Subgrade
Bedrock
Elevation (mASL)
Distance (m)
File Name: 60191228 - Case PD2A.gsz

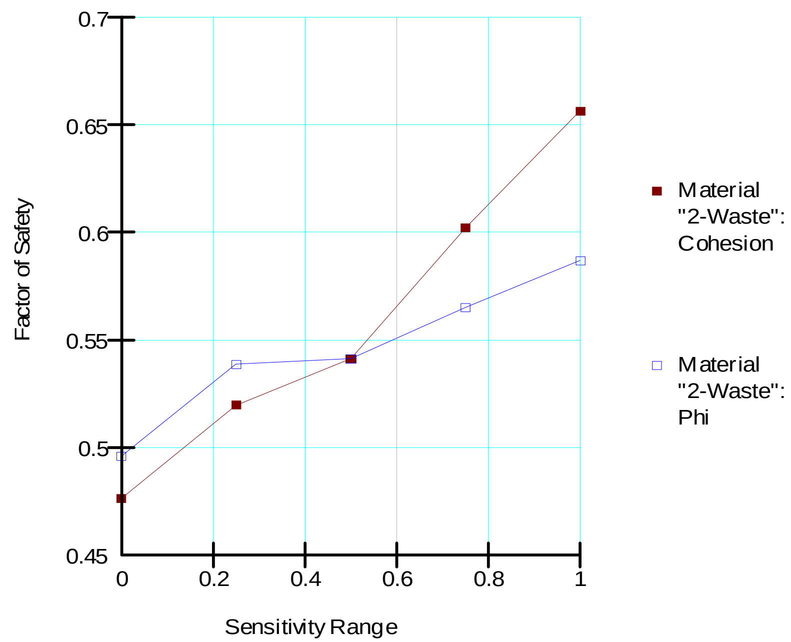
Project Name: West Carleton Environmental Centre
Project No.: 60242342
Task: Preliminary Seismic Slope Stability Analysis
Date: Jan-2012

Sensitivity Analysis

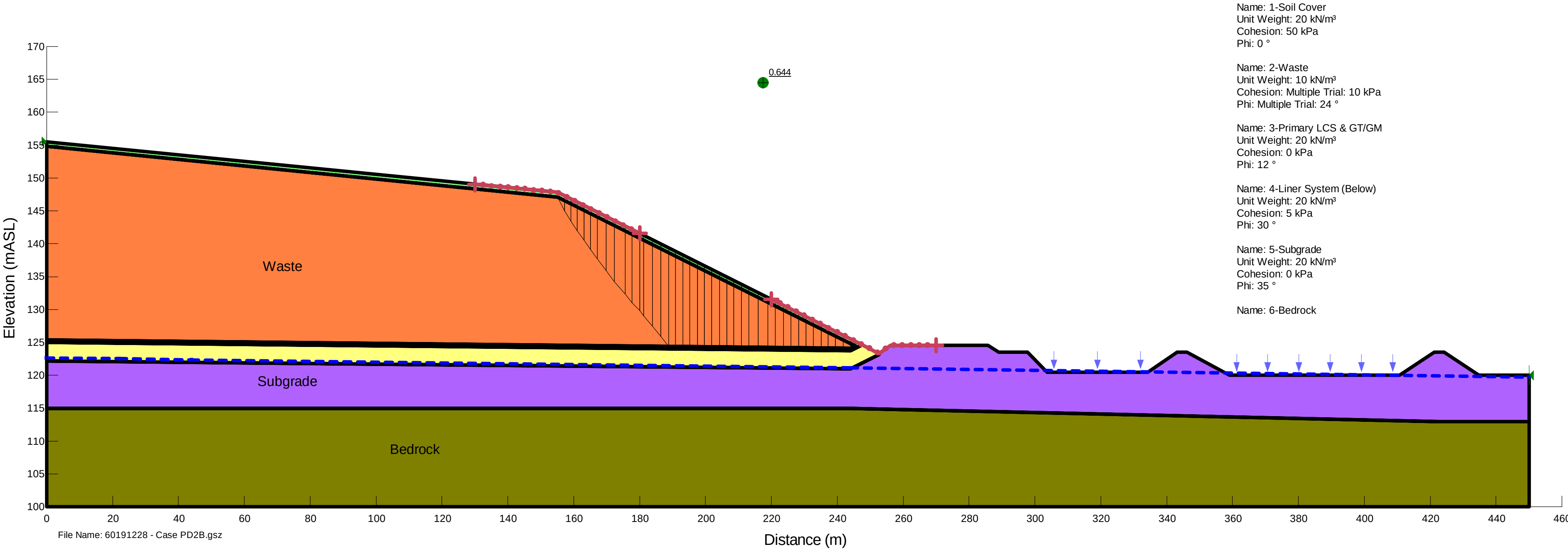
Case PD2A

(Critical Interface Friction Angle ϕ: 8 Degree)

Input Data		
Sensitivity Range	Corresponding "2-Waste" Cohension Value (kPa)	Corresponding "2-Waste" Phi Value (Degree)
0	0	20
0.25	5	22
0.5	10	24
0.75	15	26
1	20	28



Name: Case PD2B



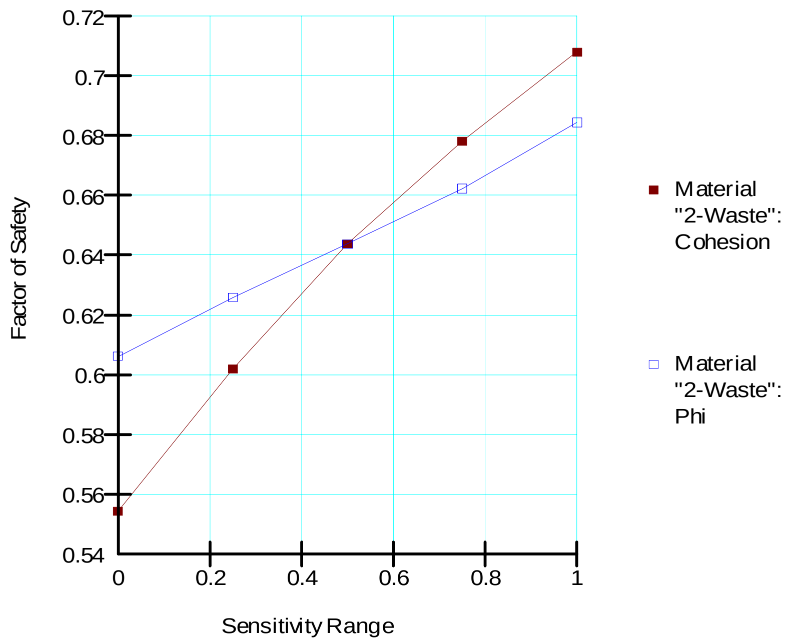
Project Name: West Carleton Environmental Centre
Project No.: 60242342
Task: Preliminary Seismic Slope Stability Analysis
Date: Jan-2012

Sensitivity Analysis

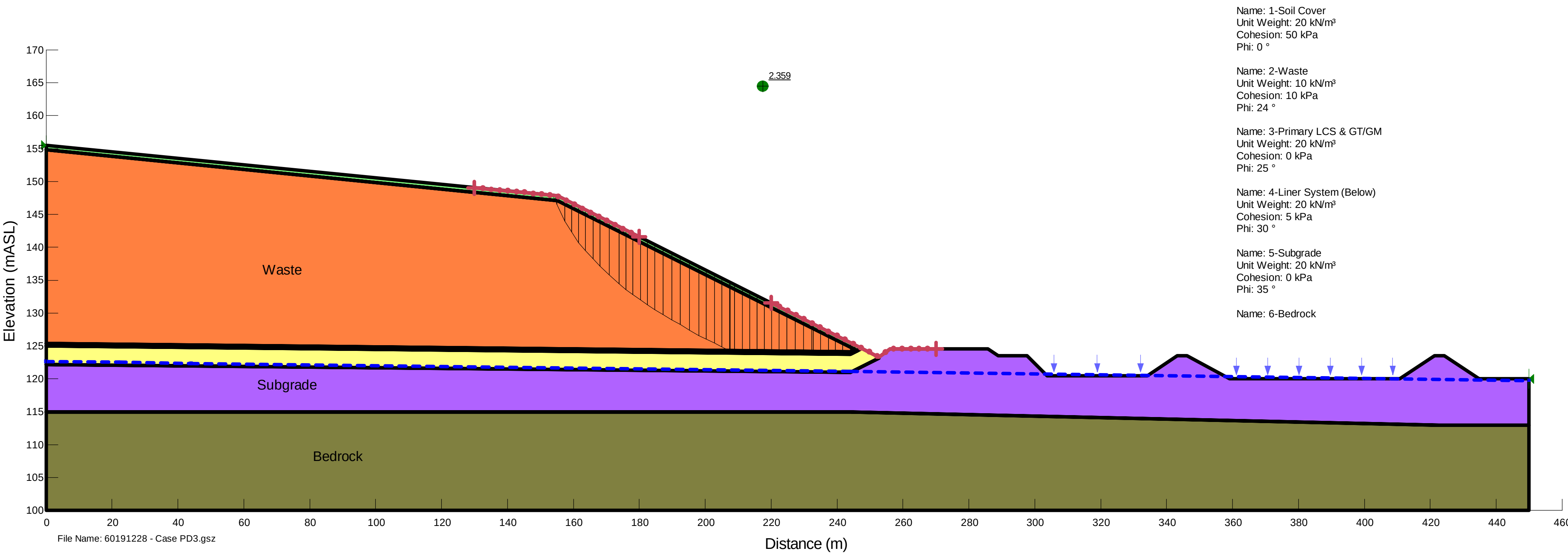
Case PD2B

(Critical Interface Friction Angle ϕ: 12 Degree)

Input Data		
Sensitivity Range	Corresponding "2-Waste" Cohension Value (kPa)	Corresponding "2-Waste" Phi Value (Degree)
0	0	20
0.25	5	22
0.5	10	24
0.75	15	26
1	20	28

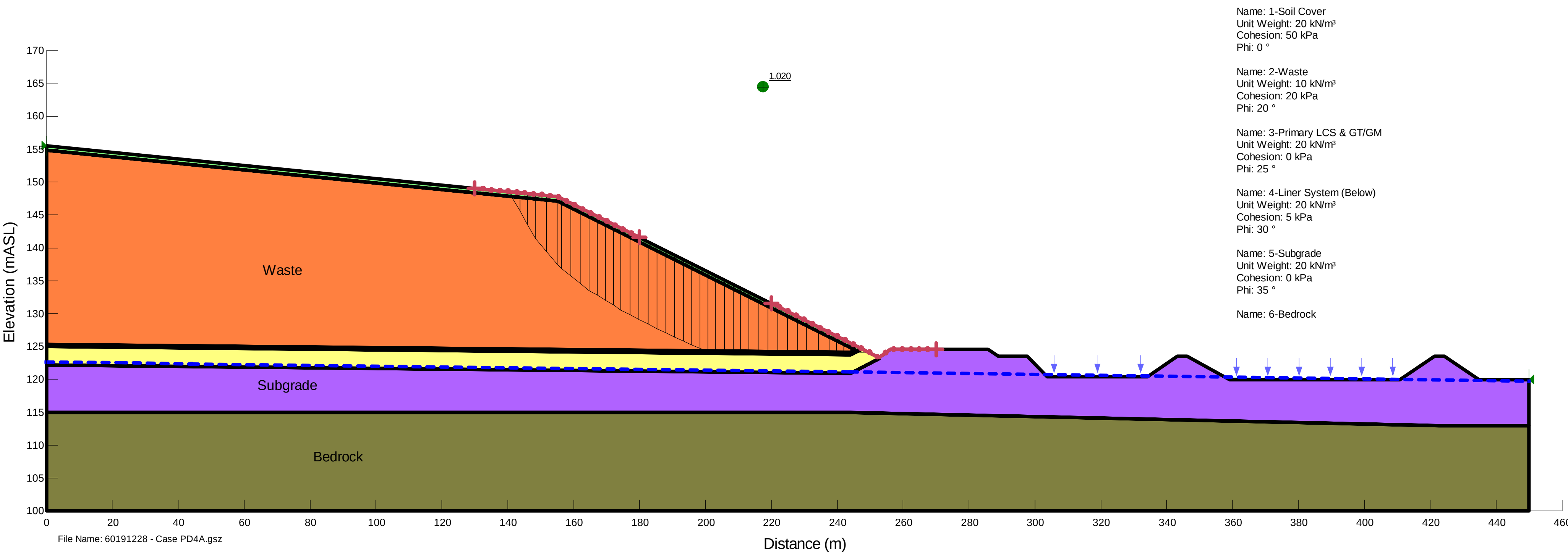


Name: Case PD3



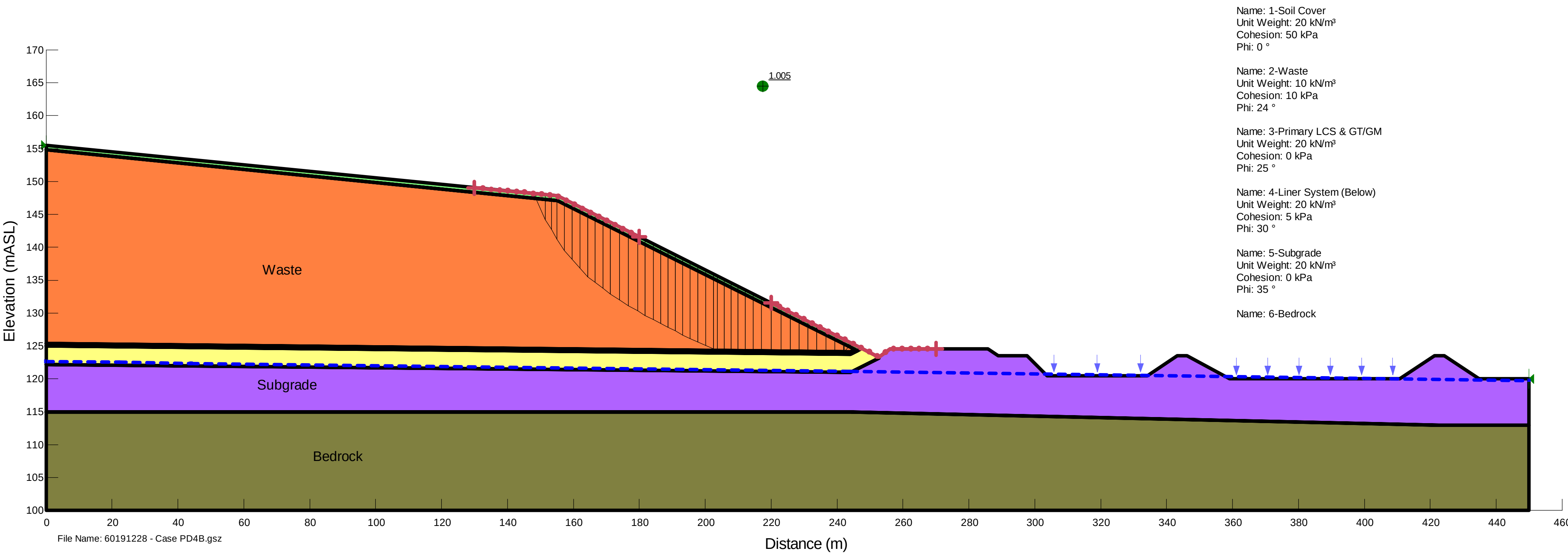
File Name: 60191228 - Case PD3.gsz

Name: Case PD4A

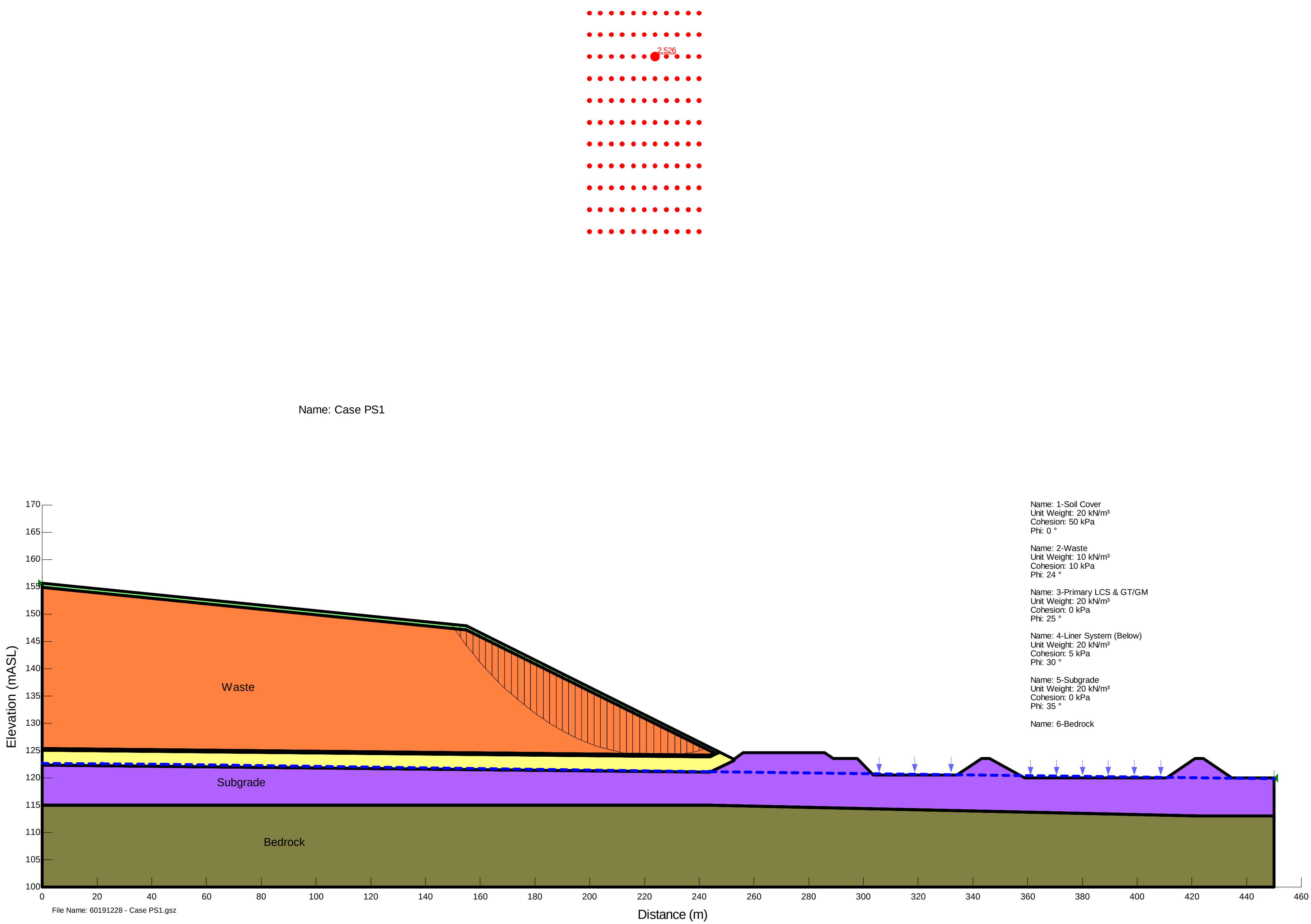


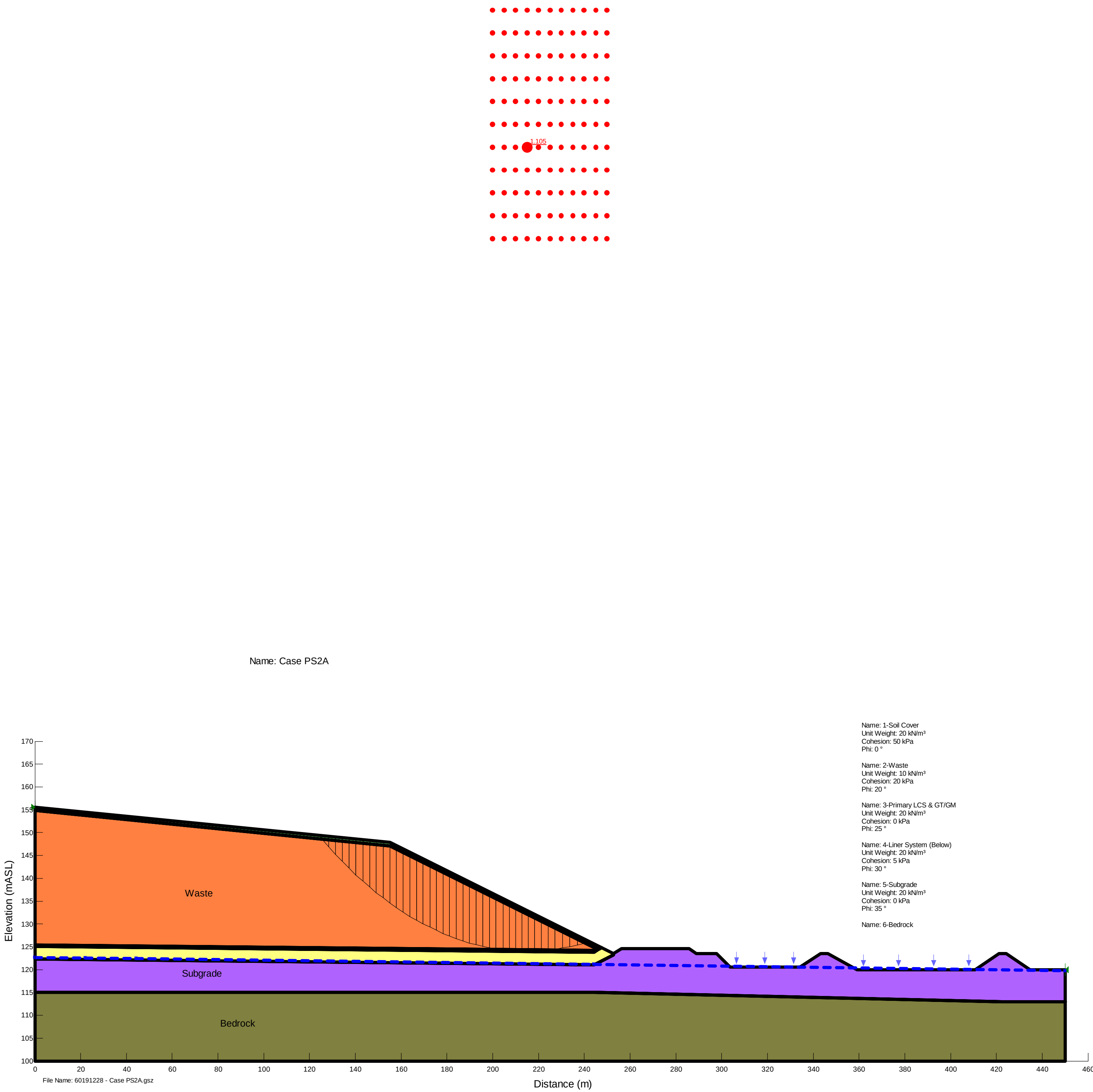
File Name: 60191228 - Case PD4A.gsz

Name: Case PD4B



File Name: 60191228 - Case PD4B.gsz


2.526
Name: Case PS1
Waste
Subgrade
Bedrock
Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 10 kPa
Phi: 24 °
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °
Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: 6-Bedrock
Elevation (mASL)
Distance (m)
File Name: 60191228 - Case PS1.gsz


1.105
Name: Case PS2A
Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 20 kPa
Phi: 20 °
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °
Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: 6-Bedrock
Waste
Subgrade
Bedrock
Elevation (mASL)
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
Distance (m)
File Name: 60191228 - Case PS2A.gsz

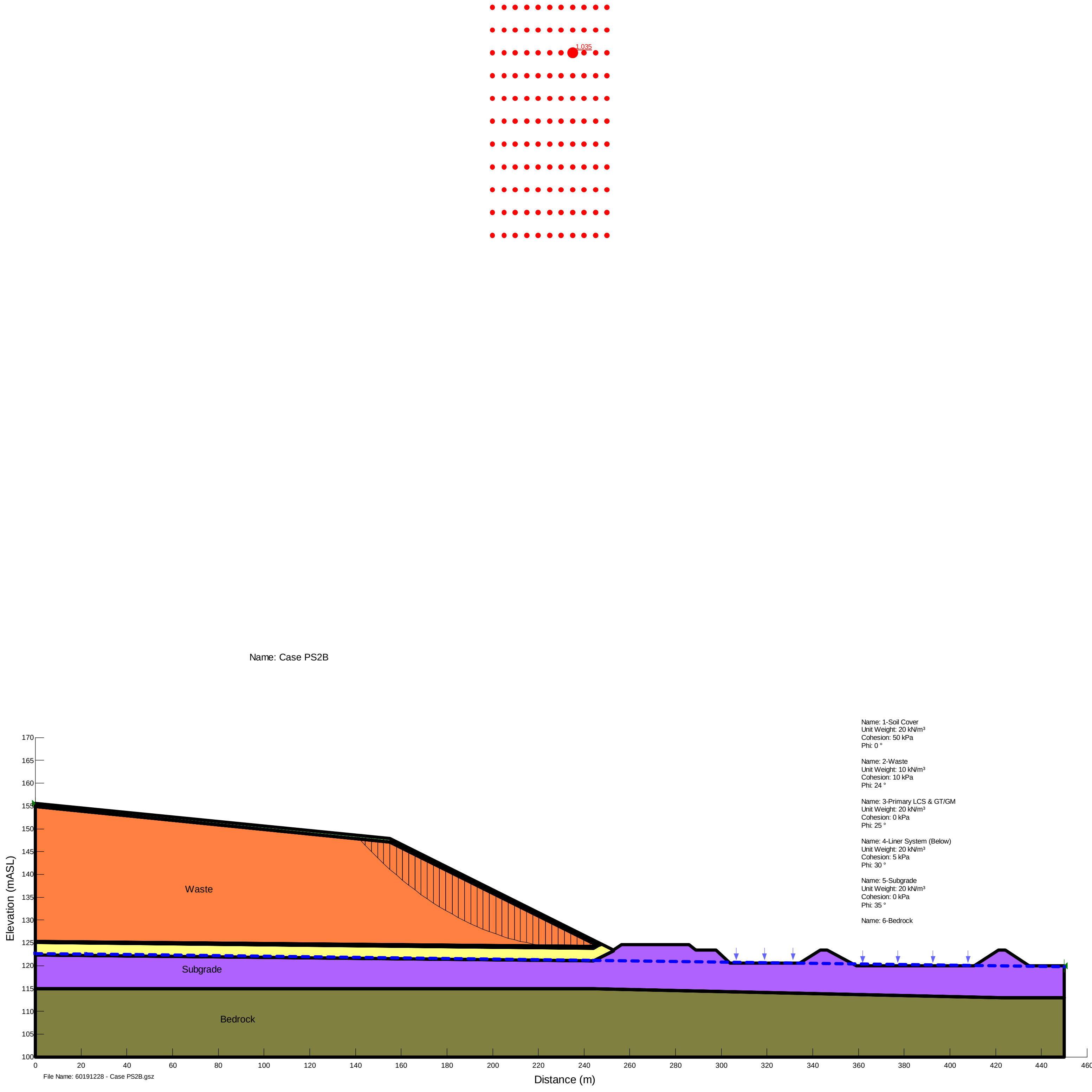

1.035
Name: Case PS2B
Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 10 kPa
Phi: 24 °
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °
Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: 6-Bedrock
Waste
Subgrade
Bedrock
Elevation (mASL)
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
Distance (m)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
File Name: 60191228 - Case PS2B.gsz

Table SS1. Key Input Parameters

Project Name: West Carleton Environmental Centre
Project Number: 60242342
Task: Preliminary Seismic Slope Stability Analyses
Date: January 2012

Parameters	Preliminary Values Assumed	Unit	Notes
Subgrade			Source - Alston Associates Inc Report Aug 2, 2011 "Preliminary Geotechnical Evaluation, Proposed New Landfill Mound, Waste Management, Carp, Ontatio (Revised)".
Friction Angle	35	degree	The effective friction angle measured by direct shear test on a sample of the silty sand soil of 39^{o} is higher than would be predicted on the basis of penetration index values measured by in situ testing (CPT and DCPT) according to the report.
Cohesion	0	kPa	
Density	16.5	kN/m^3	Density based on the initial water contents and dry densities before the direct shear test on the sample of silty sand soil.
Liner System			The G2 liner system from the primary compacted clay liner down is modelled as a single unit.
Friction Angle	30	degree	
Cohesion	5	kPa	
Density	20	kN/m^3	
Primary Leachate Collection System, Geotextile and Geomembrane			All the Interfaces from the bottom of the waste to top of the primary clay liner is modelled as a single unit. The shear strength of the weakest interface shall govern the shear strength of this unit. The interface shear strength will depend on the actual construction materials used.
Friction Angle (smooth HDPE)	8	degree	Geotextile/Geomembrane interface assumed critical. Generalized interface shear strength based on Robert Koerner "Design with Geosynthetics" 5th Edition, for a smooth High Density Polyethylene (HDPE) geomembrane and a non-woven needle-punched geotextile .
Friction Angle (textured HDPE)	25	degree	Critical interface depends on the actual construction materials used, and may be at a geotextile interface or a geomembrane interface. For the preliminary analysis, the assumed critical shear strength assumed is not less than those showed in Robert Koerner's book "Design with Geosynthetics" 5th Edition. The soil, geotextile and textured geomembrane shall be selected in the detailed design to ensure adequate factor of safety.
Cohesion	0	kPa	
Density	20	kN/m^3	
Waste			Assumed preliminary strength parameters based on Singh S and Murphy B, "Evaluation of the Stability of Sanitary Landfills" in "Geotechnical of Waste Fills – Theory and Practice"ASTM STP 1070, 1990.
Friction Angle	24, (20 to 28 sensitivity analysis)	degree	
Cohesion	10, (0 to 20 sensitivity analysis)	kPa	
Density	10	kN/m^3	
Final Cover			Strength based on generalized unconfined compression strength based on Karl Terzaghi and Ralph Peck "Soil Mechanics in Engineering Practice" 2nd Edition, for a clay with medium consistency .
Friction Angle	0	degree	
Cohesion	50	kPa	
Density	20	kN/m^3	

Notes
1. All these preliminary input parameters to be updated in the detailed design.
2. The parameters and values will depend on the actual type of construction materials selected.
3. Dry condition was assumed for all cases.

Table SS2: Summary of Slope Stability Results

Project Name: West Carleton Environmental Centre
Project No.: 60191228
Task: Preliminary Seismic Slope Stability Analysis
Date: Jan-2012

Summary of the Factor of Safety

	Results	Inputs				
Case ID	Factor of Safety	Waste Strength		Critical Interface Friction Angle ø (degree)	Seismic	Critical Slip Surface Type
		Cohesion C (kPa)	Friction Angle ø (degree)			
PD1	**1.576**	10	24	8	No	Composite
PD2A	**0.541**	10	24	8	0.31g (horz)	Composite
PD2B	**0.644**	10	24	12	0.31g (horz)	Composite
PD3	**2.359**	10	24	25	No	Composite
PD4A	**1.020**	20	20	25	0.31g (horz)	Composite
PD4B	**1.005**	10	24	25	0.31g (horz)	Composite
PS1	**2.526**	10	24	25	No	Circular
PS2A	**1.105**	20	20	25	0.31g (horz)	Circular
PS2B	**1.035**	10	24	25	0.31g (horz)	Circular

Notes:
1. Input parameters see Table SS1.
2. Critical Interface Friction Angles for Cases PD1, PD2A, and PD2B were assumed for a smooth geomembrane. A textured geomem
3. Critical slip surfaces and calculation of Factor of Safety shown as attached.
4. Sensitivity analysis conducted for Cases PD1, PD2A, and PD2B, the plots of the results are shown as attached.

Appendix B

Leachate Generation Rate Estimation

Appendix B. Leachate Generation Rate Estimation

Background

HELP (Hydrologic Evaluation of Landfill Performance), is a quasi-two-dimensional hydrologic model for predicting landfill hydrologic processes, testing the effectiveness of landfill designs, and assessing groundwater recharge rates. The model uses the following input data:

- Weather (precipitation, temperature, solar radiation, evapotranspiration parameters).
- Soil (porosity, field capacity, wilting point, saturated hydraulic conductivity).
- Engineering design data (liners, leachate and runoff collection systems, surface slope).

The modeled system can be multi-layered, consisting of combinations of natural (i.e., soil) and artificial materials (i.e., geomembranes) with an option to install horizontal drainage and sloped layers (e.g., caps, surface drainage and removal systems). HELP uses numerical solution techniques that account for the effects of surface storage, snow melt, runoff, infiltration and evapo-transpiration, vegetation growth, soil moisture storage, lateral subsurface drainage, and unsaturated vertical drainage or leakage through soil geomembrane or composite liners.

For the preliminary evaluation of leachate generation rates, the implementation of HELP contained in the software WHI UnSat Suite Plus version 2.2.0.3 by Waterloo Hydrogeologic (now Shlumberger Water Services) was used. Specifically, the model was used to estimate infiltration into the new landfill for a range of scenarios that will exist during the operating and post-closure period. For the purposes of this assessment changes in moisture storage within the landfill were assumed to be zero, and the estimated infiltration rate was considered representative of the leachate generation rate (e.g. infiltration = total precipitation – runoff – evapotranspiration = leachate generation).

Model Parameters

Model input parameters included:

- Aspects of the conceptual design presented in the FCR (e.g., area, slope, waste thickness, liner and leachate collection system design),
- Weather data including precipitation, temperature, solar radiation and evapotranspiration as generated by HELP using coefficients for Ottawa and compared to Environment Canada data;

- Soil parameters including porosity, field capacity, and wilting point were taken from the default HELP model database; and,
- Saturated hydraulic conductivity values from the default HELP model database and using results of on-site soil investigations.

The specific scenarios are described in Section 5.2 of the main report.

Model Input/Output

The infiltration values for the modelled scenarios are presented in Table 5-1 in the main report. Summaries of the input data and model results for each scenario follow.

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** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE **
** HELP MODEL VERSION 3.07 (1 November 1997) **
** DEVELOPED BY ENVIRONMENTAL LABORATORY **
** USAE WATERWAYS EXPERIMENT STATION **
** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY **
** **
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PRECIPITATION DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP_weather1.dat
TEMPERATURE DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP_weather2.dat
SOLAR RADIATION DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP_weather3.dat
EVAPOTRANSPIRATION DATA: C:\WHI\UNSAT22\data\P13364.VHP_weather4.dat
SOIL AND DESIGN DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP\I_392374.inp
OUTPUT DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP\O_392374.prt

TIME: 12:59 DATE: 7/12/2011

****

TITLE: No Waste

****

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2154 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 4.90
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34

THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0123 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 6

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 37.00 CM
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL

INITIAL SOIL WATER CONTENT = 0.0621 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.580000000000E-02 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9
THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #21 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF 0.% AND
A SLOPE LENGTH OF 30. METERS.

SCS RUNOFF CURVE NUMBER = 0.30
FRACTION OF AREA ALLOWING RUNOFF = 0.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 20.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 6.032 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 7.940 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 0.260 CM
INITIAL SNOW WATER = 3.716 CM
INITIAL WATER IN LAYER MATERIALS = 105.930 CM
TOTAL INITIAL WATER = 109.646 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 20.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.2	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	358.237	(39.8094)	3582.37	39.611
LATERAL DRAINAGE COLLECTED FROM LAYER 2	547.77297	(94.21336)	5477.730	60.56789
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.07897	(0.02597)	0.790	0.00873
AVERAGE HEAD ON TOP OF LAYER 3	9.281	(3.283)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.04914	(0.01318)	0.491	0.00543
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00830	(0.00204)	0.083	0.00092
AVERAGE HEAD ON TOP OF LAYER 9	0.604	(0.162)		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00802	(0.02468)	0.080	0.00089
CHANGE IN WATER STORAGE	-1.672	(2.8234)	-16.72	-0.185

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	0.000	0.00000	0
DRAINAGE COLLECTED FROM LAYER 2	15.74062	157.40622	770002
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.006391	0.06391	770002
AVERAGE HEAD ON TOP OF LAYER 3	305.995		
MAXIMUM HEAD ON TOP OF LAYER 3	391.188		
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	82.9 METERS		
DRAINAGE COLLECTED FROM LAYER 8	0.00021	0.00211	2440020
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000034	0.00034	2440020
AVERAGE HEAD ON TOP OF LAYER 9	0.946		
MAXIMUM HEAD ON TOP OF LAYER 9	1.875		
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	2.0 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.080197	0.80197	1690020
SNOW WATER	236.91	2369.1375	730012
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3970		
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0130		

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner

by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	5.8764	0.1959
2	0.0076	0.0127
3	0.0000	0.0000
4	33.9000	0.4520
5	0.0176	0.0352
6	0.9600	0.0320
7	0.0050	0.0100
8	2.3284	0.0629
9	0.0000	0.0000
10	33.9000	0.4520
11	28.3926	0.2839
SNOW WATER	0.913	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                  HELP MODEL VERSION 3.07 (1 November 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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******************************************************************************


PRECIPITATION DATA FILE:      C:\WHI\UNSAT22\data\P13364.VHP\_weather1.dat
TEMPERATURE DATA FILE:        C:\WHI\UNSAT22\data\P13364.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:    C:\WHI\UNSAT22\data\P13364.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:      C:\WHI\UNSAT22\data\P13364.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:    C:\WHI\UNSAT22\data\P13364.VHP\I_393060.inp
OUTPUT DATA FILE:             C:\WHI\UNSAT22\data\P13364.VHP\O_393060.prt


TIME:   16:34       DATE:    7/15/2011


******************************************************************************

    TITLE:   Daily Cover - Sand

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    NOTE:   INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER   1
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER     9
          THICKNESS                     =      15.00     CM
          POROSITY                      =       0.4370 VOL/VOL
          FIELD CAPACITY                =       0.0620 VOL/VOL
          WILTING POINT                 =       0.0240 VOL/VOL
          INITIAL SOIL WATER CONTENT    =       0.4364 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.580000000000E-02 CM/SEC
        NOTE:   SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY   4.90
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER   2
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER    18
          THICKNESS                     =    1800.00     CM
          POROSITY                      =       0.6710 VOL/VOL
          FIELD CAPACITY                =       0.2920 VOL/VOL
          WILTING POINT                 =       0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT    =       0.2989 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.100000224000E-02 CM/SEC


                                  LAYER   3
                                  --------

                    TYPE 2 - LATERAL DRAINAGE LAYER
                       MATERIAL TEXTURE NUMBER    20
          THICKNESS                     =       0.50     CM
```

POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.1588 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0841 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34
THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3413 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL

```
WILTING POINT                    =     0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000      CM/SEC


                    LAYER   9
                    --------

          TYPE 2 - LATERAL DRAINAGE LAYER
            MATERIAL TEXTURE NUMBER  21
THICKNESS                        =    30.00    CM
POROSITY                         =     0.3970 VOL/VOL
FIELD CAPACITY                   =     0.0320 VOL/VOL
WILTING POINT                    =     0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.300000000000      CM/SEC


                    LAYER 10
                    --------

          TYPE 2 - LATERAL DRAINAGE LAYER
            MATERIAL TEXTURE NUMBER  20
THICKNESS                        =     0.50    CM
POROSITY                         =     0.8500 VOL/VOL
FIELD CAPACITY                   =     0.0100 VOL/VOL
WILTING POINT                    =     0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000      CM/SEC


                    LAYER 11
                    --------

          TYPE 2 - LATERAL DRAINAGE LAYER
            MATERIAL TEXTURE NUMBER   2
THICKNESS                        =    37.00    CM
POROSITY                         =     0.4370 VOL/VOL
FIELD CAPACITY                   =     0.0620 VOL/VOL
WILTING POINT                    =     0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.580000000000E-02 CM/SEC
SLOPE                            =     0.50    PERCENT
DRAINAGE LENGTH                  =    225.0    METERS


                    LAYER 12
                    --------

          TYPE 4 - FLEXIBLE MEMBRANE LINER
            MATERIAL TEXTURE NUMBER  35
THICKNESS                        =     0.10    CM
POROSITY                         =     0.0000 VOL/VOL
FIELD CAPACITY                   =     0.0000 VOL/VOL
WILTING POINT                    =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY              =     2.00    HOLES/HECTARE
FML INSTALLATION DEFECTS         =     2.00    HOLES/HECTARE
FML PLACEMENT QUALITY            =  4 - POOR


                    LAYER 13
                    --------

            TYPE 3 - BARRIER SOIL LINER
            MATERIAL TEXTURE NUMBER  28
THICKNESS                        =    75.00    CM
POROSITY                         =     0.4520 VOL/VOL
FIELD CAPACITY                   =     0.4110 VOL/VOL
WILTING POINT                    =     0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.4520 VOL/VOL
```

EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 14

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9
THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF 5.% AND
A SLOPE LENGTH OF 225. METERS.

SCS RUNOFF CURVE NUMBER = 91.53
FRACTION OF AREA ALLOWING RUNOFF = 0.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 20.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 8.176 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 9.910 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 0.745 CM
INITIAL SNOW WATER = 3.716 CM
INITIAL WATER IN LAYER MATERIALS = 646.855 CM
TOTAL INITIAL WATER = 650.571 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 20.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.2	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	455.956	(50.5753)	4559.56	50.416
LATERAL DRAINAGE COLLECTED FROM LAYER 5	456.45273	(105.74087)	4564.527	50.47051
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.01227	(0.00270)	0.123	0.00136
AVERAGE HEAD ON TOP OF LAYER 6	0.982	(0.228)		
LATERAL DRAINAGE COLLECTED FROM LAYER 11	0.00831	(0.00196)	0.083	0.00092
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.00173	(0.00036)	0.017	0.00019
AVERAGE HEAD ON TOP OF LAYER 12	0.102	(0.024)		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	-8.022	(3.0306)	-80.22	-0.887

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	0.000	0.00000	0
DRAINAGE COLLECTED FROM LAYER 5	4.77786	47.77863	1530016
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000118	0.00118	1530016
AVERAGE HEAD ON TOP OF LAYER 6	3.771		
MAXIMUM HEAD ON TOP OF LAYER 6	7.338		
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	6.1 METERS		
DRAINAGE COLLECTED FROM LAYER 11	0.00003	0.00030	2550020
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000006	0.00006	2550020
AVERAGE HEAD ON TOP OF LAYER 12	0.137		
MAXIMUM HEAD ON TOP OF LAYER 12	0.273		
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	0.4 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000000	0.00000	0
SNOW WATER	236.91	2369.1375	730012

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4955

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0372

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	6.1881	0.4125
2	525.4789	0.2919
3	0.0361	0.0721
4	2.2431	0.0748
5	0.2031	0.3385
6	0.0000	0.0000
7	33.9000	0.4520
8	0.0050	0.0100
9	0.9600	0.0320
10	0.0050	0.0100
11	2.2990	0.0621
12	0.0000	0.0000
13	33.9000	0.4520
14	28.3955	0.2840
SNOW WATER	0.913	

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** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE **
** HELP MODEL VERSION 3.07 (1 November 1997) **
** DEVELOPED BY ENVIRONMENTAL LABORATORY **
** USAE WATERWAYS EXPERIMENT STATION **
** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY **
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PRECIPITATION DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP_weather1.dat
TEMPERATURE DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP_weather2.dat
SOLAR RADIATION DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP_weather3.dat
EVAPOTRANSPIRATION DATA: C:\WHI\UNSAT22\data\P13364.VHP_weather4.dat
SOIL AND DESIGN DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP\I_393060.inp
OUTPUT DATA FILE: C:\WHI\UNSAT22\data\P13364.VHP\O_393060.prt

TIME: 15: 3 DATE: 7/18/2011

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TITLE: Daily Cover – Silty Clay

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9

THICKNESS = 15.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4388 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 4.90
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS = 1800.00 CM
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000224000E-02 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS = 0.50 CM

POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0465 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0521 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34
THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0221 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL

WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 11

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 37.00 CM
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.580000000000E-02 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 12

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 13

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 14

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9
THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 225. METERS.

SCS RUNOFF CURVE NUMBER = 91.53
FRACTION OF AREA ALLOWING RUNOFF = 0.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 20.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 8.079 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 10.135 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 5.050 CM
INITIAL SNOW WATER = 27.708 CM
INITIAL WATER IN LAYER MATERIALS = 633.276 CM
TOTAL INITIAL WATER = 660.984 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 20.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.3	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	572.045	(329.8968)	5720.45	63.252
LATERAL DRAINAGE COLLECTED FROM LAYER 5	140.66826	(62.40474)	1406.683	15.55385
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00420	(0.00179)	0.042	0.00046
AVERAGE HEAD ON TOP OF LAYER 6	0.303	(0.134)		
LATERAL DRAINAGE COLLECTED FROM LAYER 11	0.00284	(0.00061)	0.028	0.00031
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.00070	(0.00013)	0.007	0.00008
AVERAGE HEAD ON TOP OF LAYER 12	0.035	(0.008)		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	191.679	(14.5522)	1916.79	21.194

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	0.000	0.00000	0
DRAINAGE COLLECTED FROM LAYER 5	1.65396	16.53956	3120019
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000046	0.00046	3120019
AVERAGE HEAD ON TOP OF LAYER 6	1.305		
MAXIMUM HEAD ON TOP OF LAYER 6	2.580		
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.6 METERS		
DRAINAGE COLLECTED FROM LAYER 11	0.00001	0.00010	3490015
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000002	0.00002	3490015
AVERAGE HEAD ON TOP OF LAYER 12	0.046		
MAXIMUM HEAD ON TOP OF LAYER 12	0.093		
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	0.2 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000000	0.00000	0
SNOW WATER	4261.40	42613.9723	3370019

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4389

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2525

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	6.5817	0.4388
2	525.6372	0.2920
3	0.0227	0.0454
4	1.5266	0.0509
5	0.0119	0.0198
6	0.0000	0.0000
7	33.9000	0.4520
8	0.0050	0.0100
9	0.9600	0.0320
10	0.0050	0.0100
11	2.2956	0.0620
12	0.0000	0.0000
13	33.9000	0.4520
14	28.3934	0.2839

SNOW WATER 411.104

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07 (1 November 1997)                 **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\WHI\UNSAT22\data\P13364.VHP\_weather1.dat
TEMPERATURE DATA FILE:       C:\WHI\UNSAT22\data\P13364.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:   C:\WHI\UNSAT22\data\P13364.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:     C:\WHI\UNSAT22\data\P13364.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:   C:\WHI\UNSAT22\data\P13364.VHP\I_392355.inp
OUTPUT DATA FILE:            C:\WHI\UNSAT22\data\P13364.VHP\O_392355.prt


TIME:  16:31     DATE:   7/15/2011


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    TITLE:  Interim Cover – Sand, no Runoff

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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
           COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                             LAYER  1
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                  TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   9
        THICKNESS                  =    30.00    CM
        POROSITY                   =     0.4370 VOL/VOL
        FIELD CAPACITY             =     0.0620 VOL/VOL
        WILTING POINT              =     0.0240 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.2868 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  = 0.580000000000E-02 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.90
             FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                             LAYER  2
                             --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  18
        THICKNESS                  =  1800.00    CM
        POROSITY                   =     0.6710 VOL/VOL
        FIELD CAPACITY             =     0.2920 VOL/VOL
        WILTING POINT              =     0.0770 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.2996 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  = 0.100000224000E-02 CM/SEC


                             LAYER  3
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                   TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER  20
        THICKNESS                  =     0.50    CM
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POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.1582 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0841 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34
THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3388 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL

WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 11

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 37.00 CM
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.580000000000E-02 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 12

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 13

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 14

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9
THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.%
AND A SLOPE LENGTH OF 225. METERS.

SCS RUNOFF CURVE NUMBER = 81.18
FRACTION OF AREA ALLOWING RUNOFF = 0.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 20.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 7.562 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 8.740 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 0.480 CM
INITIAL SNOW WATER = 3.716 CM
INITIAL WATER IN LAYER MATERIALS = 650.227 CM
TOTAL INITIAL WATER = 653.944 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 20.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.2	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	430.368	(48.9930)	4303.68	47.586
LATERAL DRAINAGE COLLECTED FROM LAYER 5	482.40860	(99.00222)	4824.086	53.34048
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.01301	(0.00251)	0.130	0.00144
AVERAGE HEAD ON TOP OF LAYER 6	1.038	(0.214)		
LATERAL DRAINAGE COLLECTED FROM LAYER 11	0.00881	(0.00213)	0.088	0.00097
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.00182	(0.00039)	0.018	0.00020
AVERAGE HEAD ON TOP OF LAYER 12	0.108	(0.026)		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	-8.390	(2.9943)	-83.90	-0.928

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	0.000	0.00000	0
DRAINAGE COLLECTED FROM LAYER 5	5.00681	50.06815	1540016
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000123	0.00123	1540016
AVERAGE HEAD ON TOP OF LAYER 6	3.951		
MAXIMUM HEAD ON TOP OF LAYER 6	7.682		
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	6.3 METERS		
DRAINAGE COLLECTED FROM LAYER 11	0.00003	0.00032	2690020
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000006	0.00006	2690020
AVERAGE HEAD ON TOP OF LAYER 12	0.144		
MAXIMUM HEAD ON TOP OF LAYER 12	0.288		
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	0.4 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000000	0.00000	0
SNOW WATER	236.91	2369.1375	730012

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4370

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0240

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	7.9269	0.2642
2	526.0202	0.2922
3	0.0980	0.1960
4	2.5817	0.0861
5	0.1577	0.2628
6	0.0000	0.0000
7	33.9000	0.4520
8	0.0050	0.0100
9	0.9600	0.0320
10	0.0050	0.0100
11	2.2993	0.0621
12	0.0000	0.0000
13	33.9000	0.4520
14	28.3956	0.2840

SNOW WATER 0.913

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.07 (1 November 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\WHI\UNSAT22\data\P13364.VHP\_weather1.dat
TEMPERATURE DATA FILE:        C:\WHI\UNSAT22\data\P13364.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:   C:\WHI\UNSAT22\data\P13364.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:      C:\WHI\UNSAT22\data\P13364.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:   C:\WHI\UNSAT22\data\P13364.VHP\I_392355.inp
OUTPUT DATA FILE:             C:\WHI\UNSAT22\data\P13364.VHP\O_392355.prt


TIME:   16:42       DATE:    7/15/2011


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      TITLE:   Interim Cover – Silty Clay, no Runoff

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      NOTE:   INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER   1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER     9
          THICKNESS                     =       30.00     CM
          POROSITY                      =        0.4520 VOL/VOL
          FIELD CAPACITY                =        0.4110 VOL/VOL
          WILTING POINT                 =        0.3110 VOL/VOL
          INITIAL SOIL WATER CONTENT    =        0.4373 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =   0.120000000000E-05 CM/SEC
        NOTE:   SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY   4.90
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER   2
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   18
          THICKNESS                     =     1800.00     CM
          POROSITY                      =        0.6710 VOL/VOL
          FIELD CAPACITY                =        0.2920 VOL/VOL
          WILTING POINT                 =        0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT    =        0.2920 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =   0.100000224000E-02 CM/SEC


                                   LAYER   3
                                   --------

                          TYPE 2 - LATERAL DRAINAGE LAYER
                            MATERIAL TEXTURE NUMBER   20
          THICKNESS                     =        0.50     CM
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POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0518 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0552 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34
THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0298 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL

WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 11

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 37.00 CM
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.580000000000E-02 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 12

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 13

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 14

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9

THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 225. METERS.

SCS RUNOFF CURVE NUMBER = 81.18
FRACTION OF AREA ALLOWING RUNOFF = 0.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 20.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 9.009 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 9.040 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 6.220 CM
INITIAL SNOW WATER = 27.710 CM
INITIAL WATER IN LAYER MATERIALS = 639.874 CM
TOTAL INITIAL WATER = 667.584 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 20.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.2	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	570.558	(329.1116)	5705.58	63.087
LATERAL DRAINAGE COLLECTED FROM LAYER 5	141.97449	(61.89933)	1419.745	15.69828
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00426	(0.00176)	0.043	0.00047
AVERAGE HEAD ON TOP OF LAYER 6	0.306	(0.133)		
LATERAL DRAINAGE COLLECTED FROM LAYER 11	0.00288	(0.00063)	0.029	0.00032
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.00070	(0.00013)	0.007	0.00008
AVERAGE HEAD ON TOP OF LAYER 12	0.035	(0.008)		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	191.860	(14.5530)	1918.60	21.214

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	0.000	0.00000	0
DRAINAGE COLLECTED FROM LAYER 5	1.19788	11.97881	1820015
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000034	0.00034	1820015
AVERAGE HEAD ON TOP OF LAYER 6	0.945		
MAXIMUM HEAD ON TOP OF LAYER 6	1.874		
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.0 METERS		
DRAINAGE COLLECTED FROM LAYER 11	0.00001	0.00010	3530015
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000002	0.00002	3530015
AVERAGE HEAD ON TOP OF LAYER 12	0.047		
MAXIMUM HEAD ON TOP OF LAYER 12	0.094		
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	0.2 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000000	0.00000	0
SNOW WATER	4264.60	42646.0377	3370019

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4520

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.3110

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	13.1498	0.4383
2	525.6000	0.2920
3	0.0246	0.0492
4	1.5983	0.0533
5	0.0147	0.0245
6	0.0000	0.0000
7	33.9000	0.4520
8	0.0050	0.0100
9	0.9600	0.0320
10	0.0050	0.0100
11	2.2956	0.0620
12	0.0000	0.0000
13	33.9000	0.4520
14	28.3934	0.2839

SNOW WATER 411.457

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.07 (1 November 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\WHI\UNSAT22\data\P13364.VHP\_weather1.dat
TEMPERATURE DATA FILE:        C:\WHI\UNSAT22\data\P13364.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:    C:\WHI\UNSAT22\data\P13364.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:      C:\WHI\UNSAT22\data\P13364.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:    C:\WHI\UNSAT22\data\P13364.VHP\I_392355.inp
OUTPUT DATA FILE:             C:\WHI\UNSAT22\data\P13364.VHP\O_392355.prt


TIME:   10:12       DATE:    7/22/2011


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     TITLE:   Interim Cover – Sand, with Runoff

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     NOTE:   INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER   1
                              --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER     9
          THICKNESS                    =       30.00     CM
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.0620 VOL/VOL
          WILTING POINT                =      0.0240 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2022 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.580000000000E-02 CM/SEC
        NOTE:   SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY   4.90
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER   2
                              --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER    18
          THICKNESS                    =     1800.00     CM
          POROSITY                     =      0.6710 VOL/VOL
          FIELD CAPACITY               =      0.2920 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2996 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000224000E-02 CM/SEC


                              LAYER   3
                              --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER    20
          THICKNESS                    =        0.50     CM
```

POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.1582 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3584 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34
THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.8500 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 10000.0 METERS

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL

WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0335 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 11

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 37.00 CM
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0621 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.580000000000E-02 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 12

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 13

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 14

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9
THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
AND A SLOPE LENGTH OF 225. METERS.

SCS RUNOFF CURVE NUMBER = 82.02
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 20.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 5.023 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 8.740 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 0.480 CM
INITIAL SNOW WATER = 3.716 CM
INITIAL WATER IN LAYER MATERIALS = 656.277 CM
TOTAL INITIAL WATER = 659.993 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 20.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.3	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	238.185	(70.2486)	2381.85	26.336
EVAPOTRANSPIRATION	429.488	(48.3066)	4294.88	47.489
LATERAL DRAINAGE COLLECTED FROM LAYER 5	107.68433	(0.56176)	1076.843	11.90678
PERCOLATION/LEAKAGE THROUGH LAYER 7	28.00435	(13.33787)	280.043	3.09647
AVERAGE HEAD ON TOP OF LAYER 6	3608.919	(1588.742)		
LATERAL DRAINAGE COLLECTED FROM LAYER 11	19.07765	(14.38698)	190.776	2.10944
PERCOLATION/LEAKAGE THROUGH LAYER 13	1.58442	(0.96538)	15.844	0.17519
AVERAGE HEAD ON TOP OF LAYER 12	204.581	(130.521)		
PERCOLATION/LEAKAGE THROUGH LAYER 14	1.67791	(1.05222)	16.779	0.18553
CHANGE IN WATER STORAGE	108.282	(2.7945)	1082.82	11.973

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	131.337	1313.37166	680017
DRAINAGE COLLECTED FROM LAYER 5	0.29699	2.96988	3480020
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.136980	1.36980	3480020
AVERAGE HEAD ON TOP OF LAYER 6	6078.541		
MAXIMUM HEAD ON TOP OF LAYER 6	8986.114		
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2608.3 METERS		
DRAINAGE COLLECTED FROM LAYER 11	0.13103	1.31034	1180020
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.007629	0.07629	2320017
AVERAGE HEAD ON TOP OF LAYER 12	370.095		
MAXIMUM HEAD ON TOP OF LAYER 12	483.423		
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	91.7 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.080335	0.80335	2030006
SNOW WATER	236.91	2369.1375	730012

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3745

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0240

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	5.1954	0.1732
2	743.6016	0.4131
3	0.4250	0.8500
4	11.9100	0.3970
5	0.5100	0.8500
6	0.0000	0.0000
7	33.9000	0.4520
8	0.0419	0.0837
9	1.7456	0.0582
10	0.0419	0.0837
11	16.1680	0.4370
12	0.0000	0.0000
13	33.9000	0.4520
14	28.2050	0.2821

SNOW WATER 0.913

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                  HELP MODEL VERSION 3.07 (1 November 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\WHI\UNSAT22\data\P13364.VHP\_weather1.dat
TEMPERATURE DATA FILE:       C:\WHI\UNSAT22\data\P13364.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:   C:\WHI\UNSAT22\data\P13364.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:     C:\WHI\UNSAT22\data\P13364.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:   C:\WHI\UNSAT22\data\P13364.VHP\I_392355.inp
OUTPUT DATA FILE:            C:\WHI\UNSAT22\data\P13364.VHP\O_392355.prt


TIME:    9:49       DATE:    7/22/2011


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    TITLE:   Interim Cover – Silty Clay, with Runoff

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    NOTE:   INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER   1
                                 --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER     9
         THICKNESS                    =       30.00     CM
         POROSITY                     =        0.4520 VOL/VOL
         FIELD CAPACITY               =        0.4110 VOL/VOL
         WILTING POINT                =        0.3110 VOL/VOL
         INITIAL SOIL WATER CONTENT   =        0.4373 VOL/VOL
         EFFECTIVE SAT. HYD. COND.    =  0.120000000000E-05 CM/SEC
       NOTE:   SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY   4.90
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                 LAYER   2
                                 --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   18
         THICKNESS                    =     1800.00     CM
         POROSITY                     =        0.6710 VOL/VOL
         FIELD CAPACITY               =        0.2920 VOL/VOL
         WILTING POINT                =        0.0770 VOL/VOL
         INITIAL SOIL WATER CONTENT   =        0.2920 VOL/VOL
         EFFECTIVE SAT. HYD. COND.    =  0.100000224000E-02 CM/SEC


                                 LAYER   3
                                 --------

                      TYPE 2 - LATERAL DRAINAGE LAYER
                        MATERIAL TEXTURE NUMBER   20
         THICKNESS                    =        0.50     CM
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POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0512 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.1572 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34
THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.8500 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 10000.0 METERS

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL

WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0323 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 11

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 37.00 CM
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.580000000000E-02 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 12

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 13

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 14

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9
THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
AND A SLOPE LENGTH OF 225. METERS.

SCS RUNOFF CURVE NUMBER = 82.02
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 20.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 9.009 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 9.040 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 6.220 CM
INITIAL SNOW WATER = 3.716 CM
INITIAL WATER IN LAYER MATERIALS = 643.438 CM
TOTAL INITIAL WATER = 647.155 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 20.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.3	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	506.405	(92.1686)	5064.05	55.994
EVAPOTRANSPIRATION	377.196	(43.7506)	3771.96	41.707
LATERAL DRAINAGE COLLECTED FROM LAYER 5	23.74165	(11.26074)	237.417	2.62514
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.08668	(0.10137)	0.867	0.00958
AVERAGE HEAD ON TOP OF LAYER 6	9.331	(11.904)		
LATERAL DRAINAGE COLLECTED FROM LAYER 11	0.06718	(0.03321)	0.672	0.00743
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.01091	(0.00484)	0.109	0.00121
AVERAGE HEAD ON TOP OF LAYER 12	0.826	(0.408)		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.00802	(0.02468)	0.080	0.00089
CHANGE IN WATER STORAGE	-3.022	(1.9660)	-30.22	-0.334

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	134.109	1341.08964	680017
DRAINAGE COLLECTED FROM LAYER 5	0.19880	1.98801	3530001
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.002561	0.02561	3530001
AVERAGE HEAD ON TOP OF LAYER 6	113.046		
MAXIMUM HEAD ON TOP OF LAYER 6	221.582		
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	199.3 METERS		
DRAINAGE COLLECTED FROM LAYER 11	0.00042	0.00416	2740003
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000063	0.00063	2740003
AVERAGE HEAD ON TOP OF LAYER 12	1.868		
MAXIMUM HEAD ON TOP OF LAYER 12	3.678		
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	3.5 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.080195	0.80195	920006
SNOW WATER	236.91	2369.1375	730012

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4518

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.3110

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	13.1233	0.4374
2	525.6000	0.2920
3	0.0246	0.0492
4	1.5921	0.0531
5	0.3665	0.6109
6	0.0000	0.0000
7	33.9000	0.4520
8	0.0050	0.0100
9	0.9600	0.0320
10	0.0050	0.0100
11	2.3223	0.0628
12	0.0000	0.0000
13	33.9000	0.4520
14	28.3978	0.2840

SNOW WATER 0.913

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.07 (1 November 1997)                  **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\WHI\UNSAT22\data\P13364.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\UNSAT22\data\P13364.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\UNSAT22\data\P13364.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\UNSAT22\data\P13364.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\UNSAT22\data\P13364.VHP\I_392228.inp
OUTPUT DATA FILE:           C:\WHI\UNSAT22\data\P13364.VHP\O_392228.prt


TIME:  11:39     DATE:   9/22/2011


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   TITLE:  Final Cover

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   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
          COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                          LAYER  1
                          --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   7
        THICKNESS                  =    15.00   CM
        POROSITY                   =     0.4730 VOL/VOL
        FIELD CAPACITY             =     0.2220 VOL/VOL
        WILTING POINT              =     0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.3762 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  = 0.520001164800E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.90
             FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER  28
        THICKNESS                  =    60.00   CM
        POROSITY                   =     0.4370 VOL/VOL
        FIELD CAPACITY             =     0.0620 VOL/VOL
        WILTING POINT              =     0.0240 VOL/VOL
```

INITIAL SOIL WATER CONTENT = 0.4370 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.376000000000E-01 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 2800.00 CM
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2964 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000224000E-02 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.1486 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0834 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 6

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34
THICKNESS = 0.60 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3176 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 33.0000000000 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 7

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21
THICKNESS = 30.00 CM
POROSITY = 0.3970 VOL/VOL
FIELD CAPACITY = 0.0320 VOL/VOL
WILTING POINT = 0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000000000 CM/SEC

LAYER 11

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20
THICKNESS = 0.50 CM
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL

INITIAL SOIL WATER CONTENT = 0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

LAYER 12

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2
THICKNESS = 37.00 CM
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.580000000000E-02 CM/SEC
SLOPE = 0.50 PERCENT
DRAINAGE LENGTH = 225.0 METERS

LAYER 13

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35
THICKNESS = 0.10 CM
POROSITY = 0.0000 VOL/VOL
FIELD CAPACITY = 0.0000 VOL/VOL
WILTING POINT = 0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY = 2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS = 2.00 HOLES/HECTARE
FML PLACEMENT QUALITY = 4 - POOR

LAYER 14

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28
THICKNESS = 75.00 CM
POROSITY = 0.4520 VOL/VOL
FIELD CAPACITY = 0.4110 VOL/VOL
WILTING POINT = 0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.120000000000E-05 CM/SEC

LAYER 15

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9
THICKNESS = 100.00 CM
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.2840 VOL/VOL
WILTING POINT = 0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2839 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.190000000000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
GOOD STAND OF GRASS, A SURFACE SLOPE OF 25.%
AND A SLOPE LENGTH OF 225. METERS.

SCS RUNOFF CURVE NUMBER = 67.59
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 1.0000 HECTARES
EVAPORATIVE ZONE DEPTH = 15.0 CM
INITIAL WATER IN EVAPORATIVE ZONE = 6.198 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 7.095 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 1.560 CM
INITIAL SNOW WATER = 3.716 CM
INITIAL WATER IN LAYER MATERIALS = 964.060 CM
TOTAL INITIAL WATER = 967.777 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Ottawa CANA

STATION LATITUDE = 45.32 DEGREES
MAXIMUM LEAF AREA INDEX = 4.00
START OF GROWING SEASON (JULIAN DATE) = 123
END OF GROWING SEASON (JULIAN DATE) = 282
EVAPORATIVE ZONE DEPTH = 15.0 CM
AVERAGE ANNUAL WIND SPEED = 17.70 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 79.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
57.7	50.4	62.2	77.7	83.5	81.5
76.8	95.0	82.4	87.3	83.7	84.3

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.5	-8.3	-2.4	6.4	13.3	17.9
21.2	19.6	14.3	7.7	1.0	-7.2

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Ottawa ON
AND STATION LATITUDE = 45.37 DEGREES

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	904.39	(104.063)	9044.0	100.00
RUNOFF	240.066	(68.9372)	2400.66	26.544
EVAPOTRANSPIRATION	446.247	(49.2948)	4462.47	49.342
PERCOLATION/LEAKAGE THROUGH LAYER 2	219.62388	(48.65881)	2196.239	24.28407
AVERAGE HEAD ON TOP OF LAYER 2	0.332	(0.069)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	225.96916	(65.58995)	2259.692	24.98567
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00634	(0.00172)	0.063	0.00070
AVERAGE HEAD ON TOP OF LAYER 7	0.487	(0.143)		
LATERAL DRAINAGE COLLECTED FROM LAYER 12	0.00438	(0.00085)	0.044	0.00048
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.00100	(0.00017)	0.010	0.00011
AVERAGE HEAD ON TOP OF LAYER 13	0.054	(0.010)		
PERCOLATION/LEAKAGE THROUGH LAYER 15	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	-7.892	(2.2915)	-78.92	-0.873

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 and their dates (DDDYYYY)

	(MM)	(CU. METERS)	
PRECIPITATION	54.00	540.00000	1440012
RUNOFF	132.996	1329.95583	680017
PERCOLATION/LEAKAGE THROUGH LAYER 2	36.713547	367.13547	1190003
AVERAGE HEAD ON TOP OF LAYER 2	43.679		
DRAINAGE COLLECTED FROM LAYER 6	3.64854	36.48542	1300009
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000093	0.00093	1300009
AVERAGE HEAD ON TOP OF LAYER 7	2.879		
MAXIMUM HEAD ON TOP OF LAYER 7	5.632		
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	4.9 METERS		

DRAINAGE COLLECTED FROM LAYER 12	0.00001	0.00015	3550017
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000003	0.00003	3550017
AVERAGE HEAD ON TOP OF LAYER 13	0.067		
MAXIMUM HEAD ON TOP OF LAYER 13	0.133		
LOCATION OF MAXIMUM HEAD IN LAYER 12 (DISTANCE FROM DRAIN)	0.2 METERS		
PERCOLATION/LEAKAGE THROUGH LAYER 15	0.000000	0.00000	0
SNOW WATER	236.91	2369.1375	730012

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4332

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(CM)	(VOL/VOL)
1	5.3621	0.3575
2	26.2200	0.4370
3	817.6000	0.2920
4	0.0340	0.0679
5	2.2108	0.0737
6	0.1927	0.3211
7	0.0000	0.0000
8	33.9000	0.4520
9	0.0050	0.0100
10	0.9600	0.0320
11	0.0050	0.0100
12	2.2963	0.0621
13	0.0000	0.0000
14	33.9000	0.4520
15	28.3940	0.2839

SNOW WATER 0.913

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Appendix C

Contaminant Flux Modelling