Protecting, Enhancing, and Restoring Our Environment

May 16, 2018

Ms. Cathy Stepp
Regional Administrator
EPA Region V
77 West Jackson Blvd.
Chicago, IL 60604

Mr. Jack Schinderle
Director, Waste Management and Radiological Protection Division
Michigan Department of Environmental Quality
525 West Allegan Street
Lansing, MI 48933

**Subject:** **Proposed Permit Modification - Upgrades to MC VI-G Phase 2 Liner Design**
**Revision 1**
**Wayne Disposal, Inc.**
**Belleville, Wayne County, Michigan**

Dear Ms. Stepp and Mr. Schinderle:

On behalf of Wayne Disposal, Inc. (WDI), CTI and Associates, Inc. (CTI) is submitting this Revision 1 to the May 3, 2018 Permit Modification Letter Report for your review and approval. The May 3, 2018 letter report details proposed upgrades to the design of the Master Cell VI-G Phase 2 (MC VI-G Phase 2) liner. The purpose of this Revision 1 is to respond to comments WDI has received from the Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality.

WDI and CTI received comments as follows: Comments from the MDEQ dated May 3, 2018, Comments from the MDEQ dated May 9, 2018, and Comments from the EPA dated May 14, 2018. These comments and responses are included herein as Attachment C, Correspondence Regarding the WDI 2018 Permit Modification, Revision 1. This revised Attachment C replaces the original Attachment C included with the May 3, 2018 Permit Modification Letter Report.

Responses to the comments also resulted in changes to the original Attachments A and B included with the May 3, 2018 Permit Modification Letter Report. Therefore, this Revision 1 also includes Attachment A, Equivalency Information and References, Revision 1 and Attachment B, 2018 Permit Engineering Drawings, Revision D (revising Sheets 22A and 22B). These revised attachments supersede the original Attachments A and B included in the May 3, 2018 Permit Modification Letter Report.

If you have any questions regarding the revisions to the May 3, 2018 submittal, please feel free to contact the undersigned at (248) 486-5100 or tsoong@cticompanies.com.

Sincerely,
**CTI and Associates, Inc.**

Te-Yang Soong, Ph.D., P.E.
Principal Engineer

Cc: Kerry Durnen, US Ecology
Sylwia Scott, US Ecology
Pete Quackenbush, MDEQ
Lisa Graczyk, EPA

**List of Attachments**

Proposed Permit Modification Letter Report, May 3, 2018

| | |
|---|---|
| Attachment A: | Equivalency Information and References, Revision 1, May 16, 2018 |
| Attachment B: | 2018 Permit Engineering Drawings (under a separate cover), Revision D |
| Attachment C: | Correspondence Regarding the WDI 2018 Permit Modification, Revision 1, May 16, 2018 |
| Attachment D: | GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines |

*Protecting, Enhancing, and Restoring Our Environment*

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**Subject:** **Proposed Permit Modification - Upgrades to MC VI-G Phase 2 Liner Design**
**Wayne Disposal, Inc.**
**Belleville, Wayne County, Michigan**

Dear Ms. Stepp and Mr. Schinderle:

On behalf of Wayne Disposal, Inc. (WDI), CTI and Associates, Inc. (CTI) is submitting this Permit Modification Letter Report for your review and approval of proposed upgrades to the design of the Master Cell VI-G Phase 2 (MC VI-G Phase 2) liner. The purpose of this change is to incorporate the numerous advantages of Geosynthetic Clay Liner (GCL).

The following sections of this letter report summarize the analysis methodology, results, and recommendations for the upgrades. Calculations and documents supporting the proposed upgrades and the revised permit engineering drawings are attached.

## Introduction

This letter report presents the basis for the proposed liner revisions for MC VI-G Phase 2 at WDI. The proposed upgrades incorporate an alternative GCL-based liner design providing the following benefits compared to the currently approved compacted clay liner (CCL) based design:

- GCL is man-made with superior consistency and reliability
- GCL has superior resistance to freeze-thaw damage and is preferred considering Michigan's climate
- GCL has superior resistance to settlement–induced tensioning
- GCL reduces the need for compaction and is more consistent in achieving the approved grades
- GCL has substantially lower hydraulic conductivity

Although it is WDI's intent to incorporate GCLs in future construction of MC VI-G Phases 3 through 6 and F subcells, this proposed design upgrade pertains only to the construction of MC VI-G Phase 2 subcells to facilitate a prompt and timely review and approval in support of the planned 2018 MC VI-G Phase 2 Subcell G2 construction. **Figure 1** shows a site plan of WDI's Master Cell VI G and F (approved by the MDEQ on May 4, 2012 and EPA on September 27, 2013). The proposed liner system upgrade presented in this letter report pertains to MC VI-G Phase 2 (consisting of Subcells G2 and G3) and is highlighted in **Figure 1**.

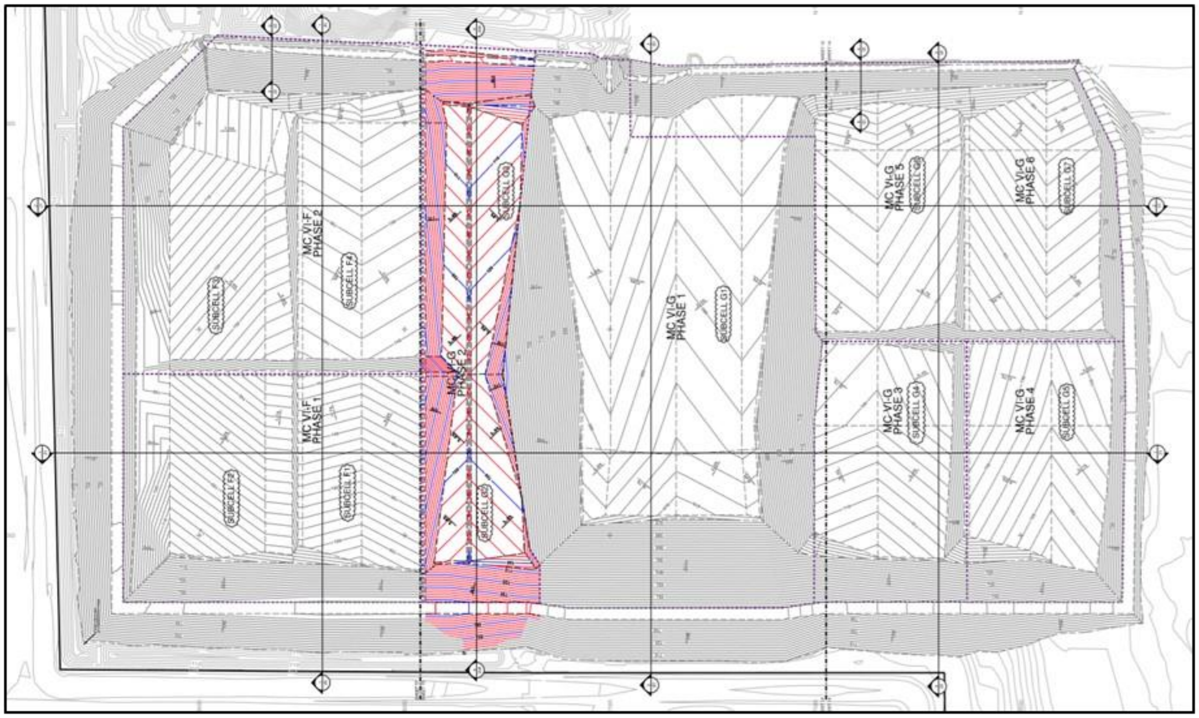


**Figure 1.** Master Cell VI-G and F Layout

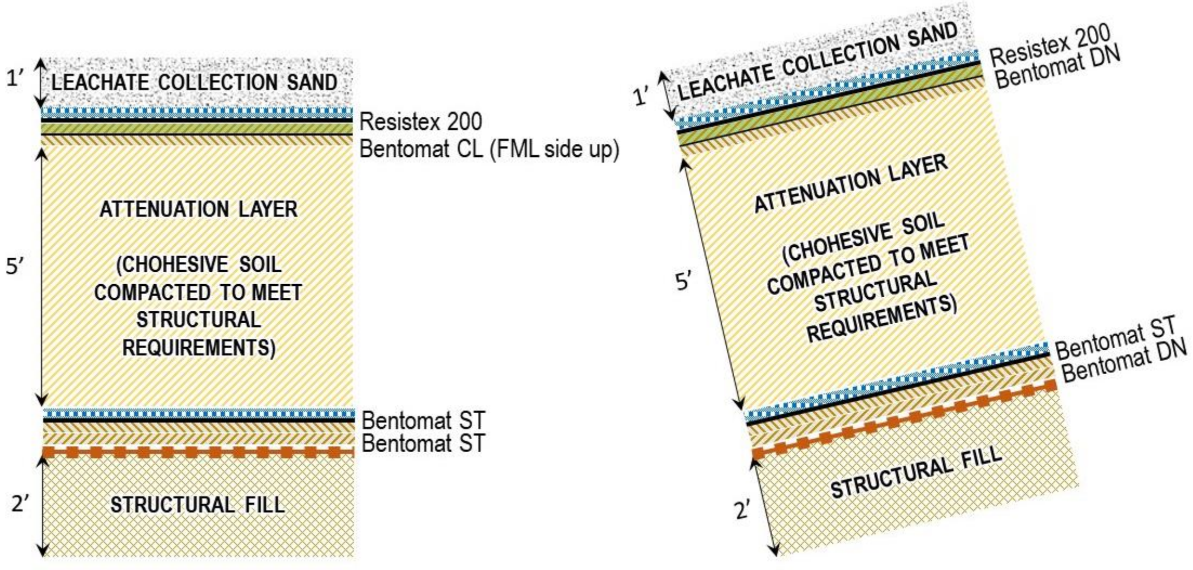
In accordance with Rule 299.9620 (4) of the Michigan Part 111 Administrative Rules, an alternate design may be approved if the owner or operator can demonstrate the design will prevent the migration of any hazardous constituent into the groundwater or surface water at least as effectively as the design requirements specified in the subrule. The following sections discuss how the proposed design satisfies this requirement.

**Proposed Liner System**

This modification proposes using GCL, in lieu of the currently approved CCL, as an alternative soil component of the liner system for the future construction of Master Cell VI-G Phase 2 subcells. GCL products are factory-manufactured hydraulic barriers consisting of a layer of sodium bentonite supported by geotextiles (woven and/or non-woven) and, in some cases, an additional film of flexible membrane liner (FML) for enhanced barrier performance. These components (sodium bentonite, geotextiles, and FML) are mechanically held together by either needling or chemical adhesive.

Sodium bentonite (the interlayer of GCL) is an effective barrier primarily because it can absorb moisture (i.e., hydrate and swell) producing a dense, uniform layer with extremely low hydraulic conductivity (on the order of $10^{-9}$ cm/sec). Sodium bentonite's exceptional hydraulic properties make GCL superior to CCL with respect to a steady state of water even though the thickness of GCL is less than CCL.

WDI is proposing to install two layers of GCL (as described in **Attachment A**) immediately beneath the primary HDPE geomembrane liner of MC VI-G Phase 2 subcells. **Figure 2** below shows the proposed liner construction details. Note that the captions of some of the other liner components (e.g., 80-mil HDPE geomembranes, double-sided geocomposite, geogrid, etc.) are omitted in **Figure 2** for clarity and because those components of the liner system are not changing. Please refer to **Attachment B**, 2018 Permit Engineering Drawings, Sheet 22A, for complete liner construction details.



For cell floor and slope ≤ 4H:1V

For slopes ≥ 4H:1V

**Figure 2.** Proposed Liner System in MC VI-G Phase 2

As shown in **Figure 2**, the proposed liner system consists of multiple layers of geosynthetic and earthen materials to optimize the performance of the base liner system. These layers, along with their respective functions, are tabulated in **Table 1** for a direct comparison between the proposed and the permitted base liner systems (in the order from top to bottom).

**Table 1**. Comparison Between Permitted and Proposed Liner Systems (cell floor from top to bottom)

<table>
<tr><th>Component</th><th>Permitted System</th><th>Proposed System</th></tr>
<tr><td rowspan="2">Primary leachate collection</td><td colspan="2">1' of drainage sand</td></tr>
<tr><td colspan="2">Double-sided drainage geocomposite</td></tr>
<tr><td>Primary geomembrane liner</td><td colspan="2">80-mil textured HDPE geomembrane</td></tr>
<tr><td rowspan="3">Primary clay liner</td><td rowspan="3">5-ft CCL<br>(K ≤ 1.0 x $10^{-7}$ cm/s)</td><td>Resistex® 200, manufactured by CETCO</td></tr>
<tr><td>Bentomat® CL, manufactured by CETCO</td></tr>
<tr><td>5-ft cohesive soil attenuation layer</td></tr>
<tr><td>Secondary leachate collection</td><td colspan="2">Double-sided drainage geocomposite</td></tr>
<tr><td>Secondary geomembrane liner</td><td colspan="2">80-mil textured HDPE geomembrane</td></tr>
<tr><td rowspan="2">Secondary clay liner</td><td rowspan="2">3-ft CCL<br>(K ≤ 1.0 x $10^{-7}$ cm/s)</td><td>Bentomat® ST, manufactured by CETCO</td></tr>
<tr><td>Bentomat® ST, manufactured by CETCO</td></tr>
<tr><td>Base reinforcement</td><td colspan="2">Bi-axial geogrid</td></tr>
<tr><td>Liner subbase</td><td colspan="2">2-ft structural fill</td></tr>
</table>

As indicated in **Table 1**, the main difference between the permitted and the proposed liner systems are the use of GCLs in lieu of CCLs. Other liner components will remain unchanged. Additionally, the only difference between the cell floor and sideslope (slope ≥ 4(H):1(V)) liners is the second GCL layer in the primary liner system (Bentomat® CL) will be replaced with a standard CETCO GCL product (Bentomat® DN) to maximize slope stability. Similarly, the second GCL layer in the secondary liner system (Bentomat® ST) will be replaced with a standard CETCO GCL product (Bentomat® DN) to maximize slope stability. Details of the GCL products proposed to be used in the construction of MC VI-G Phase 2 subcells can be found in **Attachment D** of this report.

## Equivalency Demonstration

Federal and Michigan regulations allow alternative liner designs provided "equivalence" can be demonstrated. For this report, the assessment was conducted by the following steps allowing for a technically-sound, effective and project-focused equivalency demonstration.

1. Identify various technical criterion that are relevant to the proposed MC VI-G Phase 2 base liners.
2. Divide the identified criteria into distinct categories to facilitate a direct technical comparison between GCLs (the proposed alternative) and CCLs (the approved design).
3. Identify criteria where technical equivalency between GCLs and CCLs has already been well-studied, demonstrated and documented by the lining industry (e.g., landfills, surface impoundments, mining, water-proofing of hydraulic structures, etc.) and based on past tests and project experiences, to be superior or equivalent to CCL. No additional demonstration effort is needed for these items.
4. Identify criteria which are mainly site-, project-, or product-specific items, and demonstrate equivalency.

As shown in **Table 2**, the following five items are identified and subjected to detailed comparison.

### Hydraulic Properties

- Steady state solute flux
- Chemical adsorptive capacity / Solute breakthrough time

### Physical/Mechanical Properties

- Stability of slopes
- Bearing capacity

### Construction Properties

- Puncture resistance/subgrade condition

**Table 2**. Generalized Technical Equivalency Assessment for Liners Beneath Landfills

| Category | Criterion for Evaluation | Equivalency of GCL to CCL | | | |
|---|---|---|---|---|---|
| | | GCL is superior | GCL is equivalent | Equivalency is product-, design-, or site-specific | Category irrelevant to this project |
| **Hydraulic** | Steady state water flux | X | | | Evaluation will focus on site-specific leachate |
| | Breakthrough time - water | X | | | Evaluation will focus on site-specific leachate |
| | Horizontal flow in seams or lifts | | X | | - |
| | Horizontal flow beneath geomembranes | X | | | - |
| | Steady state solute flux | | | X | - |
| | Chemical adsorptive capacity / Solute breakthrough time | | | X | - |
| | Permeability to gases | - | - | - | A non-issue when GCL is installed under FML |
| | Generation of consolidation water | X | | | - |
| **Physical/ Mechanical** | Freeze-thaw behavior | X | | | - |
| | Wet-dry behavior | X | | | - |
| | Vulnerability to erosion | - | - | - | Erosion is irrelevant in the proposed liner |
| | Total settlement | | X | | - |
| | Differential settlement | X | | | - |
| | Stability on slopes | | | X | - |
| | Bearing capacity | | | X | - |
| **Construction** | Puncture resistance | | | X | - |
| | Ease of placement | X | | | - |
| | Speed of construction | X | | | - |
| | Availability of material | X | | | - |
| | Requirements of water | X | | | - |
| | Air pollution concerns | X | | | - |
| | Quality assurance considerations | | X | | - |

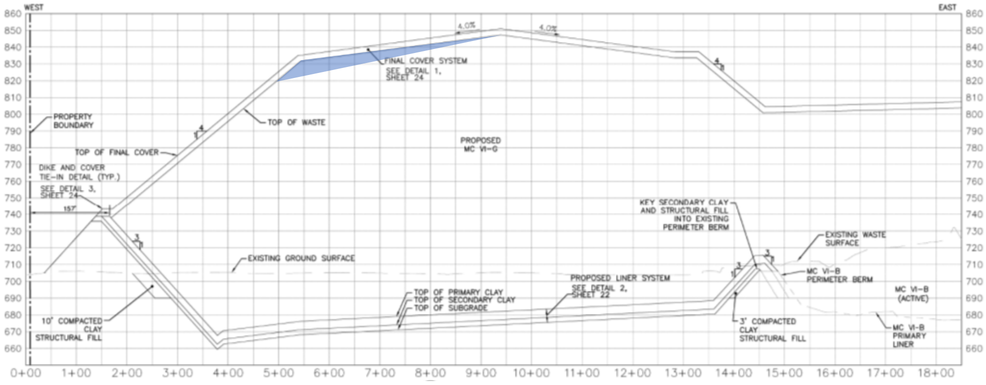
| | |
|---|---|
| 🟩 Category of which GCL is superior than CCL | 🟨 Category of which equivalency is product-, design-, or site-specific |
| 🟦 Category of which GCL is equivalent to CCL | ⬜ Category is irrelevant to this project |

WDI successfully demonstrates that the proposed GCL liner system is technically equivalent to the permitted CCL liner system in these criteria in **Attachment A**. Therefore, the proposed GCL liner system will minimize the risk of migration of hazardous constituents into the groundwater or surface water at least as effectively as the CCL design requirements specified in the rule.

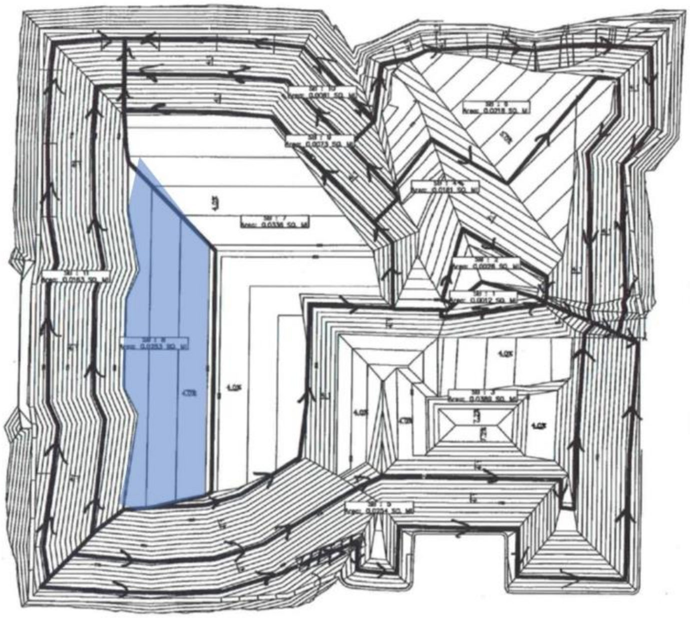
## Airspace Balance

The proposed change in liner design, as a result of replacing the 3-ft CCL in the secondary liner with two layers of GCLs, would result in a potential increase of landfill volume of 27,240 cubic yards. To off-set this gain of airspace, the top of waste grading along the western limit of MC VI-G and F were “truncated” to ensure the proposed revision will not expand the landfill volume. The proposed new top of waste grading results in a decrease in landfill volume of 27,361 cubic yards for a net landfill volume loss of 121 cubic yards.

The proposed revisions will not impact the design and performance of the final cover and stormwater management systems. **Figure 3(a)** illustrates the concept of “truncating” the top of waste grade to off-set the volume gained from replacing the 3-ft CCL in the secondary liner with 2 layers of GCL. **Figure 3(b)** illustrates the approximate extent of revisions. Both revisions are highlighted in blue.



(a) E-W Cross Section of MC VI-G Phase 2 – Illustration of Top of Waste Revision



(b) Final Grading of WDI Illustrating the Approximate Extent of the Top of Waste Revision

**Figure 3.** Modification of Waste Grading to Off-set the Gain in Airspace Due to the Proposed Revision

## Permit Drawings

The proposed upgrades to the MC VI-G Phase 2 base liner system will result in some revisions to the permit drawing sheets listed in **Table 3**. A complete set of permit drawings, including both revised and unrevised sheets, is included in **Attachment B** for ease of review and reference.

**Table 3**. List of Revised Permit Drawings

| Sheet | Title |
|---|---|
| 1 | Title sheet |
| 5 | Construction phasing plan |
| 9 | Top of secondary liner grading plan (1 of 3) |
| 10 | Top of secondary liner grading plan (2 of 3) |
| 12 | Top of primary liner grading plan (1 of 3) |
| 13 | Top of primary liner grading plan (2 of 3) |
| 16 | Final cover grading plan (1 of 2) |
| 17 | Final cover grading plan (2 of 2) |
| 20 | Cross section (1 of 3) |
| 20A | Cross section (2 of 3) |
| 21 | Cross section (3 of 3) |
| 22A | Liner system details for G2 and G3 |
| 22B | Liner system details for G2 and G3 |
| 32 | Conceptual Gas Venting System |

### MDEQ/EPA Correspondence

While preparing this 2018 WDI permit modification, discussions regarding this letter report took place between the U.S. EPA, MDEQ, WDI, and CTI. To aid in referencing this correspondence, a list of questions and responses is included in **Attachment C**. The table in **Attachment C** also includes references to the location in this letter report where further information regarding the item discussed can be found.

### GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines

The proposed base liner in MC VI-G Phase 2 includes manufacturer and product specific GCL components as shown in **Figure 2** above. These GCL components were selected based on the equivalency demonstration provided in Attachment A. Manufacturer specifications for the GCL products selected for use in the MC VI-G Phase 2 base liner are included in **Attachment D**.

In order to maximize the safety, efficiency, and physical integrity of the selected GCL, the manufacturer's CQA Manual and Installation Guidelines (**Attachment D**) will supersede the GCL section of the existing CQA Plan for the base liner of MC VI-G Phase 2.

If you have any questions regarding this submittal, please feel free to contact the undersigned at (248) 486-5100 or tsoong@cticompanies.com.

Sincerely,
**CTI and Associates, Inc.**

Te-Yang Soong, Ph.D., P.E.
Principal Engineer

Cc: Kerry Durnen, US Ecology
Sylwia Scott, US Ecology
Pete Quackenbush, MDEQ
Lisa Graczyk, EPA

**List of Attachments**

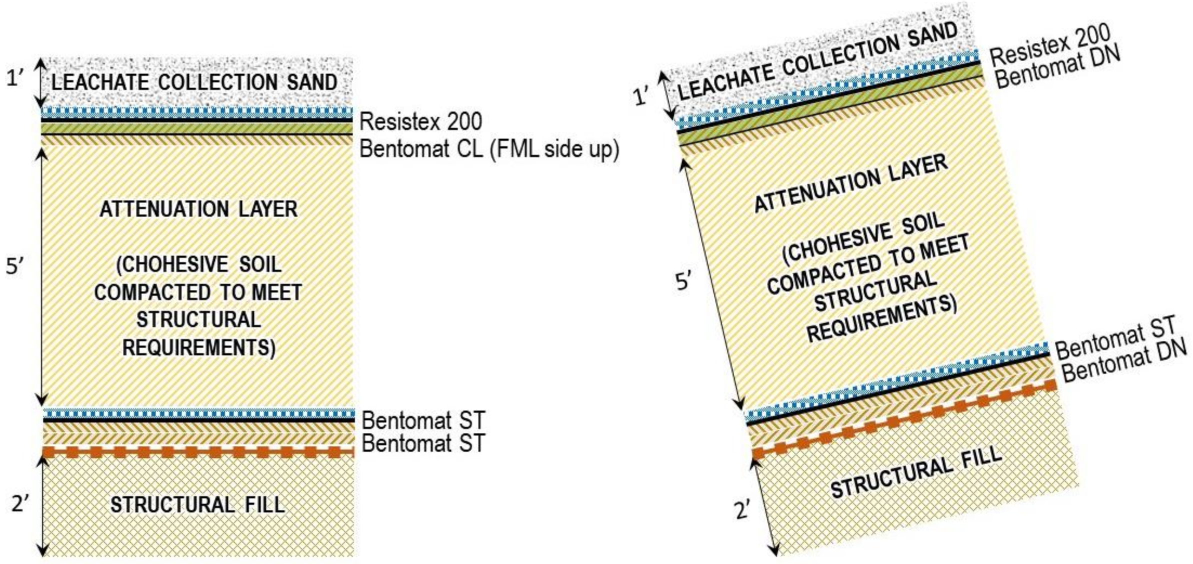
| | |
|---|---|
| Attachment A: | Equivalency Information and References |
| Attachment B: | 2018 Permit Engineering Drawings (under a separate cover) |
| Attachment C: | Correspondence Regarding the WDI 2018 Permit Modification |
| Attachment D: | GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines |

# Attachment A: Equivalency Information and References

Revision 1, May 18, 2018

## Proposed Liner System for MC VI-G Phase 2

WDI is proposing to install a polymer-treated GCL (Resistex® 200, manufactured by CETCO) immediately beneath the primary 80-mil HDPE geomembrane liner of MC VI-G Phase 2 to maximize the barrier performance of the liner system. **Figure A-1** shows the proposed liner construction details. Note that the captions of other liner components (e.g., 80-mil HDPE geomembranes, double-sided geocomposite, geogrid, etc.) are omitted in **Figure A-1** for clarity. Please refer to **Attachment B**, 2018 Permit Engineering Drawings, Sheet 22A, for more liner construction details.



For cell floor and slope ≤ 4H:1V

For slopes ≥ 4H:1V

**Figure A-1**. Proposed MC VI-G Phase 2 Base Liner Construction Detail.

To quantify the equivalency of the proposed liner system including GCL to the permitted liner system including CCL, WDI has provided the GCL manufacturer (CETCO) with site-specific leachate test data for a conservative evaluation of GCL chemical compatibility. CETCO conducted a series of tests in their R&D laboratory on the supplied sample of leachate from WDI.

After 243 hours of permeation, CETCO has measured an average permeability of 1.5 x $10^{-9}$ cm/sec with 0.7 pore volumes of leachate passing through the specimen. This means that the bentonite / polymer blend in the Resistex® 200 is hydrating and cutting off flow as designed. For the equivalency demonstration calculations (specifically, the steady-state solute flux) to be presented later, a conservative permeability of 1 x $10^{-8}$ cm/sec was used. In other words, an extra adjustment or safety factor of 6.7 was applied for additional conservatism. See **Appendix A-1** for CETCO's chemical evaluation report.

In addition to installing the polymer-treated GCL (Resistex® 200) immediately beneath the primary 80-mil HDPE geomembrane liner on the cell floor, WDI is also proposing to use another specialty GCL, Bentomat® CL, for enhanced protection. Bentomat® CL has an additional FML laminated on one side of the GCL to offer the highest level of hydraulic barrier performance. By installing this product with the FML side "facing up" towards the cell as indicated in **Figure A-1**, Bentomat® CL provides another impervious layer to isolate its own bentonite layer from contacting moisture, if any, that may migrate through the primary HDPE geomembrane liner and the overlain GCL (Resistex® 200).

For sideslopes that are steeper than 4(H):1(V), WDI proposes to replace the FML-laminated GCL (Bentomat® CL) with a standard GCL product (Bentomat® DN) for slope stability purposes. Bentomat® DN consists of two layers of needle-punched, non-woven geotextiles on both sides of the bentonite interlayer. This configuration provides superior sideslope shear resistance. The FML-laminated GCL (Bentomat® DN) to be installed on the cell floor will be extended 5-ft vertically above the toe of the sideslopes for optimized performance.

## Technical Equivalency

An equivalency assessment was conducted by the following steps allowing for a technically-sound, effective and project-focused equivalency demonstration.

1. Identify various technical criterion that are relevant to the proposed MC VI-G Phase 2 cell liners.
2. Divide the identified criterion into distinct categories to facilitate a direct technical comparison between GCLs (the proposed alternative) and CCLs (the approved design).
3. Identify criterion where technical equivalency between GCLs and CCLs has already been well-studied, demonstrated and documented by the lining industry (e.g., landfills, surface impoundments, mining, water-proofing of hydraulic structures, etc.), based on past tests and project experiences. No additional demonstration effort is needed for these items.
4. Identify criteria which are mainly site-, project-, or product-specific items, and demonstrate equivalency.

The results of Steps 1, 2 and 3 are summarized in **Table A-1** below. Both the format and content shown in the table is largely adapted from the well-referenced papers by Koerner and Daniel (1993), Bonaparte et. al. (2002), as well as from general liner engineering practice over the past two decades, with some site-specific modifications that are considered appropriate for the construction of the MC VI-G Phase 2 liner.

**Table A-1**. Generalized Technical Equivalency Assessment for Liners Beneath Landfills

| Category | Criterion for Evaluation | Equivalency of GCL to CCL | | | |
|---|---|---|---|---|---|
| | | GCL is superior | GCL is equivalent | Equivalency is product-, design-, or site-specific | Category irrelevant to this project |
| **Hydraulic** | Steady state water flux | X | | | Evaluation will focus on site-specific leachate |
| | Breakthrough time - water | X | | | Evaluation will focus on site-specific leachate |
| | Horizontal flow in seams or lifts | | X | | - |
| | Horizontal flow beneath geomembranes | X | | | - |
| | Steady state solute flux | | | X | - |
| | Chemical adsorptive capacity / Solute breakthrough time | | | X | - |
| | Permeability to gases | - | - | - | A non-issue when GCL is installed under FML |
| | Generation of consolidation water | X | | | - |
| **Physical/ Mechanical** | Freeze-thaw behavior | X | | | - |
| | Wet-dry behavior | X | | | - |
| | Vulnerability to erosion | - | - | - | Erosion is irrelevant in the proposed liner |
| | Total settlement | | X | | - |
| | Differential settlement | X | | | - |
| | Stability on slopes | | | X | - |
| | Bearing capacity | | | X | - |
| **Construction** | Puncture resistance | | | X | - |
| | Ease of placement | X | | | - |
| | Speed of construction | X | | | - |
| | Availability of material | X | | | - |
| | Requirements of water | X | | | - |
| | Air pollution concerns | X | | | - |
| | Quality assurance considerations | | X | | - |

| | |
|---|---|
| Category of which GCL is superior than CCL | Category of which equivalency is product-, design-, or site-specific |
| Category of which GCL is equivalent to CCL | Category is irrelevant to this project |

As shown in **Table A-1**, the following five items (criterion) are identified for Step 4 discussed above:

**Hydraulic Properties**

- Steady state solute flux
- Chemical adsorptive capacity / Solute breakthrough time

**Physical/Mechanical Properties**

- Stability of slopes
- Bearing capacity

**Construction Properties**

- Puncture resistance/subgrade condition

These items were subjected to detailed comparison between GCLs and CCLs as presented in the following sections.

## Hydraulic Properties

Steady state solute flux

Past testing and experience have shown that sodium bentonite (the interlayer of GCL) is chemically compatible with many common waste streams, including leachate, some petroleum hydrocarbons, deicing fluids, livestock wastes, and dilute sodium cyanide mine waste.

In certain chemical environments, the sodium ions in bentonite can be replaced with cations dissolved in the water that comes in contact with the GCL, a process referred to as cation exchange. This type of exchange reaction can reduce the amount of water that can be held in the interlayer, resulting in decreased swell.

With the design and installation configuration shown in **Figure A-1** in mind, the steady state solute flux equivalency demonstration was prepared and presented in **Tables A-2a** and **A-2b**. Please note that the following assumptions were made in the demonstration for additional conservatism:

1. Comparisons were made as if the 80-mil HDPE primary geomembrane liner does not exist. In other words, GCL's superior swelling capability to "plug" holes or imperfections in the overlying HDPE liner is completely ignored.

2. Considering the evaluation performed by the GCL manufacturer of GCL chemical compatibility with site specific leachate data, the hydraulic conductivity of the upper GCL (Resistex® 200) is assumed at 1 x $10^{-8}$ cm/sec despite the tested results suggesting a permeability of 1.5 x $10^{-9}$ cm/sec. As discussed previously, this adjustment serves to conservatively address the concern of chemical compatibility associated with site-specific leachate. This adjustment is extremely conservative since this GCL layer will be completely covered by a layer of 80-mil HDPE geomembrane liner and hydration of GCL by leachate can only take place if there is leachate leakage through liner imperfections. The chance of this assumed scenario (i.e., the entire GCL layer is exposed to leachate with an increased hydraulic conductivity) does not practically exist.

3. Values of head-on-liner used in the evaluation were selected as 12.0 inches (30.5 cm) for the cell floor (per regulation) and 6.0 inches (15.2 cm) for sideslopes steeper than 4(H):1(V). Please note that the head-on-liner over both the floor and the sideslope is calculated as not to exceed 6 inches as shown in the "Maximum head-on-liner calculation" included in **Appendix A-2**. Moreover, while only the standard GCL product (Bentomat® DN) is used in the flux calculation, the calculated maximum head-on-liner will theoretically occur near the toe of the sideslope where the specialty GCL (Bentomat® CL) will be installed. This presents an additional conservative factor of safety.

4. Technically, an "apples-to-apples" comparison of steady state solute flux should be made by comparing flux that comes from the bottom of the 5-ft attenuation layer (in the proposed design case) and from the bottom of the 5-ft CCL layer (in the permitted design case). However, the equivalency evaluation was conservatively conducted by determining the flux that flows through the two layers of GCLs and comes out the bottom of the lower GCL layer (Bentomat® CL). In other words, any flow retardation capacity that could be provided by the underlying 5-ft thick cohesive attenuation layer is completely ignored in this evaluation.

5. Consequent to assumptions 3 and 4 discussed above, the hydraulic gradient (the driving force that causes flow to take place) selected for the proposed liner case is 14 times and 8 times greater than that selected for the permitted liner case for floor and sideslope liners, respectively. This represents another very conservative assumption.

The evaluation of the steady state solute flux criteria is made by dividing the calculated steady state solute flux of the proposed liner (GCL) by the number associated with the permitted liner (CCL). The resulting "ratio", if it is less than or equal to 100%, would indicate that the performance of the proposed liner system is acceptable, and therefore technical equivalency is demonstrated.

Input parameters, assumptions, and results of the steady state solute flux evaluation are presented in **Tables A-2a** and **A-2b** for cell floor and slopes that are steeper than 4(H):1(V), respectively.

**Table A-2a**. Steady State Solute Flux Equivalency Demonstration
Liner over Cell Floor and Slopes ≤ 4(H):1(V)

| Layer | Thickness (cm) | K (cm/sec) (water) | K (cm/sec) (WDI leachate) | Additional adjustment | Adjusted K (cm/sec) | Thickness/ Perm |
|---|---|---|---|---|---|---|
| Resistex 200 | 0.95 | 3E-09 | 1.5E-09 | 6.7 | 1.0E-08 | 47,625,000 |
| Bentomat CL | 0.95 | 5E-10 | 5E-10 | 1.0 | 5E-10 | 1,905,000,000 |

*Saturated thickness of GCL = 0.375" (or 0.95 cm)*

| K equivalent | |
|---|---|
| 1E-09 | cm/sec |

$$k_v = \frac{H}{(\frac{H_1}{k_1}) + (\frac{H_2}{k_2}) + (\frac{H_3}{k_3}) + \ldots\ldots\ldots + (\frac{H_n}{k_n})}$$

**Demonstration is made by comparing the steady-state flux (Q's) using Darcy's Law Q = kiA (assuming no geomembrane )**

| Clay Liner | $K_{eq}$ (cm/sec) | head (cm) | thickness (cm) | gradient i | Flux, Q (gal/acre-day) |
|---|---|---|---|---|---|
| 5-ft of CCL | 1E-07 | 30.48 | 152.4 | 1.20 | 111 |
| Resistex 200 / Bentomat CL | 1E-09 | 30.48 | 1.91 | 17.0 | 15 |
| *Conversion: 1.0 $cm^3/sec/cm^2$ =* | *9.237E+08* | *gal/acre/day* | | **$Q_{GCL}/Q_{CCL}$ =** | **14%** |

**Table A-2b**. Steady State Solute Flux Equivalency Demonstration

Liner on Slopes ≥ 4(H):1(V)

| Layer | Thickness (cm) | K (cm/sec) (water) | K (cm/sec) (WDI leachate) | Adjustment factor | Adjusted K (cm/sec) | Thickness/ Perm |
|---|---|---|---|---|---|---|
| Resistex 200 | 0.95 | 3E-09 | 5E-09 | 2.0 | 1E-08 | 158,750,000 |
| Bentomat DN | 0.95 | 5E-09 | 5E-09 | 1.0 | 5E-09 | 190,500,000 |

*Saturated thickness of GCL = 0.375" (or 0.95 cm)*

| K equivalent | |
|---|---|
| 5.5E-09 | cm/sec |

$$k_v = \frac{H}{(\frac{H_1}{k_1}) + (\frac{H_2}{k_2}) + (\frac{H_3}{k_3}) + \dots\dots\dots + (\frac{H_n}{k_n})}$$

**Demonstration is made by comparing the steady-state flux (Q's) using Darcy's Law Q = kiA (assuming no geomembrane )**

| Clay Liner | $K_{eq}$ (cm/sec) | head (cm) | thickness (cm) | gradient i | Flux, Q (gal/acre-day) |
|---|---|---|---|---|---|
| 5-ft of CCL | 1E-07 | 15.2 | 152.4 | 1.10 | 102 |
| Resistex 200 / Bentomat DN | 5E-09 | 15.2 | 1.91 | 9.0 | 45 |
| *Conversion: 1.0 $cm^3$/sec/$cm^2$ =* | *9.237E+08* | *gal/acre/day* | | **$Q_{GCL}/Q_{CCL}$ =** | **45%** |

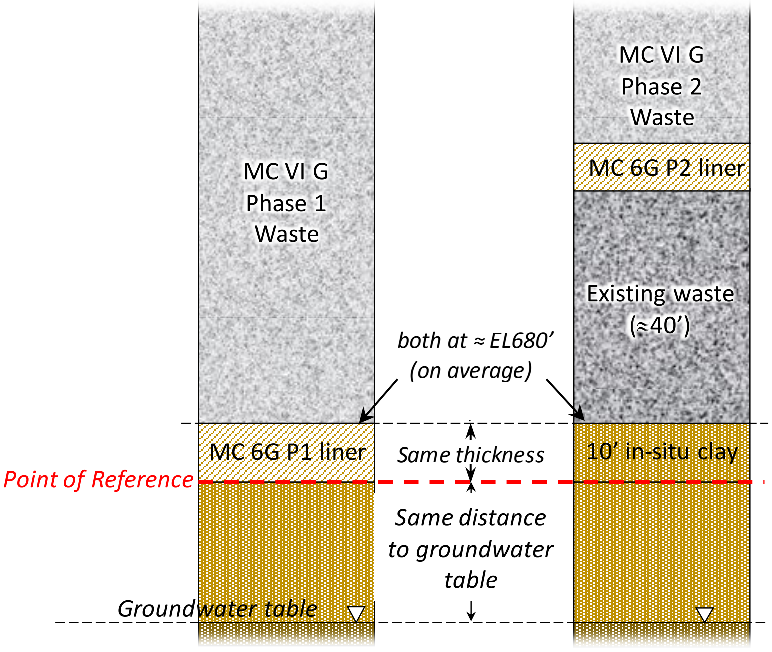
As shown in **Tables A-2a** and **A-2b**, the steady state solute flux “ratios” are 14% and 45% for the cell floor and sideslope, respectively. Both numbers are significantly less than 100% indicating the performance of the proposed liner system is superior. Therefore, technical equivalency is demonstrated and the proposed liner system is acceptable.

## Chemical adsorptive capacity / Solute breakthrough time

Federal and State regulations focus on preventing contamination of groundwater (CFR 40 Part 264.301(b) and Michigan Part 111 R299.9620(4)(a)). Therefore, selecting a point in the subsoil that has the same hydrogeological characteristics and distance to groundwater and using that point as a reference for both liner systems would be an appropriate approach in demonstrating equivalency.

As shown in **Figure A-2**, two models were established according to the concept described above: (a) permitted and constructed MC VI-G Phase 1 liner and (b) proposed MC VI-G Phase 2 liner. As shown in **Figure A-2**, the thickness of in-situ clayey subsoils under the existing waste where the proposed MC VI-G Phase 2 will be constructed, is approximately the same as the combined thickness of MC VI-G Phase 1 CCL liner and its in-situ clayey soil.

This is an important finding since numerical equivalency, in terms of chemical adsorptive capacity and solute breakthrough time, can already be achieved by the 10-ft in-situ clay present in the MC VI-G Phase 2 subsoils since all clayey soils (e.g., CCL or in-situ clay) exhibit a similar diffusion coefficient (Lake and Rowe (2005)).



(a) permitted liner (b) proposed liner

**Figure A-2**. Conceptual Model for Chemical Adsorptive Capacity and Breakthrough Time Comparison

In addition, as shown in **Figure A-1**, the proposed MC VI-G Phase 2 liner system contains 7-ft of cohesive soil layers (5-ft attenuation layer and 2-ft structural fill). Since the distance between the contaminant source (leachate above the primary liner) and the point of reference is significantly thicker for the proposed MC VI-G Phase 2 compared to MC VI-G Phase 1, the breakthrough time will be significantly increased in the proposed system.

Another factor impacting the breakthrough time is the steady state flux passing through the liner system (higher flux would lead to shorter breakthrough time). Since it has already been demonstrated (see **Tables A-2a** and **A-2b**) that the proposed GCL liner system will significantly reduce the steady state flux, the GCL liner system should also significantly increase the advective breakthrough time.

Additionally, as shown in **Figure A-2b**, approximately 40-ft of existing waste further separates the new waste in MC VI-G Phase 2 from the in-situ clay subsoil and groundwater. This existing waste layer provides additional chemical adsorptive capacity due to the following properties:

- Its anaerobic natural and high sulfide condition could bond heavy metals (Bhattacharyya et. al. (2006) and Robinson and Sum (1980))

- Non-degradable organic and other material provide additional adsorption and/or absorption capabilities for organic contaminants (De Gisi et. al. (2016) and Erses et. al. (2005))
- Additional biological activity reduces the half-life of organic pollutants and reduces potential breakthrough (Christensen et. al. (1994) and Guan et. al. (2014))
- Increases the mass transport distance and further reduces the concentration gradient (Shackelford (2013) and Xie (2015)
- Reduces the "concentration gradient" with the contaminants in the existing waste

Based on the above discussions, the performance of the proposed MC VI-G Phase 2 liner system is superior in the criterion of chemical adsorptive capacity / solute breakthrough time than the reference case (MC VI-G Phase 1 liner system). Therefore, technical equivalency is demonstrated and the proposed liner system is acceptable.

**Physical/Mechanical Properties**

Stability of slope

The GCL industry has addressed concerns related to GCL interface and internal shear resistance and its potential impact to landfill slope stability with products that will perform satisfactorily in typical landfill cell liner applications. For example, most GCL products are internally-reinforced with needle-punched fibers to ensure that the shear resistance of the bentonite interlayer exceeds standard stability requirements.

To demonstrate that the proposed liner system is technically equivalent to the permitted liner system with respect to slope stability, WDI examined the stability of the proposed liner system on the MC VI-G Phase 2 waste and liner slopes. Specifically, WDI verified that the proposed liner system does not introduce any interface and/or internal shear plane that is more critical than what is in the currently permitted liner system.

To verify stability, WDI referred to the slope stability analyses that were conducted and documented in the Basis of Design Report in the current permit (approved by the MDEQ on May 4, 2012 and EPA on September 27, 2013), where the stability of the sideslope under excavation, stability of the liner system under construction, stability of the waste mass during filling, stability of the final cover, and stability of the long-term final closure were evaluated.

Two findings of the prior investigation that are relevant to this technical equivalency demonstration, both related to interface shear resistance, are identified and listed below:

- As long as the interim waste slope during filling does not exceed an inclination of 3.5(H) to 1(V), a friction angle of 13.8 degrees or higher between any different geosynthetic-to-geosynthetic or geosynthetic-to-soil interfaces will result in satisfactory factor of safety (FS) values of 1.5 or greater.
- As long as a combination of friction and adhesion under an overburden pressure of 1.0 psi is greater than a friction angle of 21.8 degrees, stability of liner systems on slopes not steeper than 3(H) to 1(V) can be ensured.

Historical data and past experiences indicate that these requirements can be readily met by liner systems that utilize GCL products. Nevertheless, WDI will, as part of the CQA requirements, conduct direct shear tests (ASTM D6243) for relevant GCL-related interfaces (e.g., against 80-mil textured HDPE geomembranes, between different GCL products, against cohesive attenuation layer soils, etc.) as well as internal shear strength for different GCL products before approving the products to be used for construction of the MC VI-G Phase 2 liner system.

Bearing capacity

Studies and past experiences have demonstrated that an adequate thickness of cover soil (1 foot or 300 mm) will prevent a decrease in GCL thickness due to construction equipment loading thereby ensuring appropriate GCL bearing capacity. Performance equivalency can be achieved by properly specifying the installation procedure of the GCL and cover soil and a robust CQC/CQA program. A minimum thickness of 1 foot (300 mm) of cover soil is specified as a technical requirement and CQA site personnel will observe/verify/ document that such a requirement is maintained between the equipment tires/tracks and the GCL at all times during the installation process.

For the same reason, the initial (lowest) lift of the attenuation layer will be constructed with a 1-ft lift thickness to ensure GCL in the secondary liner system does not encounter loading from the construction equipment without adequate soil protection.

**Attachment D** of the Permit Modification Letter Report includes the CQA manual and Installation Guidelines for the GCL.

## Construction Properties

### Puncture resistance

Liner systems face external puncture risk from debris in overlying waste and internal puncture risk from rocks in soil liner components potentially damaging geosynthetics. In this case there is also puncture risk by debris in the underlying waste in Master Cell IV.

External puncture resistance from overlying waste: The inclusion of GCLs arguably increases the resistance of the primary liner system to punctures from overlying debris by adding additional layers of geosynthetics. But ignoring that improvement as it is not the intended purpose of the GCLs, the primary composite liner is fundamentally unchanged in terms of puncture resistance. The GCL itself is protected from above by the one foot of sand, geocomposite and 80 mil membrane.

Internal puncture resistance: The primary GCL will rest directly on the attenuation layer and the secondary GCL will rest directly on the structural fill. Stones potentially present in the attenuation layer and structural fill will be prevented from puncturing the GCL by a rigorously designed and enforced CQC/CQA program. Technical specifications for the GCL, included in **Attachment D** of the Permit Modification Letter Report, limit any stone particle in the upper most lift of the subgrade soils (i.e., the attenuation layer and structural fill) to be not larger than 1 inch (25 mm) in size. Proof-rolling of the prepared subgrade surface is also required to reduce stone particle protrusion.

External puncture resistance from underlying waste: The GCL will be protected from underlying debris by the structural fill layer. The structural fill layer will be prevented from contacting potentially damaging underlying debris (this first assumes underlying waste will be exposed which may not occur) by a rigorously designed and enforced CQC/CQA program that will include removal of debris that reasonably could penetrate the structural fill and proof-rolling of the surface on which the structural fill layer will be constructed to reduce the potential for protrusion.

Additional subgrade preparation requirements are listed in the CQA Manual and manufacturer’s specifications included in **Attachment D** of the Permit Modification Letter Report. The Certifying Engineer’s approval of the subgrade must also be obtained prior to GCL installation.

## Conclusions

Wayne Disposal, Inc. is proposing the use of GCL in the construction of MC VI-G Phase 2 Subcells G2 and G3. WDI has presented information above demonstrating that the proposed liner system is equivalent or superior to the currently permitted liner system and is capable of preventing the migration of hazardous constituents into the groundwater or surface water at least as effectively as the approved liner system.

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## List of Appendices

| | |
|---|---|
| Appendix A-1 | Chemical Compatibility Evaluation Report Provided by CETCO |
| Appendix A-2 | Maximum Head-on-Liner Calculation, Revision 1, May 16, 2018 |

# Appendix A-1: Chemical Compatibility Evaluation Report Provided by CETCO

CETCO®

**CETCO** 2870 Forbs Avenue Hoffman Estates, IL 60192
**847.851.1800** 800.527.9948 Fax 847.851.1339 **www.cetco.com**

May 1, 2018

Te-Yang Soong, Ph.D., P.E.
CTI and Associates, Inc.
28001 Cabot Drive, Ste. 250
Novi, MI 48377

RE: US Ecology's Wayne Disposal, Inc., Master Cell VI Sub-Cell G Phase 2
Geosynthetic Clay Liner – Tier I Report

Dear Mr. Soong:

The purpose of this letter is to present the results of compatibility testing of the CETCO® CG-50® bentonite used to make our Bentomat® products and the Resistex® geosynthetic clay liner (GCL) for the above mentioned project. This report is being made at the completion of the permeability testing for Resistex® 200 FLW9 GCL. All testing was performed by CETCO®'s in-house GAI-LAP accredited laboratory located in Hoffman Estates, Illinois.

Per your request, CETCO® initiated a geosynthetic clay liner (GCL) chemical compatibility evaluation as outlined in our Technical Reference (TR-345, attached) in April 2018 after receiving a representative sample of leachate. Completion of Tier I and II evaluations (see TR-345) indicated that a standard GCL (Bentomat®) in the presence of the leachate would likely not provide suitable performance as defined by permeability. CETCO®'s Resistex® 200 FLW9 GCL was also evaluated for its Tier II performance and is CETCO®'s recommended product for Tier III testing.

Permeability testing was completed in general accordance with ASTM D6766, Scenario II. For this testing, a cell pressure of 80 pounds per square inch (psi), 77 psi headwater pressure, and 75 psi tailwater pressure were utilized and represent test conditions that CETCO® utilizes in evaluating our GCL products. Permeability testing of the Resistex® 200 FLW9 product was terminated upon your request after 243.0 hours and 0.7 pore volumes of flow through the sample. The final average permeability for the Resistex® 200 FLW9 product was 1.5 x $10^{-9}$ cm/sec.

In addition to our Tier I & II results please find enclosed a copy of our Technical Data Sheet and Technical Reference. We appreciate your interest in CETCO® products. Please contact Tom Hauck, CETCO® Technical Sales Manager, at (248) 652-9274 if you have any further questions.

Table 1. Summary of final three measurements for the Resistex® 200 fLW9 product

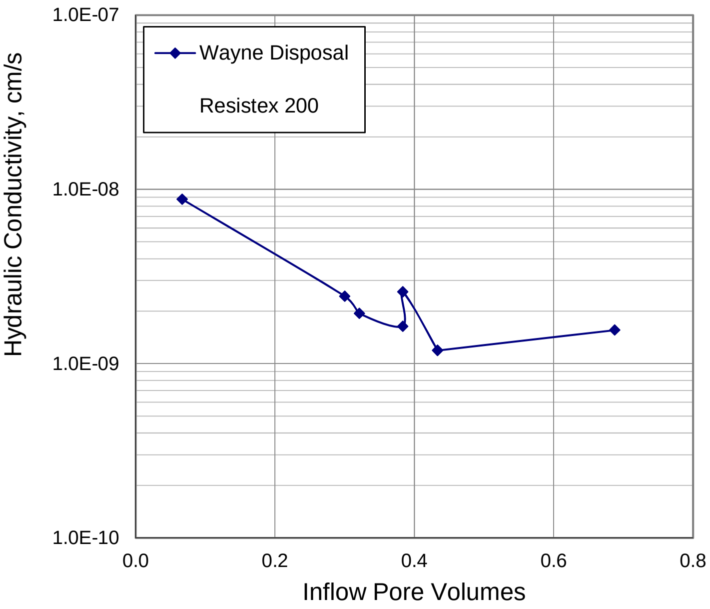
| Elapsed Time (hr) | Pore Volumes | Inflow/ Outflow | Permeability (cm/sec) |
|---|---|---|---|
| 100.0 | 0.383 | 0.96 | 1.6 x $10^{-9}$ |
| 130.7 | 0.433 | 0.96 | 1.2 x $10^{-9}$ |
| 243.0 | 0.688 | 0.96 | 1.6 x $10^{-9}$ |

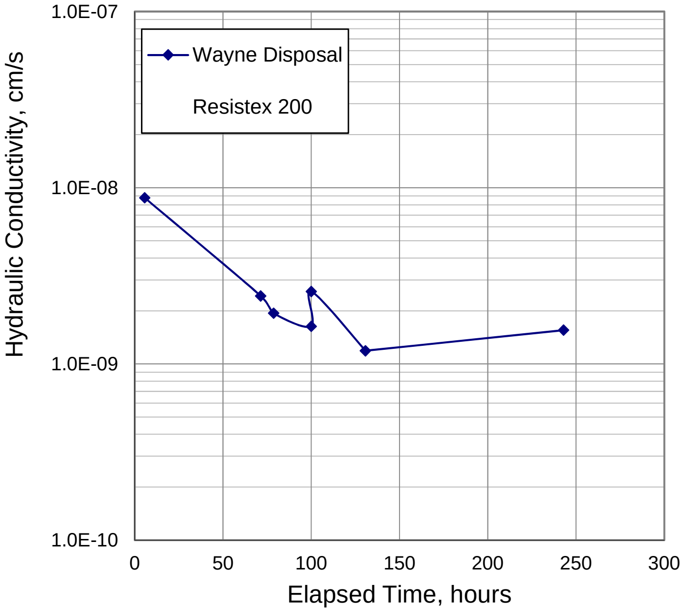
Very truly yours,

John M Allen

John M. Allen, P.E.
Technical Services Manager
CETCO® Environmental Products

Attachments (3)





Permeability with pore volumes and time for the Resistex® 200 FLW9 GCL using site specific leachate per ASTM D6766, Scenario II, for the US Ecology's Wayne Disposal, Inc., Master Cell VI Sub-Cell G Phase 2

Analytical Results for the provided leachate for US Ecology's Wayne Disposal, Inc., Master Cell VI Sub-Cell G Phase 2 Project

| | |
|---|---|
| Leachate Code Number | LT 18-1 |
| Leachate Description | leachate |
| Leachate Type | leachate |
| Actual pH | 9.250 |
| Actual EC (uS/cm) | 48,600 |
| **Calculations** | **LT 18-1** |
| ICP Estimated EC (uS/cm) (Snoeyink Jenkins) | 43281.45 |
| Ionic Strength Estimated by ICP (mol/L) | 0.693 |
| RMD Estimated by ICP (M^0.5) | 5.370 |
| Ratio of SO4/Cl | 0.190 |

| | |
|---|---|
| $Cl^-$ | 16400.000 |
| Ag+ | 0.169 |
| $Al^{3+}$ | |
| As3+ | 2.816 |
| B4O5(OH)4 | 51.462 |
| Ba2+ | 1.778 |
| $Ca^{2+}$ | 47.013 |
| Cd2+ | 0.189 |
| $Cr^{3+}$ | 0.211 |
| Cu2+ | 0.123 |
| $Fe^{+2}$ | 3.859 |
| Hg2+ | 3.527 |
| K+ | 2231.718 |
| $Mg^{2+}$ | 102.739 |
| $Mn^{2+}$ | 1.216 |
| Mo2+ | 11.253 |
| $Na^+$ | 9056.907 |
| $Ni^{3+}$ | 1.473 |
| P of PO4-3 | 10.700 |
| Pb2+ | 1.359 |
| S | 2811.831 |
| Sb+2 | 0.968 |
| Se2+ | 0.754 |
| Ti4+ | 0.124 |
| $Zn^{2+}$ | 0.532 |
| Zr4+ | 0.219 |
| **H+(Calculated)** | 0.000 |
| **OH- (Calculated)** | 0.302 |

# EVALUATING GCL CHEMICAL COMPATIBILITY

Sodium bentonite is an effective barrier primarily because it can absorb water (i.e., hydrate and swell), producing a dense, uniform layer with extremely low hydraulic conductivity, on the order of $10^{-9}$ cm/sec. Water absorption occurs because of the unique physical structure of bentonite and the complementary presence of sodium ions in the interlayer region between the bentonite platelets. Sodium bentonite's exceptional hydraulic properties allow GCLs to be used in place of much thicker soil layers in composite liner systems.

Sodium bentonite which is hydrated and permeated with relatively "clean" water will perform as an effective barrier indefinitely. In addition, past testing and experience have shown that sodium bentonite is chemically compatible with many common waste streams, including Subtitle D municipal solid waste landfill leachate (TR-101 and TR-254), some petroleum hydrocarbons (TR-103), deicing fluids (TR-109), livestock waste (TR-107), and dilute sodium cyanide mine wastes (TR-105).

In certain chemical environments, the interlayer sodium ions in bentonite can be replaced with cations dissolved in the water that comes in contact with the GCL, a process referred to as ion exchange. This type of exchange reaction can reduce the amount of water that can be held in the interlayer, resulting in decreased swell. The loss of swell usually causes increased porosity and increased GCL hydraulic conductivity. Experience and research have shown that calcium and magnesium are the most common source of compatibility problems for GCLs (Jo et al, 2001, Shackelford et al, 2000, Meer and Benson, 2004, Kolstad et al, 2004/2006). Examples of liquids with potentially high calcium and magnesium concentrations include: leachates from lime-stabilized sludge, soil, or fly ash; extremely hard water; unusually harsh landfill leachates; and acidic drainage from calcareous soil or stone. Other cations (ammonium, potassium, and sodium) may contribute to compatibility problems, but they are generally not as prevalent or as concentrated as calcium (Alther et al, 1985), with the exception of brines and seawater. Even though these highly concentrated solutions do not necessarily contain high levels of calcium, their high ionic strength can reduce the amount of bentonite swelling, resulting in increased GCL hydraulic conductivity.

This reference discusses the tools that can be used by a design engineer to evaluate GCL chemical compatibility with a site-specific leachate or other liquid.

## HOW IS GCL CHEMICAL COMPATIBILITY EVALUATED?

Ideally, concentration-based guidelines would be available for determining GCL compatibility with a site-specific waste. Unfortunately, considering the variety and chemical complexity of the liquids that may be evaluated, as well as the many variables that influence chemical compatibility (e.g., prehydration with subgrade moisture [TR-222], confining stress [TR-321], and repeated wet-dry cycling [TR-341]), it is not possible to establish such guidelines. Instead, a three-tiered approach to evaluating GCL chemical compatibility is recommended, as outlined below.

### Tier I

The first tier is a simple review of existing analytical data. The topic of GCL chemical compatibility has been the subject of much study in recent years, with several important references available in the literature. One of these references, Kolstad et al (2004/2006), reported the results of several long-term hydraulic conductivity tests involving GCLs in contact with various multivalent (i.e., containing both sodium and calcium) salt solutions. Based on the results of these tests, the researchers found that a GCL's long-term hydraulic conductivity (as determined by ASTM D6766) can be estimated if the ionic strength ($I$) and the ratio of monovalent to divalent ions ($RMD$) in the permeant solution are both known, using the following empirical expression:

$$\frac{\log K_c}{\log K_{DI}} = 0.965 - 0.976 \times I + 0.0797 \times RMD + 0.251 \times I^2 \times RMD$$

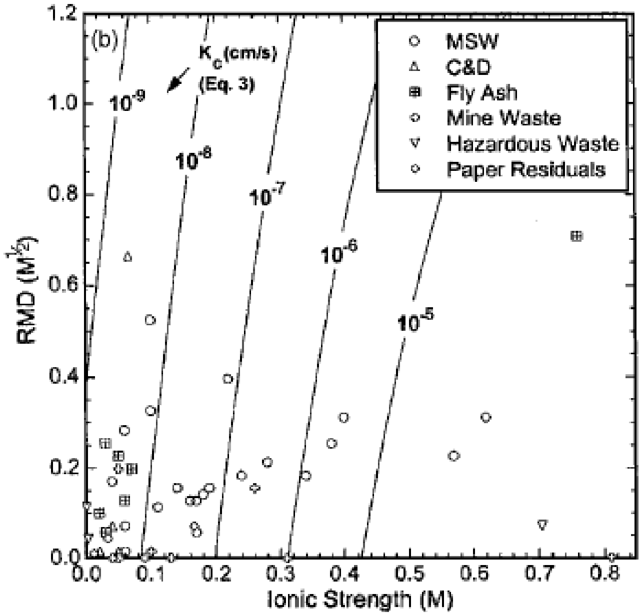
where:

$I$ = ionic strength (M) of the site-specific leachate.

$RMD$ = ratio of monovalent cation concentration to the square root of the divalent cation concentration ($M^{1/2}$) in the site-specific leachate.

$K_c$ = GCL hydraulic conductivity when hydrated and permeated with site-specific leachate (cm/sec).

$K_{DI}$ = GCL hydraulic conductivity with deionized water (cm/sec).



Using this tool, a Tier I compatibility evaluation can be performed if the major ion concentrations (typically, calcium, magnesium, sodium, and potassium) and ionic strength (estimated from either the total dissolved solids [TDS], or electrical conductivity [EC]) of the site leachate are known. For example, using the relationship above and MSW leachate data available in the literature, Kolstad et al. were able to conclude that high hydraulic conductivities (i.e., $>10^{-7}$ cm/sec) are unlikely for GCLs in base liners in many solid waste containment facilities.

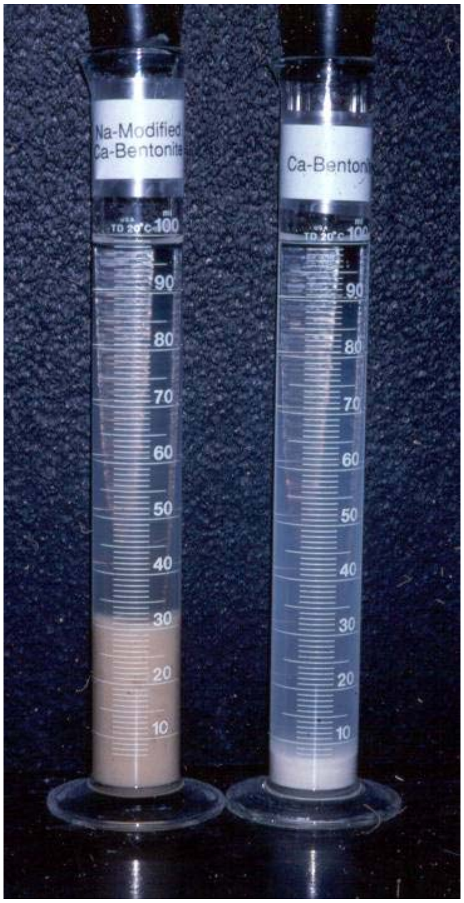
In many cases, the Tier I evaluation is sufficient to show that a site-specific leachate should not pose compatibility problems. However, if the analytical data indicate a potential impact to GCL hydraulic performance, or if there is no analytical data available, then it is necessary to proceed to the second tier, involving bentonite "screening" tests, which are described below.

## Tier II

The next tier of compatibility testing involves bentonite screening tests, performed in accordance with ASTM Method D6141. These tests are fairly straightforward, and can be performed at one of CETCO's R&D laboratories or at most commercial geosynthetics testing laboratories.

Liquid samples should be obtained very early in the project, such as during the site hydrogeological investigation. It is important that the sample collected is representative of actual site conditions. Synthetic leachate samples may also be considered for use in the compatibility tests. The objective is to create a liquid representative of that which will come in contact with the GCL. At least 1-gallon (4-Liter) of each sample should be submitted for testing. Samples should be accompanied by a chain-of-custody or information form. When a sample is received at the CETCO laboratory, the following screening tests are performed to assess compatibility:

- Fluid Loss (ASTM D5890) – A mixture of sodium bentonite and the site water/leachate is tested for fluid loss, an indicator of the bentonite's sealing ability.
- Swell Index (ASTM D5891) – Two grams of sodium bentonite are added to the site water/leachate and tested for swell index, the volumetric swelling of the bentonite.
- Water quality – The pH and EC of the site water/leachate are measured using bench-top water quality probes. pH will indicate if any strong acids (pH < 2) or bases (pH > 12) are present which might damage the bentonite clay. EC indicates the strength of dissolved salts in the water, which can hamper the swelling and sealing properties of bentonite if present at high concentrations.
- Chemistry – The site water/leachate is analyzed for major dissolved cations using ICP. The analytical results can then be used to perform a Tier I assessment, if one has not already been done.



As part of this testing, fluid loss and free swell tests are also performed on clean, deionized, or "DI" water for comparison to the results obtained with the site water/leachate sample. Sodium bentonite tested with DI water is expected to have a free swell of at least 24 mL/2g and a fluid loss less than 18 mL. Changes in bentonite swell and fluid loss indicate that the constituents dissolved in the site water may have an impact on GCL hydraulic conductivity. However, since it is only a screening tool, there are no specific values for the fluid loss and swell index tests that the clay must meet in order to be considered chemically compatible with the test liquid in question. Differences between the results of the baseline tests and those conducted with the site leachate may warrant further hydraulic testing.

A major drawback of the D6141 tests is the potential for a false “negative” result, meaning that the bentonite swell index or fluid loss might predict no impact to hydraulic performance, where in reality, there may be a long-term adverse effect. This is primarily a concern with dilute calcium or magnesium solutions, which may slowly affect GCL hydraulic performance over months or years. Short-term (2-day) bentonite screening tests would not be able to capture this type of long-term effect. This is not expected to be a concern with strong calcium or magnesium or high ionic strength solutions, which have been shown to impact GCL hydraulic conductivity almost immediately, and whose effects would therefore be captured by the short-term bentonite screening tests. Another limitation of the bentonite screening tests is their inability to simulate site conditions, such as clean water prehydration, increased confining pressure, and wet/dry cycling. These limitations can be in part addressed by moving to the third tier, a long-term GCL hydraulic conductivity test, discussed below.

### Tier III

The third-tier compatibility evaluation consists of an extended GCL hydraulic conductivity test performed in accordance with ASTM D6766. This test method is essentially a hydraulic conductivity test, but instead of permeating the GCL sample with DI water, the site-specific leachate is used. Since leachates can often be hazardous, corrosive, or volatile, the testing laboratory must have permeant interface devices, such as bladder accumulators, to contain the test liquid in a closed chamber, and prevent contamination of the flow measurement and pressure systems, or release of chemicals to the ambient air.

Method D6766 provides some flexibility in specifying the testing conditions so that certain site conditions can be simulated. For example, in situations where the GCL will be deployed on a subgrade soil that is compacted wet of optimum, the GCL will very likely hydrate from the relatively clean moisture in the subgrade (TR-222), long before it comes in contact with the potentially aggressive site leachate. Lee and Shackelford (2005) showed that a GCL which is pre-hydrated with clean water before being exposed to a harsh solution is expected to exhibit a lower hydraulic conductivity than one hydrated directly with the solution. Depending on the expected site conditions, the D6766 test can be specified to pre-hydrate the GCL with either water (Scenario 1) or the site liquid (Scenario 2).

Another site-specific consideration is confining pressure. Certain applications, such as landfill bottom liners and mine heap leach pads, involve up to several hundred feet of waste, resulting in high compressive loads on the liner systems. Although the standard confining pressure for the ASTM D6766 test is 5 psi (representing less than 10 feet of waste), the test method is flexible enough to allow greater confining pressures, thus mimicking conditions in a landfill bottom liner or heap leach pad. Petrov et al (1997) showed that higher confining pressures will decrease bentonite porosity, and tend to decrease GCL permeability. TR-321 shows that higher confining pressures will improve hydraulic conductivity even when the GCL is permeated with aggressive calcium solutions.

ASTM D6766 has two sets of termination criteria: hydraulic and chemical. To meet the hydraulic termination criterion, the ratio of inflow rate to outflow rate from the last three readings must be between 0.75 and 1.25. It normally takes between one week and one month to reach the hydraulic termination criterion. To meet the chemical termination criterion, the test must continue until at least two pore volumes of flow have passed through the sample and chemical equilibrium is established between the effluent and influent. The test method defines chemical equilibrium as effluent electrical conductivity within ±10% of the influent electrical conductivity. This requirement was put in place to ensure that a large enough volume of site liquid passes through the sample to allow slow ion exchange reactions to occur. Two pore volumes can take approximately a month to permeate through the GCL sample. However, reaching chemical equilibrium (effluent EC within 10% of influent EC), may take more than a year of testing, depending on the leachate characteristics.

ASTM D6766 is a very useful tool which provides a fairly conclusive assessment of GCL chemical compatibility with a site-specific leachate. However, the major drawback of the D6766 test is the potentially long period of time required to reach chemical equilibrium. This limitation reinforces the need for upfront compatibility testing early in the project. Clearly, requiring the contractor to perform this testing during the construction phase is not recommended.

## WHAT DO THE ASTM D6766 COMPATIBILITY TEST RESULTS MEAN?

ASTM D6766 is currently the state-of-the-practice in the geosynthetics industry for evaluating long-term chemical compatibility of a GCL with a particular site waste stream. An ASTM D6766 test that is properly run until both the hydraulic (inflow and outflow within ±25% over three consecutive readings) and chemical (effluent EC within ±10% of influent EC) termination criteria are achieved, provides a good approximation of the GCL's long-term hydraulic conductivity when exposed to the site leachate. Jo et al (2005) conducted several GCL compatibility tests with weak calcium and magnesium solutions, with some tests running longer than 2.5 years, representing several hundred pore volumes of flow. The intent of this study was to run the tests until complete ion exchange had occurred, which required even stricter chemical equilibrium termination criteria than the D6766 test. The study found that the final GCL hydraulic conductivity values measured after complete ion exchange were fairly close to (within 2 to 13 times) the hydraulic conductivity values determined by ASTM D6766 tests, which took much less time to complete.

The laboratory that performs the chemical compatibility test, whether it is the CETCO R&D laboratory or an independent third-party laboratory, is only reporting the test results under the specified testing conditions, and is not making any guarantees about actual field performance or the suitability of a GCL for a particular project. It is the design engineer's responsibility to incorporate the D6766 results into their design to determine whether the GCL will meet the overall project objectives. Neither the testing laboratory nor the GCL manufacturer can make this determination.

Also, it is important to note that the results of D6766 testing for a particular project are only applicable for that site, for the specific waste stream that is tested, and only for the specific conditions replicated by the test. For instance, D6766 testing performed at high normal loads representative of a landfill bottom liner should not be applied to a situation where the GCL will only be placed under a modest normal load, such as a landfill cover or pond. Similarly, the results of a D6766 test where the GCL was pre-hydrated with clean water should not be applied to sites located in extremely arid climates where little subgrade moisture is expected, unless water will be applied manually to the subgrade prior to deployment. And finally, since D6766 tests are normally performed on continuously hydrated GCL samples, the test results should not be applied to situations where repeated cycles of wetting and drying of the GCL are likely to occur, such as in some GCL-only landfill covers, as desiccation can worsen compatibility effects.

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6. CETCO TR-105, “Bentomat Compatibility Testing with Dilute Sodium Cyanide”.
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8. CETCO TR-109, “GCL Compatibility with Airport De-Icing Fluid”.
9. CETCO TR-222, “Hydration of GCLs Adjacent to Soil Layers”.
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# Appendix A-2: Maximum Head-on-Liner Calculation

Revision 1, May 16, 2018

A-2.1: Maximum Head-on-Liner Calculation for Cell Floor
A-2.2: Maximum Head-on-Liner Calculation for Side Slope
A-2.3: CTI 2012, Head-on-Liner Calculation using Numerical Approach
A-2.4: NTH 2012, Leachate Generation Estimation and Head Calculation

# A-2.1: Maximum Head-on-Liner Calculation for Cell Floor

Project Name: Wayne Disposal, Inc.
Client: US Ecology
Project Number: 1188070010
Project Manager: Te-Yang Soong, Ph.D., P.E.
Project Location: Belleville, Michigan
QA Manager: Xianda Zhao, Ph.D., P.E.

## Calculation Sheet Information

Calculation Medium: ☒ Electronic ☐ Hard-copy

2018 Permit Modification
Number of pages (excluding cover sheet): 2

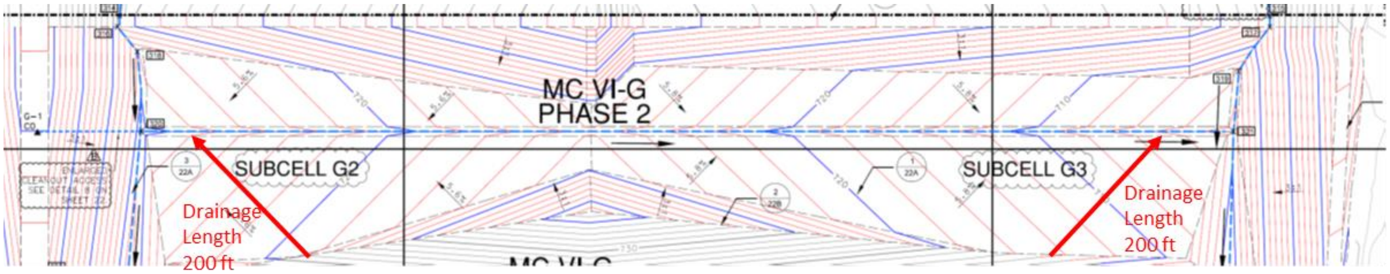
Title of Calculation: Appendix A-2.1 Maximum Floor Head-on-Liner Calculation R.01
Calculation Originator: Xianda Zhao
Calculation Contributors:
Calculation Checker: Te-Yang Soong

## Calculation Objective

1. Determine the maximum leachate head on the cell floor of the primary liner in Master Cell VI-G Phase 2 Subcells G2 and G3

## Design Criteria/Design Basis (with Reference to Source of Data)

1. Average daily peak leachate generation rates were obtained from “Leachate Generation Estimation and Head Calculation” (NTH, 2011).
2. A recessed leachate collection trench is proposed. The “free-drain” conditions for the leachate flow on the cell floor are satisfied.
3. The leachate head on liner is determined using the McEnroe Equation with a numerical method.
4. The transmissivity of the drainage Geocomposite is 2.4 x $10^{-4}$ square meters per second ($m^2$/sec) (6.1 x $10^{-5}$ $m^2$/sec prior applying the reduction factors).
5. Reduction factors of 1.75, 1.5, and 1.5 are selected for creep, chemical clogging and biological clogging, respectively.
6. The hydraulic conductivity of the protective soil over the Geocomposite is 1.0 x $10^{-5}$ meters per second (m/sec) based on R299.9619.
7. The maximum drainage length of subcells G2 and G3 is 200 ft.
8. The floor slopes of subcells G2 and G3 are 5.6% and 5.8%, respectively.



## Results/Conclusions

1. The maximum heads are 2.7 and 1.6 inches on cell floors in subcells G2 and G3, respectively. The proposed design reduced the maximum leachate head on the floors of subcells G2 and G3 compared to the permitted design (5.0 and 5.7 on cell floors in subcells G2 and G3, respectively).

## References/Source Documents

1. NTH 2011, WDI Operating License Application Master Cells VI F&G, Volume III Basis of Design Report.
2. Guideline and Manual for Planning and Design in Sewerage Systems., JSWA., 2009.
3. CTI 2012, Head-on-Liner Calculation using Numerical Approach.

## Revision Records

Checker comments provided on: ☐ Hard-copy ☒ Electronic File

| **No.** | **Revision Identifier (Number or Letter)** | **Version Type** | | **Originator Initials** | **Date** | **Checker Initials** | **Date** |
|---|---|---|---|---|---|---|---|
| | | **Draft** | **Final** | | | | |
| 1 | Rev. 0 | ☒ | ☐ | XZ | 4/29/2018 | | |
| 2 | Rev. 1 | ☐ | ☒ | XZ | 5/9/2018 | TYS | 5/9/2018 |
| 3 | | ☐ | ☐ | | | | |
| 4 | | ☐ | ☐ | | | | |
| | | ☐ | ☐ | | | | |
| | | ☐ | ☐ | | | | |
| | | ☐ | ☐ | | | | |

## Approval

☐ The Detail Check has been completed. Any significant issues not resolved between the Checker and Originator have been resolved by the Approver.

| | |
|---|---|
| | 5/9/2018 |
| Originator Signature | Date |
| | 5/9/2018 |
| Checker Signature | Date |
| | 5/9/2018 |
| Approved Signature | Date |

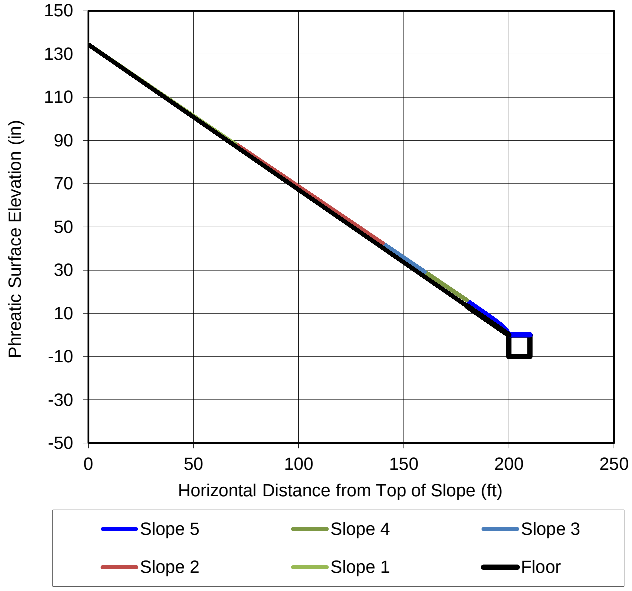
## HEAD ON LINER CALCULATIONS

## WDI MC6 G Phase 2 G2 - Floor

**R.01**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Prepared by: XZ 5/9/2018* | | | | | | | |
| *Reviewed by: TYS 5/9/2018* | | | **SLOPE 5** | **SLOPE 4** | **SLOPE 3** | **SLOPE 2** | **SLOPE 1** |
| *Approved by: XZ 5/9/2018* | *minimum y (in)* | *0.010* | **Bottom** | | | | **Top** |
| **Slope in the direction of flow** | S | ft./ft. | **5.60%** | **5.60%** | **5.60%** | **5.60%** | **5.60%** |
| Slope angle | α | radians | 0.0559 | 0.0559 | 0.0559 | 0.0559 | 0.0559 |
| **Flow length in the direction of flow** | L | ft. | **20** | **20** | **20** | **70** | **70** |
| **Rate of vertical inflow per unit area** | r | gal/acre/day | **8,960** | **8,960** | **8,960** | **8,960** | **8,960** |
| **Thickness of sand ( or protective soil)** | $t_{sand}$ | in | **3.0** | **3.0** | **3.0** | **3.0** | **2.0** |
| | | ft. | *0.250* | *0.250* | *0.250* | *0.250* | *0.167* |
| **Permeability of sand ( or protective soil)** | $K_{sand}$ | cm/sec | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** |
| **Thickness of geonet** | $t_{geonet}$ | in. | **0.200** | **0.200** | **0.200** | **0.200** | **0.200** |
| | | ft. | **0.017** | **0.017** | **0.017** | **0.017** | **0.017** |
| **Geonet transmissivity** | m2/s | m2/s | **2.40E-04** | **2.40E-04** | **2.40E-04** | **2.40E-04** | **2.40E-04** |
| **Reduction Factor** | | | **3.96** | **3.96** | **3.96** | **3.96** | **3.96** |
| Permeability of geonet | $K_{geonet}$ | cm/sec | 1.19E+00 | 1.19E+00 | 1.19E+00 | 1.19E+00 | 1.19E+00 |
| **Combined (apparent) permeability** | $K_{app}$ | **cm/sec** | **1.45E-01** | **1.45E-01** | **1.45E-01** | **1.45E-01** | **2.08E-01** |
| | | | | | | | |
| **Leachate Head at Discharge Point** | **h at L=0** | in | **0.10** | **2.63** | **2.35** | **2.05** | **1.03** |
| **Step Size** | dL | in | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Unit Width** | W | ft | 1 | 1 | 1 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Maximum head on liner (McEnroe numerical) in each slope** | **in** | **2.69** | **2.63** | **2.35** | **2.05** | **1.03** |
| **Maximum head on liner location (McEnroe numerical) in each slope** | **ft** | **187.49** | **180.00** | **160.00** | **140.00** | **70.00** |
| | | *0.26* | *0.32* | *0.73* | *1.31* | *1.38* |
| **Maximum head on liner (McEnroe numerical) in all slope** | **in** | **2.69** | | | | |



**McEnroe 1993 "Maximum Saturated Depth over Landfill Liner"**
*Journal of Environmental Engineering*

For Slope 1

$$y_{i+1} = y_i + \left( \tan\alpha_1 - \frac{r_1 x_i}{k_1 y_i \cos^2\alpha_1} \right)(x_{i+1} - x_i)$$

Fore Slopes 2 - 5

$$y_{i+1} = y_i + \left( \tan\alpha_j - \frac{\sum_{f=1}^{j-1} r_f L_f + r_j \left( x_i - \sum_{f=1}^{j-1} L_f \right)}{k_j y_i \cos^2\alpha_j} \right)(x_{i+1} - x_i)$$

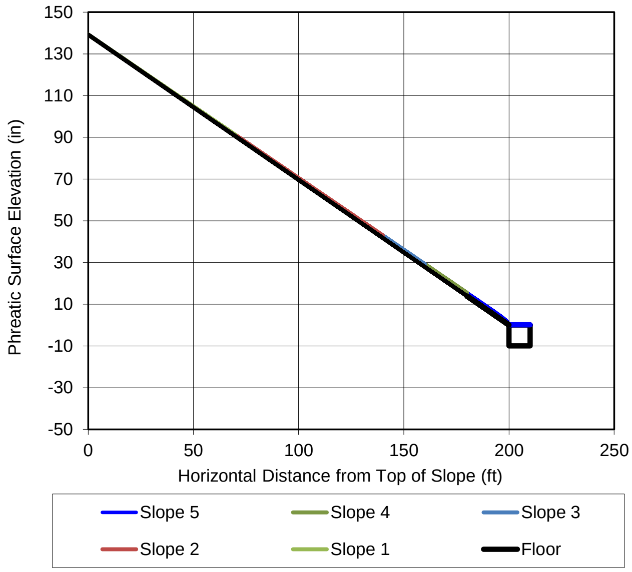
## HEAD ON LINER CALCULATIONS

## WDI MC6 G Phase 2 G3 - Floor

*R.01*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Prepared by: XZ 5/9/2018* | | | | | | | |
| *Reviewed by: TYS 5/9/2018* | | | **SLOPE 5** | **SLOPE 4** | **SLOPE 3** | **SLOPE 2** | **SLOPE 1** |
| *Approved by: XZ 5/9/2018* | *minimum y (in)* | *0.010* | **Bottom** | | | | **Top** |
| **Slope in the direction of flow** | S | ft./ft. | **5.80%** | **5.80%** | **5.80%** | **5.80%** | **5.80%** |
| Slope angle | α | radians | 0.0579 | 0.0579 | 0.0579 | 0.0579 | 0.0579 |
| **Flow length in the direction of flow** | L | ft. | **20** | **20** | **20** | **70** | **70** |
| **Rate of vertical inflow per unit area** | r | gal/acre/day | **7,874** | **7,874** | **7,874** | **7,874** | **7,874** |
| **Thickness of sand ( or protective soil)** | $t_{sand}$ | in | **2.0** | **2.0** | **2.0** | **2.0** | **2.0** |
| | | ft. | *0.167* | *0.167* | *0.167* | *0.167* | *0.167* |
| **Permeability of sand ( or protective soil)** | $K_{sand}$ | cm/sec | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** |
| **Thickness of geonet** | $t_{geonet}$ | in. | **0.200** | **0.200** | **0.200** | **0.200** | **0.200** |
| | | ft. | **0.017** | **0.017** | **0.017** | **0.017** | **0.017** |
| **Geonet transmissivity** | m2/s | m2/s | **2.40E-04** | **2.40E-04** | **2.40E-04** | **2.40E-04** | **2.40E-04** |
| **Reduction Factor** | | | **3.94** | **3.94** | **3.94** | **3.94** | **3.94** |
| Permeability of geonet | $K_{geonet}$ | cm/sec | 1.20E+00 | 1.20E+00 | 1.20E+00 | 1.20E+00 | 1.20E+00 |
| **Combined (apparent) permeability** | $K_{app}$ | **cm/sec** | **2.09E-01** | **2.09E-01** | **2.09E-01** | **2.09E-01** | **2.09E-01** |
| | | | | | | | |
| **Leachate Head at Discharge Point** | **h at L=0** | in | **0.10** | **1.54** | **1.37** | **1.20** | **0.60** |
| **Step Size** | dL | in | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Unit Width** | W | ft | 1 | 1 | 1 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Maximum head on liner (McEnroe numerical) in each slope** | **in** | **1.62** | **1.54** | **1.37** | **1.20** | **0.60** |
| **Maximum head on liner location (McEnroe numerical) in each slope** | **ft** | **191.63** | **180.00** | **160.00** | **140.00** | **70.00** |
| | | *0.34* | *0.43* | *0.69* | *1.00* | *2.56* |
| **Maximum head on liner (McEnroe numerical) in all slope** | **in** | **1.62** | | | | |



**McEnroe 1993 "Maximum Saturated Depth over Landfill Liner"**
*Journal of Environmental Engineering*

For Slope 1

$$y_{i+1} = y_i + \left( \tan\alpha_1 - \frac{r_1 x_i}{k_1 y_i \cos^2 \alpha_1} \right) (x_{i+1} - x_i)$$

Fore Slopes 2 - 5

$$y_{i+1} = y_i + \left( \tan\alpha_j - \frac{\sum_{f=1}^{j-1} r_f L_f + r_j \left( x_i - \sum_{f=1}^{j-1} L_f \right)}{k_j y_i \cos^2 \alpha_j} \right) (x_{i+1} - x_i)$$

# A-2.2: Maximum Head-on-Liner Calculation for Side Slope

Project Name: Wayne Disposal, Inc.
Project Number: 1188070010
Project Location: Belleville, Michigan
Client: US Ecology
Project Manager: Te-Yang Soong, Ph.D., P.E.
QA Manager: Xianda Zhao, Ph.D., P.E.

## Calculation Sheet Information

Calculation Medium: ☒ Electronic ☐ Hard-copy

2018 Permit Modification
Number of pages (excluding cover sheet): 4

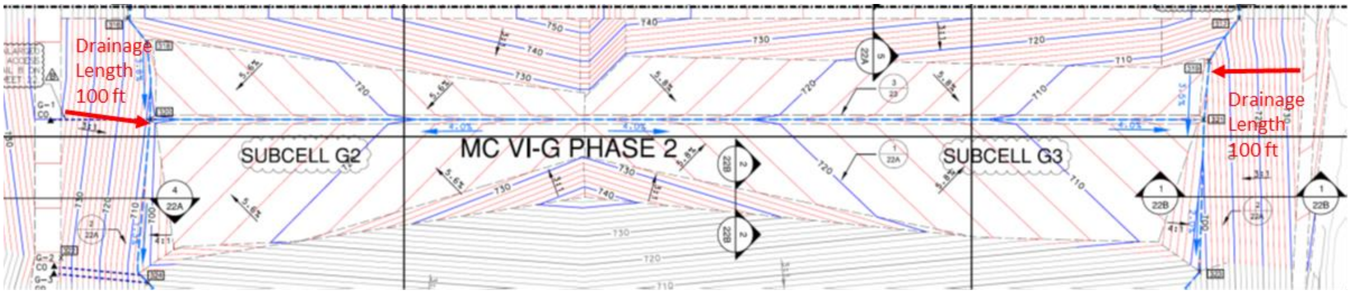
Title of Calculation: Appendix A-2.2 Maximum Sideslope Head-on-Liner Calculation R.01
Calculation Originator: Xianda Zhao
Calculation Contributors:
Calculation Checker: Te-Yang Soong

## Calculation Objective

1. Determine the maximum leachate head on the side slope of the primary liner in Master Cell VI-G Phase 2 Subcells G2 and G3

## Design Criteria/Design Basis (with Reference to Source of Data)

1. Average daily peak leachate generation rates were obtained from "Leachate Generation Estimation and Head Calculation" (NTH, 2011).
2. Liquid depth in the leachate collection pipe is determined using Manning's equation.
3. The leachate head on liner is determined using the McEnroe Equation with a numerical method.
4. The minimum slope of the leachate collection pipe is assumed at 1%.
5. The transmissivity of the drainage Geocomposite is 1.2 x $10^{-4}$ square meters per second ($m^2$/sec) (3.0 x $10^{-5}$ $m^2$/sec prior applying the reduction factors based on R299.9619).
6. Reduction factors of 1.75, 1.5, and 1.5 are selected for creep, chemical clogging and biological clogging, respectively.
7. The hydraulic conductivity of the protective soil over the Geocomposite is 1.0 x $10^{-5}$ meters per second (m/sec) based on R299.9619.
8. The acreages of subcells G2 and G3 are 3.05 and 4.28 acres, respectively.



## Results/Conclusions

1. A liquid depth of 2 inches was used to determine the flow capacity of the leachate collection pipe in the toe drain. The factors of safety are 3.8 and 3.1 for subcells G2 and G3, respectively. A total leachate depth of 5.18 inches was calculated for the toe drain.
2. Using a starting leachate level of 5.18 inches at the toe of the slope, the head on liner was determined. The maximum head is located at the starting point (toe of the side slope) and at a depth of **5.18** inches.

## References/Source Documents

1. NTH 2011, WDI Operating License Application Master Cells VI F&G, Volume III Basis of Design Report.
2. Guideline and Manual for Planning and Design in Sewerage Systems., JSWA., 2009.
3. CTI 2012, Head-on-Liner Calculation using Numerical Approach.

## Revision Records

Checker comments provided on: ☐ Hard-copy ☒ Electronic File

| **No.** | **Revision Identifier (Number or Letter)** | **Version Type** | | **Originator Initials** | **Date** | **Checker Initials** | **Date** |
|---|---|---|---|---|---|---|---|
| | | **Draft** | **Final** | | | | |
| 1 | Rev. 0 | ☒ | ☐ | XZ | 4/24/2018 | | |
| 2 | Rev. 1 | ☐ | ☒ | XZ | 5/9/2018 | TYS | 5/9/2018 |
| 3 | | ☐ | ☐ | | | | |
| 4 | | ☐ | ☐ | | | | |
| | | ☐ | ☐ | | | | |
| | | ☐ | ☐ | | | | |
| | | ☐ | ☐ | | | | |

## Approval

☐ The Detail Check has been completed. Any significant issues not resolved between the Checker and Originator have been resolved by the Approver.

Xiande Zhao

5/9/2018

Originator Signature

Date

5/9/2018

Checker Signature

Date

5/9/2018

Approved Signature

Date

# FLOW CAPACITY CALCULATION FOR SUBCELL G2

***Prepared by*** *XZ* ***Date*** *4/24/2018*
***Reviewed by*** *TYS* ***Date*** *4/25/2018*
***Approved by*** *XZ* ***Date*** *4/25/2018*

| | | |
|---|---|---|
| **Cell Area** | 3.05 | ac |
| **Perculation Rate** | 0.33 | inch |
| | 8960 | gpad |
| **Req. Q** | 3654 | ft3/day |
| | 19.0 | gpm |

| | | |
|---|---|---|
| **Stone Bed** | 2 | **inch** |
| **Pipe Wall Thickness** | 1.182 | **inch** |
| **Liquid depth in Pipe** | 2 | **inch** |
| **Liquid depth in Trench** | **5.18** | **inch** |

| **PARTIAL FULL PIPE** | | |
|---|---|---|
| **d (in)** | 6.12 | |
| **h (in)** | 2 | |
| **S** | 0.01 | |
| **n** | 0.011 | |
| | | |
| **r** | 0.255 | ft |
| **h** | 0.166666667 | ft |
| **α** | 0.353736348 | radians |
| | 20.26759978 | degree |
| **Θ** | 2.434119958 | radians |
| | 139.4648004 | degree |
| | | |
| A (ft2) | 0.058008961 | |
| P (ft) | 0.620700589 | |
| Rh (ft) | 0.093457235 | |
| | | |
| **Q (ft3/s)** | **0.162** | **FS** |
| **Q (gpm)** | **72.625** | **3.8** |
| **Q (gpd)** | **104,579.36** | |
| **Q (m3/s)** | 0.0046 | |
| | | |
| **V (ft/s)** | **2.790** | |

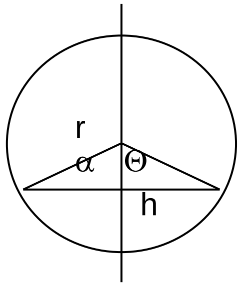
$$\alpha = \sin^{-1}\frac{r-h}{r} \text{ in radians}$$

$$\theta = \pi - 2\alpha$$

$$A = r^{2}\frac{\theta}{2} - (r-h)\left(\sqrt{2rh - h^{2}}\right)$$

$$P = r\theta$$

$$R = \frac{A}{P} = \frac{r}{2} - \frac{(r-h)\sqrt{2rh - h^{2}}}{r\theta}$$



$$Q_{allow} = \frac{1.49}{n} A R_h^{2/3} S^{1/2}$$

1.49 = conversion constant (SI to US)
n = 0.11 for HDPE pipe
A = Flow Area
P=wetted perimeter
Rh=hydraulic radius=area/perimeter

# FLOW CAPACITY CALCULATION FOR SUBCELL G3

*Prepared by* *XZ* *Date* *4/24/2018*
*Reviewed by* *TYS* *Date* *4/25/2018*
*Approved by* *XZ* *Date* *4/25/2018*

| | | |
|---|---|---|
| **Cell Area** | 4.28 | ac |
| **Perculation Rate** | 0.29 | inch |
| | 7874 | gpad |
| **Req. Q** | 4506 | ft3/day |
| | 23.4 | gpm |

| | | |
|---|---|---|
| **Stone Bed** | 2 | **inch** |
| **Pipe Wall Thickness** | 1.182 | **inch** |
| **Liquid depth in Pipe** | 2 | **inch** |
| **Liquid depth in Trench** | **5.18** | **inch** |

| **PARTIAL FULL PIPE** | | |
|---|---|---|
| **d (in)** | 6.12 | |
| **h (in)** | 2 | |
| **S** | 0.01 | |
| **n** | 0.011 | |
| | | |
| **r** | 0.255 | ft |
| **h** | 0.166666667 | ft |
| **α** | 0.353736348 | radians |
| | 20.26759978 | degree |
| **Θ** | 2.434119958 | radians |
| | 139.4648004 | degree |
| | | |
| A (ft2) | 0.058008961 | |
| P (ft) | 0.620700589 | |
| Rh (ft) | 0.093457235 | |
| | | |
| **Q (ft3/s)** | **0.162** | **FS** |
| **Q (gpm)** | **72.625** | **3.1** |
| **Q (gpd)** | **104,579.36** | |
| **Q (m3/s)** | 0.0046 | |
| | | |
| **V (ft/s)** | **2.790** | |

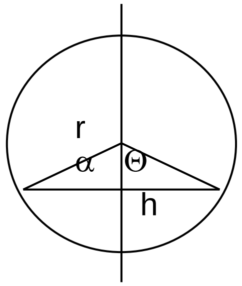
$$\alpha = \sin^{-1}\frac{r-h}{r} \quad \text{in radians}$$

$$\theta = \pi - 2\alpha$$

$$A = r^{2}\frac{\theta}{2} - (r-h)\left(\sqrt{2rh - h^{2}}\right)$$

$$P = r\theta$$

$$R = \frac{A}{P} = \frac{r}{2} - \frac{(r-h)\sqrt{2rh - h^{2}}}{r\theta}$$



$$Q_{allow} = \frac{1.49}{n} A R_h^{2/3} S^{1/2}$$

1.49 = conversion constant (SI to US)
n = 0.11 for HDPE pipe
A = Flow Area
P=wetted perimeter
Rh=hydraulic radius=area/perimeter

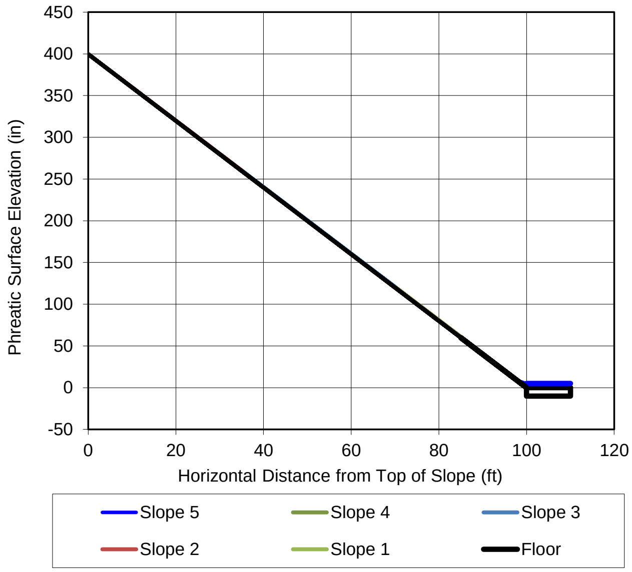
# HEAD ON LINER CALCULATIONS

## WDI MC6 G Phase 2 G2 - Side Slope

***R.01***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Prepared by: XZ 5/9/2018* | | | | | | | |
| *Reviewed by: TYS 5/9/2018* | | | **SLOPE 5** | **SLOPE 4** | **SLOPE 3** | **SLOPE 2** | **SLOPE 1** |
| *Approved by: XZ 5/9/2018* | *minimum y (in)* | *0.010* | **Bottom** | | | | **Top** |
| **Slope in the direction of flow** | S | ft./ft. | **33.30%** | **33.30%** | **33.30%** | **33.30%** | **33.30%** |
| Slope angle | α | radians | 0.3215 | 0.3215 | 0.3215 | 0.3215 | 0.3215 |
| **Flow length in the direction of flow** | L | ft. | **15** | **15** | **35** | **35** | **0** |
| **Rate of vertical inflow per unit area** | r | gal/acre/day | **8,960** | **8,960** | **8,960** | **8,960** | **8,960** |
| **Thickness of sand ( or protective soil)** | $t_{sand}$ | in | **6.0** | **6.0** | **6.0** | **6.0** | **6.0** |
| | | ft. | *0.500* | *0.500* | *0.500* | *0.500* | *0.500* |
| **Permeability of sand ( or protective soil)** | $K_{sand}$ | cm/sec | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** |
| **Thickness of geonet** | $t_{geonet}$ | in. | **0.200** | **0.200** | **0.200** | **0.200** | **0.000** |
| | | ft. | **0.017** | **0.017** | **0.017** | **0.017** | **0.000** |
| **Geonet transmissivity** | m2/s | m2/s | **1.18E-04** | **1.18E-04** | **1.18E-04** | **1.18E-04** | **1.18E-04** |
| **Reduction Factor** | | | **3.94** | **3.94** | **3.94** | **3.94** | **3.94** |
| Permeability of geonet | $K_{geonet}$ | cm/sec | 5.91E-01 | 5.91E-01 | 5.91E-01 | 5.91E-01 | 0.00E+00 |
| **Combined (apparent) permeability** | $K_{app}$ | **cm/sec** | **3.84E-02** | **3.84E-02** | **3.84E-02** | **3.84E-02** | **1.00E-03** |
| | | | | | | | |
| **Leachate Head at Discharge Point** | **h at L=0** | in | **5.18** | **0.86** | **0.71** | **0.35** | **0.01** |
| **Step Size** | dL | in | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Unit Width** | W | ft | 1 | 1 | 1 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Maximum head on liner (McEnroe numerical) in each slope** | **in** | **5.18** | **0.86** | **0.71** | **0.35** | **0.01** |
| **Maximum head on liner location (McEnroe numerical) in each slope** | **ft** | **100.00** | **85.00** | **70.00** | **35.00** | **0.00** |
| | | *1.04* | *28.50* | *30.15* | *34.17* | *35.88* |
| **Maximum head on liner (McEnroe numerical) in all slope** | **in** | **5.18** | | | | |



**McEnroe 1993 "Maximum Saturated Depth over Landfill Liner"**
*Journal of Environmental Engineering*

For Slope 1

$$y_{i+1} = y_i + \left( \tan \alpha_1 - \frac{r_1 x_i}{k_1 y_i \cos^2 \alpha_1} \right) (x_{i+1} - x_i)$$

Fore Slopes 2 - 5

$$y_{i+1} = y_i + \left( \tan \alpha_j - \frac{\sum_{f=1}^{j-1} r_f L_f + r_j \left( x_i - \sum_{f=1}^{j-1} L_f \right)}{k_j y_i \cos^2 \alpha_j} \right) (x_{i+1} - x_i)$$

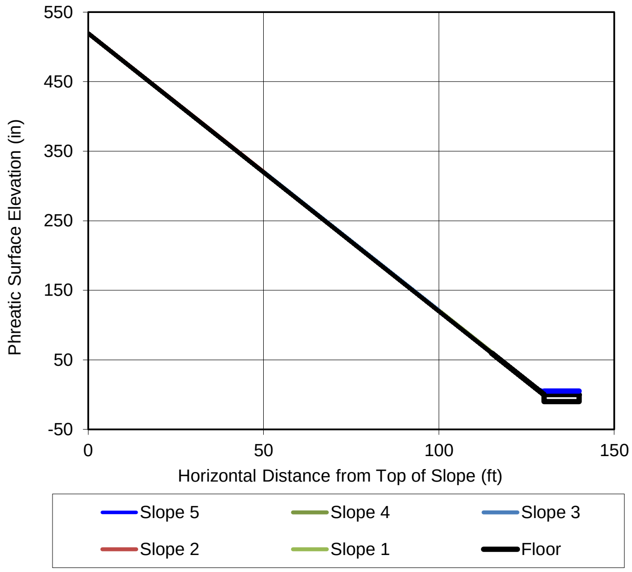
## HEAD ON LINER CALCULATIONS

## WDI MC6 G Phase 2 G3 - Side Slope

*R.01*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Prepared by: XZ 5/9/2018* | | | | | | | |
| *Reviewed by: TYS 5/9/2018* | | | **SLOPE 5** | **SLOPE 4** | **SLOPE 3** | **SLOPE 2** | **SLOPE 1** |
| *Approved by: XZ 5/9/2018* | *minimum y (in)* | *0.010* | **Bottom** | | | | **Top** |
| **Slope in the direction of flow** | S | ft./ft. | **33.30%** | **33.30%** | **33.30%** | **33.30%** | **33.30%** |
| Slope angle | α | radians | 0.3215 | 0.3215 | 0.3215 | 0.3215 | 0.3215 |
| **Flow length in the direction of flow** | L | ft. | **15** | **15** | **50** | **50** | **0** |
| **Rate of vertical inflow per unit area** | r | gal/acre/day | **7,874** | **7,874** | **7,874** | **7,874** | **7,874** |
| **Thickness of sand ( or protective soil)** | $t_{sand}$ | in | **6.0** | **6.0** | **6.0** | **6.0** | **6.0** |
| | | ft. | *0.500* | *0.500* | *0.500* | *0.500* | *0.500* |
| **Permeability of sand ( or protective soil)** | $K_{sand}$ | cm/sec | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** |
| **Thickness of geonet** | $t_{geonet}$ | in. | **0.200** | **0.200** | **0.200** | **0.200** | **0.000** |
| | | ft. | **0.017** | **0.017** | **0.017** | **0.017** | **0.000** |
| **Geonet transmissivity** | m2/s | m2/s | **1.18E-04** | **1.18E-04** | **1.18E-04** | **1.18E-04** | **1.18E-04** |
| **Reduction Factor** | | | **3.94** | **3.94** | **3.94** | **3.94** | **3.94** |
| Permeability of geonet | $K_{geonet}$ | cm/sec | 5.91E-01 | 5.91E-01 | 5.91E-01 | 5.91E-01 | 0.00E+00 |
| **Combined (apparent) permeability** | $K_{app}$ | **cm/sec** | **3.84E-02** | **3.84E-02** | **3.84E-02** | **3.84E-02** | **1.00E-03** |
| | | | | | | | |
| **Leachate Head at Discharge Point** | **h at L=0** | in | **5.18** | **1.02** | **0.89** | **0.45** | **0.01** |
| **Step Size** | dL | in | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Unit Width** | W | ft | 1 | 1 | 1 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Maximum head on liner (McEnroe numerical) in each slope** | **in** | **5.18** | **1.02** | **0.89** | **0.45** | **0.01** |
| **Maximum head on liner location (McEnroe numerical) in each slope** | **ft** | **130.00** | **115.00** | **100.00** | **50.00** | **0.00** |
| | | *1.04* | *26.79* | *28.19* | *33.12* | *35.88* |
| **Maximum head on liner (McEnroe numerical) in all slope** | **in** | **5.18** | | | | |



**McEnroe 1993 "Maximum Saturated Depth over Landfill Liner"**
*Journal of Environmental Engineering*

For Slope 1

$$y_{i+1} = y_i + \left( \tan \alpha_1 - \frac{r_1 x_i}{k_1 y_i \cos^2 \alpha_1} \right) (x_{i+1} - x_i)$$

Fore Slopes 2 - 5

$$y_{i+1} = y_i + \left( \tan \alpha_j - \frac{\sum_{f=1}^{j-1} r_f L_f + r_j \left( x_i - \sum_{f=1}^{j-1} L_f \right)}{k_j y_i \cos^2 \alpha_j} \right) (x_{i+1} - x_i)$$

# A-2.3: CTI 2012, Head-on-Liner Calculation using Numerical Approach

**CALCULATION SHEET**
Client: Landfill
Project: Head-on-Liner Calculation
Calculation: Head-on-liner calculation using numerical approach

Project No.:
Calculated By: XZ Date: 3/6/2012
Checked By: TY Date: 3/9/2012
Approved By: KF Date: 5/30/2012

# HEAD-ON-LINER CALCULATION USING NUMERICAL APPROACH

## OBJECTIVE

To determine the maximum saturated leachate depth within leachate drainage media above an impermeable liner using a numerical implementation of the McEnroe (1993) Equations .

## DESIGN CRITERIA, ASSUMPTIONS AND METHODOLOGY

The head-on-liner calculation is conducted according to the following procedure:

1. Determine the average transmissivity value of drainage geocomposite using test results obtained under the design normal stress. This value is reduced through the application of several reduction factors as described in following equation (Koerner 2005):

$$\theta_{allow} = \frac{\theta_{test}}{RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC}} \qquad (1)$$

Where,
$RF_{IN}$ = reduction factor for intrusion (or elastic deformation)
$RF_{CR}$ = reduction factor for creep deformation
$RF_{CC}$ = reduction factor for chemical clogging
$RF_{BC}$ = reduction factor for biological clogging
$\theta_{allow}$ = allowable transmissivity for the geocomposite, $m^2/s$
$\theta_{test}$ = tested transmissivity for the geocomposite, $m^2/s$

2. Determine the combined (apparent) hydraulic conductivity of the drainage layer (geocomposite overlain by a sand layer) using the equation by Qian et al. (2004):

$$k_{combined} = k_{geonet} + \left(k_{sand} - k_{geonet}\right)\frac{t_{sand}{}^{2}}{\left(t_{sand} + t_{geonet}\right)^{2}} \qquad (2)$$

where,
$k_{combined}$ = combined hydraulic conductivity of the saturated drainage layer (cm/s)
$k_{sand}$ = hydraulic conductivity of sand (cm/s)
$k_{geonet}$ = hydraulic conductivity of geocomposite (cm/s)
$t_{sand}$ = thickness of the saturated sand layer (in)
$t_{geonet}$ = thickness of geocomposite (in)

3. Head-on-liner calculation – McEnroe (1993) Method (valid only for free draining condition)

A commonly used method for calculating the maximum head-on-liner was developed by McEnroe (1993). McEnroe (1993) developed a differential equation to describe the flow in the drainage layer using the extended Dupuit assumptions. McEnroe also derived an analytical solution from the governing differential equation to determine the maximum head (saturated depth) buildup under free draining conditions. McEnroe's 1993 method (under free draining conditions) is expressed as:

If R<1/4

$$y_{\max} = LS * \left(R - RS + R^2S^2\right)^{1/2} * \left\{\left[(1-A-2R)(1+A-2RS)\right]/\left[(1+A-2R)(1-A-2RS)\right]\right\}^{1/(2A)} \quad (3)$$

If R=1/4

$$y_{\max} = LSR*(1-2RS)/(1-2R)*\exp\left\{2R*(S-1)/\left[(1-2RS)(1-2R)\right]\right\} \quad (4)$$

If R>=1/4

$$y_{\max} = LS*\left(R - RS + R^2S^2\right)^{1/2} * \exp\left\{(1/B)*\tan^{-1}\left[(2RS-1)/B\right] - (1/B)*\tan^{-1}\left[(2R-1)/B\right]\right\} \quad (5)$$

The parameters "R", "A", and "B" used in the above equations are defined as:

$$R = q/\left(k\sin^2\alpha\right) \quad (6)$$

$$A = (1-4R)^{1/2} \quad (7)$$

$$B = (4R-1)^{1/2} \quad (8)$$

Where: $k$ = hydraulic conductivity of the saturated drainage layer
$L$ = drainage length
$q$ = leachate infiltration rate
$\alpha$ = slope angle

There are several limitations to the McEnroe (1993) method:

a. The analytical solution requires "free draining conditions".
b. Hydraulic conductivity, leachate infiltration rate, and slope angle must be consistent along the entire drainage length.

4. Head-on-liner calculation –numerical approach

The McEnroe (1993) method is an analytical solution of the differential equation governing flow under free draining conditions. However, this differential equation can be integrated numerically to describe the saturated depth profile based on the boundary conditions. In other words, the governing differential equation can be solved numerically without preconditions such as the free-draining requirement.

The differential equation governing flow along a single drainage length is McEnroe (1993):

$$ky\left(\frac{dy}{dx} - \tan\alpha\right)\cos^2\alpha + rx = 0 \quad (9)$$

where,

$k$ = hydraulic conductivity of the combined saturated drainage layer (cm/s)
$y$ = saturated liquid depth over the liner (cm or in)
$x$ = horizontal coordinate (cm or in)
$r$ = leachate infiltration rate (cm/s)
$\alpha$ = slope angle

Equation 9 can be rearranged into finite difference form:

$$y_{i+1} = y_i + \left( \tan\alpha - \frac{rx_i}{ky_i \cos^2 \alpha} \right) dx \qquad (10)$$

$$dx = x_{i+1} - x_i$$

Equation 10 can be numerically integrated using a pre-selected saturated liquid depth ( $y_L$ ) at the low point of the drainage path, where "$x$" is equivalent to the maximum drainage length (Figure 1). The procedure will result in a full phreatic surface profile. From this profile the maximum head-on-liner value can be determined.

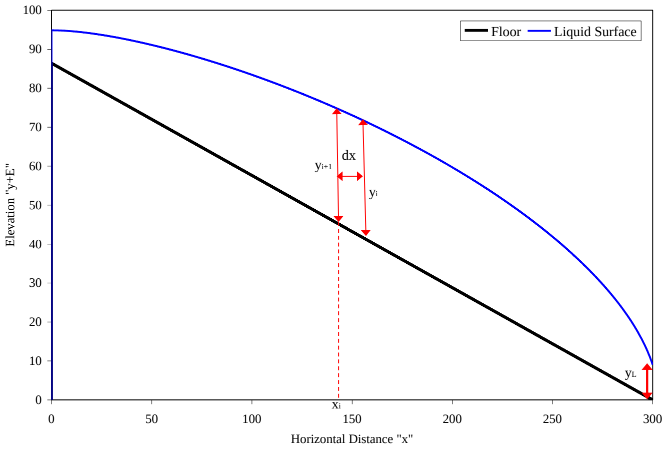


**Figure 1. Example of Phreatic Leachate Surface**

For a drainage system with multiple slopes (Figure 2), Equation 10 is arranged for each slope segment. Note that dimensions shown in Figure 2 are arbitrarily selected for illustrative purposes.

For slope segment 1: $0 \le x_i \le L_1$

$$y_{i+1} = y_i + \left( \tan\alpha_1 - \frac{r_1 x_i}{k_1 y_i \cos^2 \alpha_1} \right) \left( x_{i+1} - x_i \right) \qquad \text{Eq. 11}$$

at $x = L_1$: $y$ is equal to the value calculated from segment 2 at the same value of $x$.

For other slope segments (segment j where j >1): $\sum_{f=1}^{j-1} L_f \le x_i \le \sum_{f=1}^{j} L_f$ :

$$y_{i+1} = y_i + \left( \tan\alpha_j - \frac{\sum_{f=1}^{j-1} r_f L_f + r_j\left( x_i - \sum_{f=1}^{j-1} L_f \right)}{k_j y_i \cos^2\alpha_j} \right)\left(x_{i+1} - x_i\right) \qquad \text{Eq. 12}$$

at $x = \sum_{f=1}^{j-1} L_f$ : $y$ is equal to the value calculated from segment *j-1* at the same value of $x$.

Where

$k_1$ and $k_j$ = combined hydraulic conductivity of the saturated drainage layer in slope segments 1 and *j*, respectively
$r_1$ and $r_j$ = leachate infiltration rate to slope segments 1 and *j*, respectively
$\alpha_1$ and $\alpha_j$ = slope angle of slope segments 1 and *j*, respectively
$L_1$ and $L_j$ = total drainage length of slope segments 1 and *j*, respectively

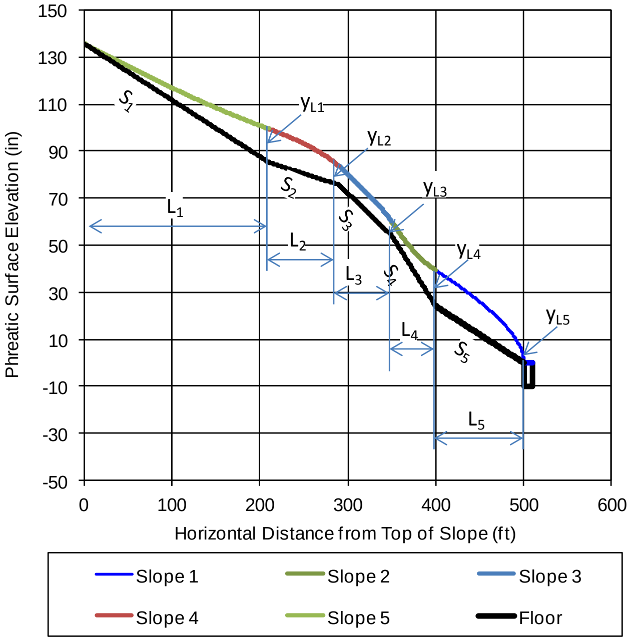


**Figure 2. Example of Multiple Phreatic Leachate Surface**

## VERIFICATION OF THE NUMERICAL MODEL

A spreadsheet (in Microsoft Excel) was developed for the numerical integration of Equations 11 and 12. This spreadsheet included five slope segments. Multiple input parameters can be adjusted independently for each slope segment (Figure 3). To verify the accuracy of the numerical model results, the maximum values of leachate head on liner were calculated using a variety of input parameters and compared to the results estimated using the McEnroe (1993) method. Due to the limitations of the McEnroe (1993) method, constant values of leachate infiltration rate, slope angle, and permeability were applied to all slope segments in the numerical model and the free draining conditions were simulated using the numerical approach by applying a small leachate depth at the lowest point of the slope.

## Test 1: Step distance for numerical integration

The maximum head-on-liner values were calculated using both the McEnroe (1993) Method and the numerical approach for six different permeability values (Table 1) and five leachate infiltration rates (Table 2). Four integration step distances (ranging from 0.2 to 3 inches) were used. In both tests, the results from the numerical approach are very close to the results calculated using McEnroe (1993) method. Therefore, the numerical approach was verified. Moreover, the incremental variation in numerical integration step distance (dx) did not significantly impact the results under the trial conditions. To minimize the file size and reduce computation time, an integration step distance of **0.5 inches** is recommended when using the numerical modeling approach.

**Table 1. Sensitivity of Numerical Approach to Integration Step Distance for Various Permeability Values.**

| INPUT PARAMETERS | | | | | |
|---|---|---|---|---|---|
| | | **Infiltration Rate (gpad)** | **Drainage Length (ft)** | **Slope** | **Liquid Depth at Lowest Point (in)** |
| **Numerical Solution** | Slope 1 | 3,000 | 140 | 2.00% | - |
| | Slope 2 | 3,000 | 235 | 2.00% | - |
| | Slope 3 | 3,000 | 200 | 2.00% | - |
| | Slope 4 | 3,000 | 75 | 2.00% | - |
| | Slope 5 | 3,000 | 350 | 2.00% | 1.0 |
| **McEnroe 93 Method** | | 3,000 | 1,000 | 2.00% | free drain |

| RESULTS | | | | | |
|---|---|---|---|---|---|
| **Sand k (cm/s)** | **Ymax (in)** | | | | |
| | **McEnroe 93** | **Numerical** | | | |
| | | **dx=0.2 in** | **dx=0.5 in** | **dx=1.0 in** | **dx=3.0 in** |
| 0.01 | 112.35 | 102.98 | 112.35 | 112.38 | 112.56 |
| 0.05 | 30.64 | 30.61 | 30.65 | 30.65 | 30.67 |
| 0.10 | 16.63 | 16.63 | 16.64 | 16.64 | 16.65 |
| 0.50 | 3.70 | 3.70 | 3.70 | 3.70 | 3.70 |
| 1.00 | 1.89 | 1.89 | 1.89 | 1.89 | 1.89 |
| 5.00* | 0.39 | 0.39 | 0.39 | 0.39 | 0.57 |

**Table 2. Sensitivity of Numerical Approach to Integration Step Distance for Various Permeability Values and Leachate Infiltration Rates**

| INPUT PARAMETERS | | | | |
|---|---|---|---|---|
| | | Drainage Length (ft) | Slope | Liquid Depth at Lowest Point (in) |
| Numerical Solution | Slope 1 | 140 | 2.00% | - |
| | Slope 2 | 235 | 2.00% | - |
| | Slope 3 | 200 | 2.00% | - |
| | Slope 4 | 75 | 2.00% | - |
| | Slope 5 | 350 | 2.00% | 1.0 |
| McEnroe 93 Method | | 1,000 | 2.00% | free drain |

| RESULTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Infiltration Rate r (gpad) | Sand k (cm/s) | r/k* | Ymax (in) | | | | |
| | | | McEnroe 93 | Numerical | | | |
| | | | | dx=0.2 in | dx=0.5 in | dx=1.0 in | dx=3.0 in |
| 100 | 0.01 | 1.08E-05 | 6.02 | 6.02 | 6.02 | 6.02 | 6.03 |
| 500 | 0.01 | 5.41E-05 | 26.16 | 26.16 | 26.17 | 26.17 | 26.19 |
| 1,000 | 0.05 | 2.17E-05 | 11.50 | 11.50 | 11.50 | 11.50 | 11.51 |
| 3,000 | 0.05 | 6.50E-05 | 30.64 | 30.61 | 30.65 | 30.65 | 30.67 |
| 5,000 | 0.05 | 1.08E-04 | 47.18 | 47.18 | 47.18 | 47.19 | 47.23 |
| 5,000 | 0.10 | 5.41E-05 | 26.16 | 26.16 | 26.17 | 26.17 | 26.19 |
| 5,000 | 0.50 | 1.08E-05 | 6.02 | 6.02 | 6.02 | 6.02 | 6.03 |

Note:
* The ratio of infiltration rate and hydraulic conductivity of the drainage layer will control the maximum leachate depth on the liner (see Eq. 12).

## Test 2: Starting leachate depth

In the numerical integration approach, a starting leachate depth at the lowest point (discharge point) of the slopes will be needed to initialize the integration. Four starting leachate depths were used in this test. The maximum head-on-liner values from both the McEnroe (1993) Method and the numerical solution were calculated for four different permeability values (Table 3). The results from the numerical approach are very close to the results calculated using the McEnroe (1993) method with one exception. Under the high permeability condition, the maximum head-on-linear was determined to be 3.70 inches using McEnroe 93 method. The results from numerical approach with a starting leachate depth of 1 inch or less were same as the value calculated from the McEnroe (1993) method. However, if the starting leachate depth was selected as 9 inches, the maximum leachate depth will occur at the starting point. This result indicates that the numerical integration approach can be used to determine the maximum head-on-liner when the "free draining" condition is not satisfied. In most cases, a starting leachate depth of **1.0 inch** can be used to represent the "free draining” condition. Note that under same conditions such as very high value of the ratio between infiltration rate and conductivity (high infiltration rate and low conductivity), the low starting leachate depth may result unstable solutions from the model. If it is occurred, user can adjust the staring value. A stable result can be verified by the trails and demonstrate that the the numerical solution is stable and not unduly affected by the starting leachate depth

**Table 3. Sensitivity of Numerical Solution to the Starting Leachate Depth**

| **INPUT PARAMETERS** | | | | | |
|---|---|---|---|---|---|
| | | **Infiltration Rate (gpad)** | **Drainage Length (ft)** | **Slope** | **Liquid Depth at Lowest Point (in)** |
| **Numerical Solution** | Slope 1 | 3,000 | 140 | 2.00% | - |
| | Slope 2 | 3,000 | 235 | 2.00% | - |
| | Slope 3 | 3,000 | 200 | 2.00% | - |
| | Slope 4 | 3,000 | 75 | 2.00% | - |
| | Slope 5 | 3,000 | 350 | 2.00% | - |
| **McEnroe 93 Method** | | 3,000 | 1,000 | 2.00% | free drain |

| **RESULTS** | | | | | |
|---|---|---|---|---|---|
| **Sand k (cm/s)** | **Ymax (in)** | | | | |
| | **McEnroe 93** | **Numerical dx=0.5 in** | | | |
| | | **Yo=0.1 in** | **Yo=0.5 in** | **Yo=1 in** | **Yo=9 in** |
| 0.01 | 112.35 | 112.83 | 112.37 | 112.35 | 112.45 |
| 0.05 | 30.64 | 30.67 | 30.65 | 30.65 | 30.80 |
| 0.10 | 16.63 | 16.64 | 16.64 | 16.64 | 16.85 |
| 0.50 | 3.70 | 3.70 | 3.70 | 3.70 | 9.00 |

## Test 3: Add geocomposite layer

To improve the drainage capacity of the drainage layer, a geocomposite layer can be added under the sand drainage layer. The combined hydraulic conductivity can be calculated using Equation 2. Two permeability values for sand with and without geocomposite layer were tested. The results from the numerical approach are very close to the values calculated using McEnroe 93 method (Table 4).

**Table 4. Head-on-Liner Calculation with and without Geocomposite Layer**

| **INPUT PARAMETERS** | | | | | |
|---|---|---|---|---|---|
| | | **Infiltration Rate (gpad)** | **Drainage Length (ft)** | **Slope** | **Liquid Depth at Lowest Point (in)** |
| **Numerical Solution** | Slope 1 | 3,000 | 70 | 2.00% | - |
| | Slope 2 | 3,000 | 117 | 2.00% | - |
| | Slope 3 | 3,000 | 100 | 2.00% | - |
| | Slope 4 | 3,000 | 38 | 2.00% | - |
| | Slope 5 | 3,000 | 175 | 2.00% | 1.0 |
| **McEnroe 93 Method** | | 3,000 | 500 | 2.00% | free drain |
| **RESULTS** | | | | | |
| **Sand k (cm/s)** | **Geocomposite** | **Saturated Depth (inch)** | **Combined k (cm/s)** | **Ymax (in)** | |
| | | | | **McEnroe 93** | **Numerical dx=0.5 in** |
| 0.0100 | no | n/e | 0.010 | 112.35 | 112.35 |
| 0.0100 | yes | 6.4 | 0.138 | 6.19 | 6.20 |
| 0.0010 | no | n/e | 0.001 | 267.21 | 266.93 |
| 0.0010 | yes | 7.8 | 0.108 | 7.78 | 7.79 |

n/e: no effect on the results.

## DESIGN EXAMPLES USING THE NUMERICAL APPROACH

Six design examples are presented below to demonstrate the application of the numerical approach to the calculation of the maximum head-on-liner values. Descriptions and results for each example are summarized in Table 5. The detailed input parameters and phreatic surface plot for each example is presented in Figures 4 to 9, respectively. As demonstrated in Table 5, the numerical approach can accomodate multiple design conditions. In all design examples, the head-on-liner value cannot be estimated using the McEnroe (1993) method due to the complexity of the system.

**Table 5. Summary of Design Examples**

| EXAMPLE | DESCRIPTION | Max Head-on-Liner (INCHES) |
|---|---|---|
| 1 | Single slope with different leachate infiltration rates for each slope segment | 8.08 |
| 2 | Five slopes with constant leachate infiltration rate for each slope segment | 16.64 |
| 3 | Five slopes with different leachate infiltration rates for each slope segment | 8.08 |
| 4 | Single slope with constant leachate infiltration rate; Increased flow capacity in bottom two slope segments by installing geocomposite layer | 11.73 |
| 5 | Five slopes with different leachate infiltration rates for each slope segment; High infiltration rate at top of the slope (representing open conditions); Increased flow capacity in bottom two slope segments by installing geocomposite layer | 10.48 |
| 6 | Single slope with constant leachate infiltration rate; Increased flow capacity by installing geocomposite layer in all slope segments; Applied different leachate depths for each slope segment; no trench at lowest point of the slope (no "free drain") and the leachate depth is 9 inches at lowest point (discharge point). | 10.74 |

## CONCLUSION

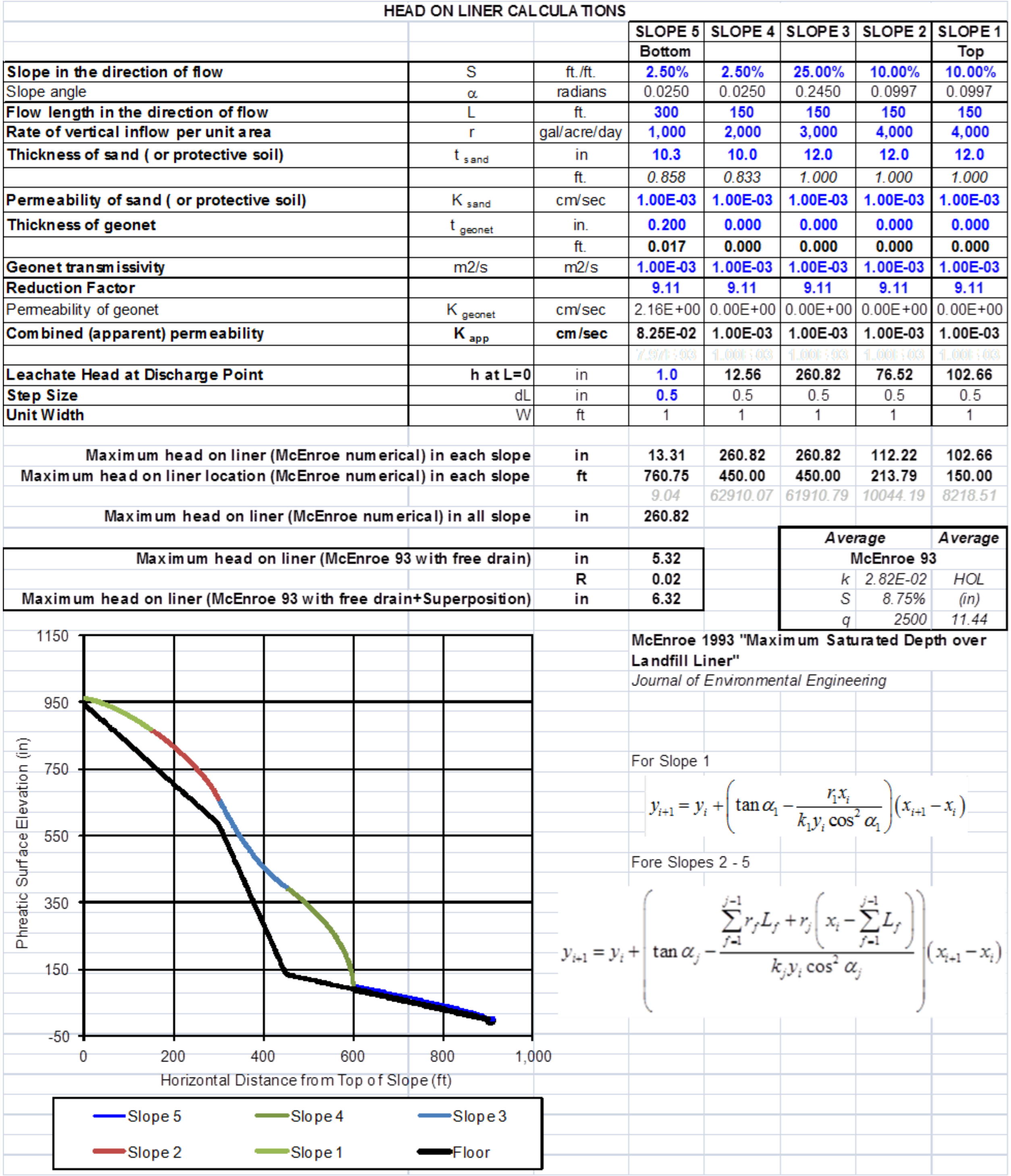
A numerical approach was developed to solve the differential equation governing flow in permeable media above an impermeable barrier presented by McEnroe (1993). This new approach was verified by analyzing multiple different boundary conditions and comparing the results to those calculated using analytical solutions developed by McEnroe (1993). Several design examples were provided to demonstrate the capability of this approach.

## REFERENCES

Koerner, R. M. (2005). *Designing with Geosynthetics*, 5th ed. Upper Saddle River, NJ: Prentice Hall.

McEnroe, B. (1993) “Maximum Saturated Depth over Landfill Liner” Journal of Environmental Engineering, Val. 119, No.2, Page 262-270

Qian, X.D., Gray, D.H., and Koerner, R.M. (2004), “Estimation of Maximum Liquid Head over Landfill Barriers,” Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 130:5, 488-497



HEAD ON LINER CALCULATIONS

| | | | SLOPE 5 | SLOPE 4 | SLOPE 3 | SLOPE 2 | SLOPE 1 |
|---|---|---|---|---|---|---|---|
| | | | Bottom | | | | Top |
| **Slope in the direction of flow** | S | ft./ft. | 2.50% | 2.50% | 25.00% | 10.00% | 10.00% |
| Slope angle | α | radians | 0.0250 | 0.0250 | 0.2450 | 0.0997 | 0.0997 |
| **Flow length in the direction of flow** | L | ft. | 300 | 150 | 150 | 150 | 150 |
| **Rate of vertical inflow per unit area** | r | gal/acre/day | 1,000 | 2,000 | 3,000 | 4,000 | 4,000 |
| **Thickness of sand ( or protective soil)** | $t_{sand}$ | in | 10.3 | 10.0 | 12.0 | 12.0 | 12.0 |
| | | ft. | 0.858 | 0.833 | 1.000 | 1.000 | 1.000 |
| **Permeability of sand ( or protective soil)** | $K_{sand}$ | cm/sec | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 |
| **Thickness of geonet** | $t_{geonet}$ | in. | 0.200 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | ft. | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Geonet transmissivity** | m2/s | m2/s | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 |
| **Reduction Factor** | | | 9.11 | 9.11 | 9.11 | 9.11 | 9.11 |
| Permeability of geonet | $K_{geonet}$ | cm/sec | 2.16E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **Combined (apparent) permeability** | $K_{app}$ | **cm/sec** | **8.25E-02** | **1.00E-03** | **1.00E-03** | **1.00E-03** | **1.00E-03** |
| | | | 7.97E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 |
| **Leachate Head at Discharge Point** | h at L=0 | in | 1.0 | 12.56 | 260.82 | 76.52 | 102.66 |
| **Step Size** | dL | in | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| **Unit Width** | W | ft | 1 | 1 | 1 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Maximum head on liner (McEnroe numerical) in each slope** | **in** | **13.31** | **260.82** | **260.82** | **112.22** | **102.66** |
| **Maximum head on liner location (McEnroe numerical) in each slope** | **ft** | **760.75** | **450.00** | **450.00** | **213.79** | **150.00** |
| | | *9.04* | *62910.07* | *61910.79* | *10044.19* | *8218.51* |
| **Maximum head on liner (McEnroe numerical) in all slope** | **in** | **260.82** | | | | |

| | | |
|---|---|---|
| **Maximum head on liner (McEnroe 93 with free drain)** | **in** | **5.32** |
| | **R** | **0.02** |
| **Maximum head on liner (McEnroe 93 with free drain+Superposition)** | **in** | **6.32** |

| | | |
|---|---|---|
| ***Average*** | | ***Average*** |
| **McEnroe 93** | | |
| *k* | *2.82E-02* | *HOL* |
| *S* | *8.75%* | *(in)* |
| *q* | *2500* | *11.44* |

**McEnroe 1993 "Maximum Saturated Depth over Landfill Liner"**

*Journal of Environmental Engineering*

For Slope 1

$$y_{i+1} = y_i + \left(\tan\alpha_1 - \frac{r_1 x_i}{k_1 y_i \cos^2\alpha_1}\right)(x_{i+1} - x_i)$$

Fore Slopes 2 - 5

$$y_{i+1} = y_i + \left(\tan\alpha_j - \frac{\sum_{f=1}^{j-1} r_f L_f + r_j\left(x_i - \sum_{f=1}^{j-1} L_f\right)}{k_j y_i \cos^2\alpha_j}\right)(x_{i+1} - x_i)$$

Figure 3. Input and Output Sheet in the Head-on-Liner Calculation Spreadsheet

## EXAMPLE 1: Variance in Leachate Infiltration Rates

| INPUT PARAMETERS (dx=0.5 in) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Infiltration Rate (gpad)** | **Drainage Length (ft)** | **Slope** | **Combined k (cm/s)** | **Liquid Depth at Lowest Point (in)** | **Max Head-on-Liner (in)** |
| **Numerical Solution** | Slope 1 | 3,000 | 140 | 2.00% | 0.10 | - | 2.90 |
| | Slope 2 | 2,000 | 235 | 2.00% | 0.10 | - | 5.95 |
| | Slope 3 | 1,000 | 200 | 2.00% | 0.10 | - | 7.18 |
| | Slope 4 | 500 | 75 | 2.00% | 0.10 | - | 7.43 |
| | Slope 5 | 500 | 350 | 2.00% | 0.10 | 1.0 | 8.08 |
| | | | | | | **OVERALL** | 8.08 |
| **McEnroe 93 Method** | | 3,000 | 1,000 | 2.00% | 0.10 | free drain | 16.63 |

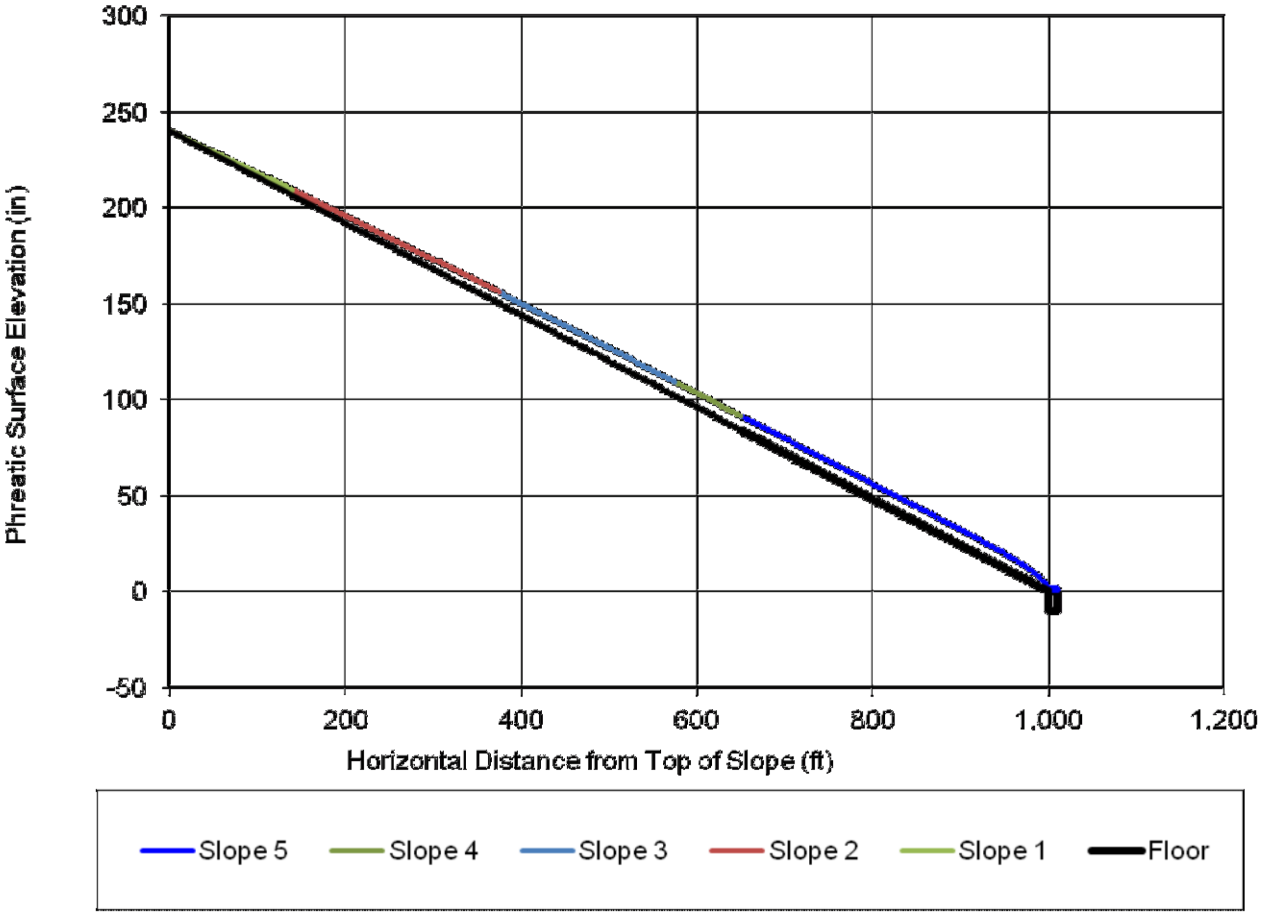


Figure 4. Design Example 1
Variance in Leachate Infiltration Rates

## EXAMPLE 2: Variance in Slopes

| INPUT PARAMETERS (dx=0.5 in) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Infiltration Rate (gpad) | Drainage Length (ft) | Slope | Combined k (cm/s) | Liquid Depth at Lowest Point (in) | Max Head-on-Liner (in) |
| **Numerical Solution** | Slope 1 | 3,000 | 140 | 20.00% | 0.10 | - | 0.83 |
| | Slope 2 | 3,000 | 235 | 12.00% | 0.10 | - | 1.48 |
| | Slope 3 | 3,000 | 200 | 10.00% | 0.10 | - | 12.28 |
| | Slope 4 | 3,000 | 75 | 2.00% | 0.10 | - | 13.82 |
| | Slope 5 | 3,000 | 350 | 2.00% | 0.10 | 1.0 | 16.64 |
| | | | | | | **OVERALL** | 16.64 |
| **McEnroe 93 Method** | | 3,000 | 1,000 | 2.00% | 0.10 | free drain | 16.63 |

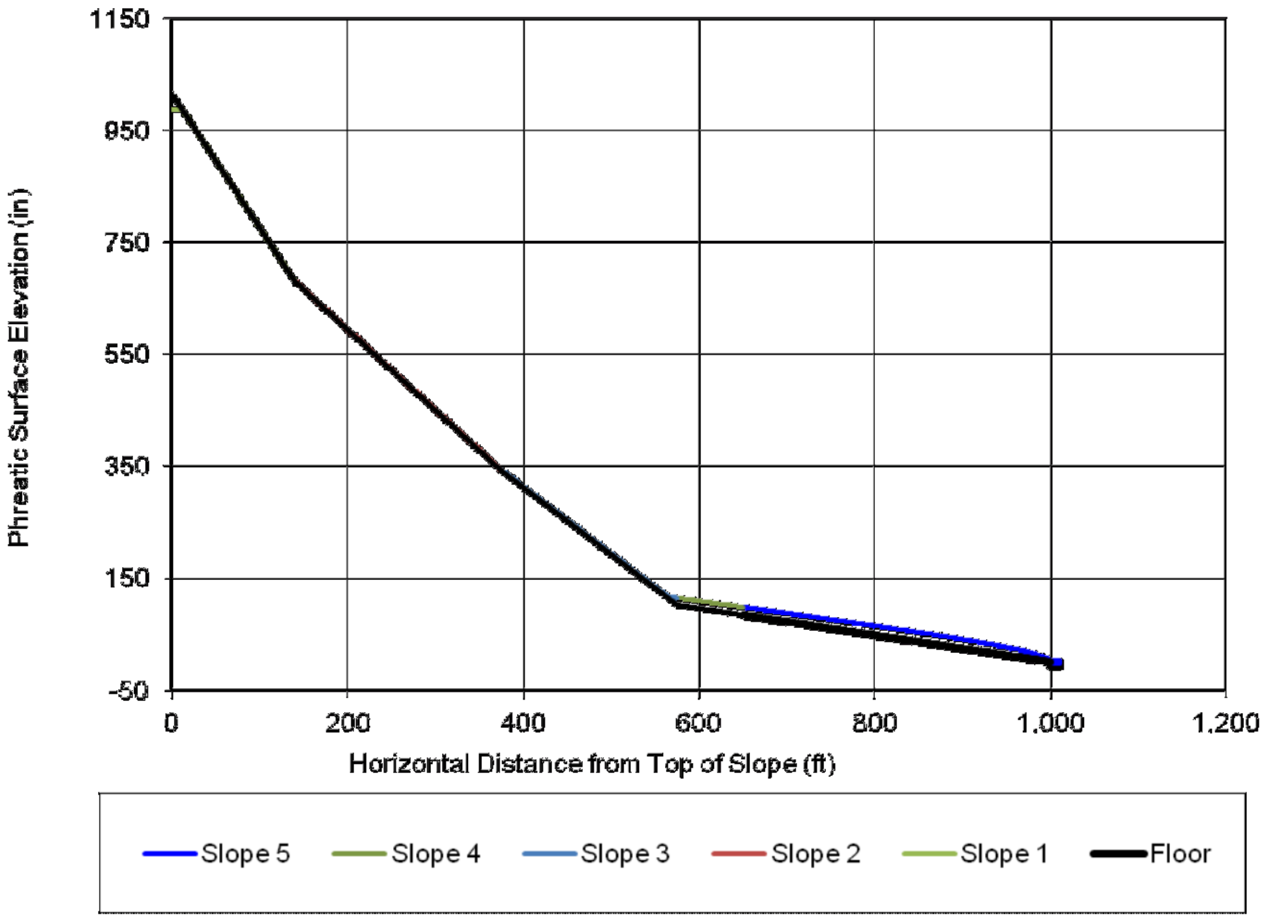


**Figure 5. Design Example 2**
**Variance in Slopes**

## EXAMPLE 3: Variance in Slopes and Leachate Infiltration Rates

**INPUT PARAMETERS (dx=0.5 in)**

| | | Infiltration Rate (gpad) | Drainage Length (ft) | Slope | Combined k (cm/s) | Liquid Depth at Lowest Point (in) | Max Head-on-Liner (in) |
|---|---|---|---|---|---|---|---|
| **Numerical Solution** | Slope 1 | 3,000 | 140 | 20.00% | 0.10 | - | 0.83 |
| | Slope 2 | 2,000 | 235 | 12.00% | 0.10 | - | 1.17 |
| | Slope 3 | 1,000 | 200 | 10.00% | 0.10 | - | 7.18 |
| | Slope 4 | 500 | 75 | 2.00% | 0.10 | - | 7.43 |
| | Slope 5 | 500 | 350 | 2.00% | 0.10 | 1.0 | 8.08 |
| | | | | | | **OVERALL** | 8.08 |
| **McEnroe 93 Method** | | 3,000 | 1,000 | 2.00% | 0.10 | free drain | 16.63 |

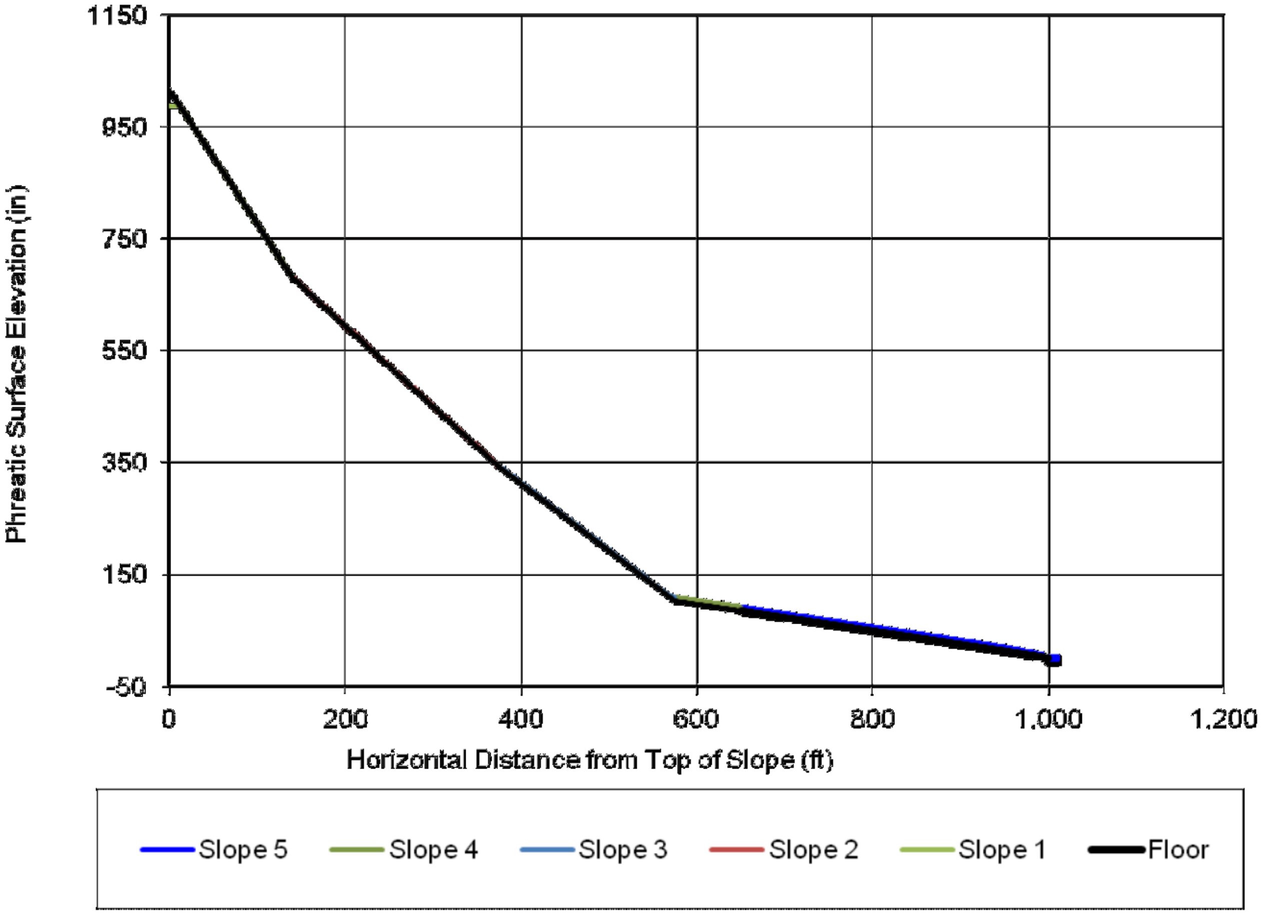


**Figure 6. Design Example 3**
**Variance in Leachate Infiltration Rates and Slopes**

## EXAMPLE 4: Variance in Combined Permeabilitiy

| INPUT PARAMETERS (dx=0.5 in) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Infiltration Rate (gpad) | Drainage Length (ft) | Slope | Combined k (cm/s) | Geonet Layer | Saturated Sand Thickness (in) | Liquid Depth at Lowest Point (in) | Max Head-on-Liner (in) |
| **Numerical Solution** | Slope 1 | 3,000 | 150 | 2.50% | 0.050 | no | - | - | 5.30 |
| | Slope 2 | 3,000 | 150 | 2.50% | 0.050 | no | - | - | 10.35 |
| | Slope 3 | 3,000 | 150 | 2.50% | 0.050 | no | - | - | 11.73 |
| | Slope 4 | 3,000 | 150 | 2.50% | 0.184 | yes | 6.00 | - | 5.84 |
| | Slope 5 | 3,000 | 150 | 2.50% | 0.166 | yes | 7.00 | 1.0 | 6.49 |
| | | | | | | | | **OVERALL** | 11.73 |
| **McEnroe 93 Method** | | 3,000 | 750 | 2.50% | 0.050 | | | free drain | 19.45 |

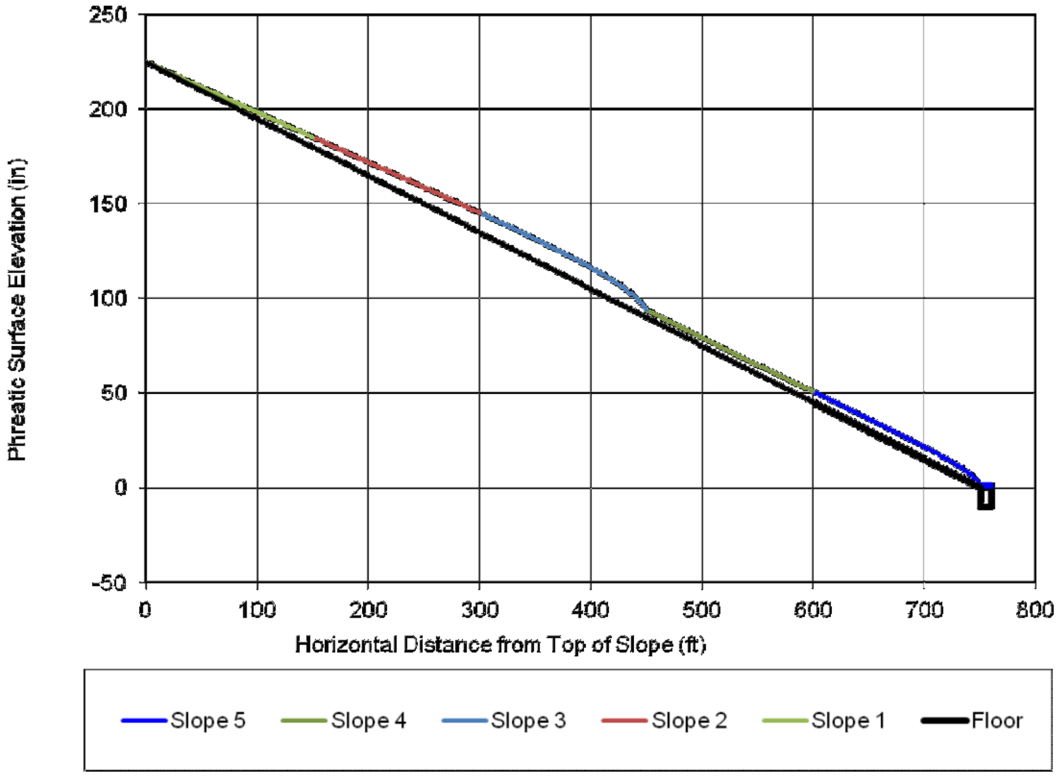


Figure 7. Design Example 4:
Variance in Combined Permeability (using geocomposite)

## EXAMPLE 5: Variance in Slopes, Leachate Infiltration Rates, and Combined Permeability

**INPUT PARAMETERS (dx=0.5 in)**

| | | Infiltration Rate (gpad) | Drainage Length (ft) | Slope | Combined k (cm/s) | Geonet Layer | Saturated Sand Thickness (in) | Liquid Depth at Lowest Point (in) | Max Head-on-Liner (in) |
|---|---|---|---|---|---|---|---|---|---|
| Numerical Solution | Slope 1 | 4,000 | 150 | 10.00% | 0.020 | no | - | - | 4.03 |
| | Slope 2 | 4,000 | 150 | 10.00% | 0.020 | no | - | - | 7.39 |
| | Slope 3 | 3,000 | 150 | 25.00% | 0.020 | no | - | - | 8.48 |
| | Slope 4 | 2,000 | 150 | 2.50% | 0.103 | yes | 10.00 | - | 10.15 |
| | Slope 5 | 500 | 300 | 2.50% | 0.101 | yes | 10.30 | 1.0 | 10.48 |
| | | | | | | | | **OVERALL** | 10.48 |
| **McEnroe 93 Method** | | 4,000 | 900 | 2.50% | 0.020 | | | free drain | 64.99 |

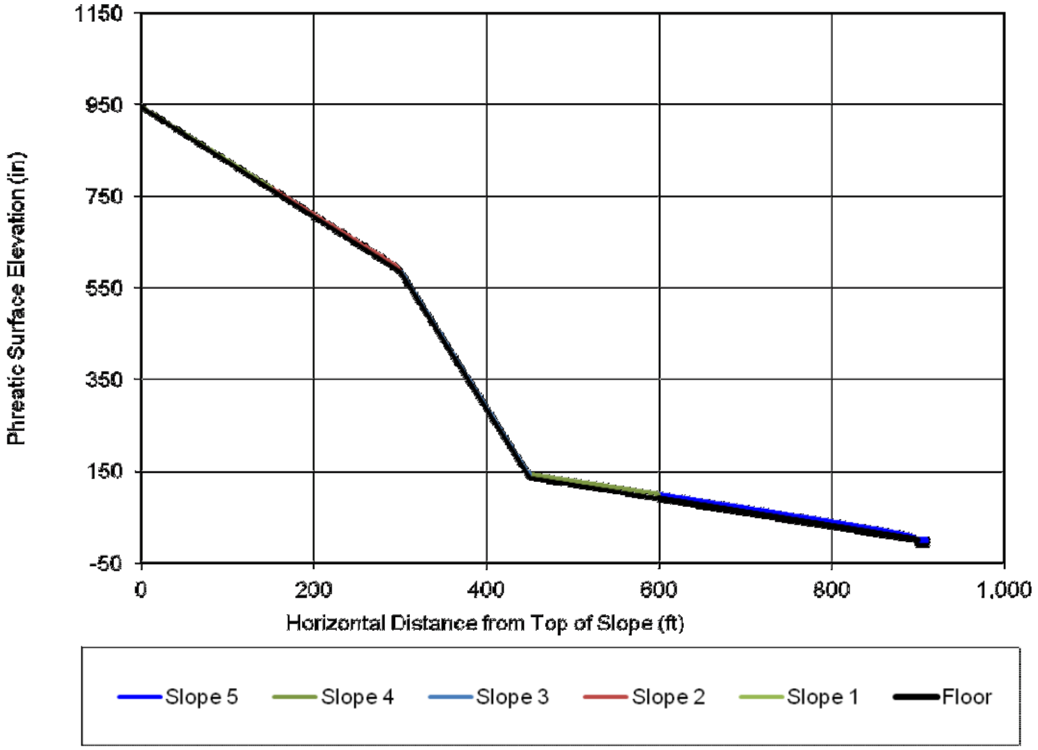


**Figure 8. Design Example 5:**
**Variance in Slopes, Leachate Infiltration Rates, and Combined Permeability**

## EXAMPLE 6: No Resisted Trench (free drain condition is not satisfied)

| INPUT PARAMETERS (dx=0.5 in) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Infiltration Rate (gpad) | Drainage Length (ft) | Slope | Combined k (cm/s) | Geonet Layer | Saturated Sand Thickness (in) | Liquid Depth at Lowest Point (in) | Max Head-on-Liner (in) |
| Numerical Solution | Slope 1 | 3,000 | 100 | 2.00% | 0.661 | yes | 1.00 | - | 0.96 |
| | Slope 2 | 3,000 | 100 | 2.00% | 0.248 | yes | 3.79 | - | 3.94 |
| | Slope 3 | 3,000 | 100 | 2.00% | 0.120 | yes | 7.72 | - | 7.89 |
| | Slope 4 | 3,000 | 100 | 2.00% | 0.095 | yes | 10.22 | - | 10.39 |
| | Slope 5 | 3,000 | 100 | 2.00% | 0.078 | yes | 10.63 | 9.0 | 10.74 |
| | | | | | | | | OVERALL | 10.74 |
| McEnroe 93 Method | | 3,000 | 500 | 2.00% | 0.078 | | | free drain+superposition | 19.39 |

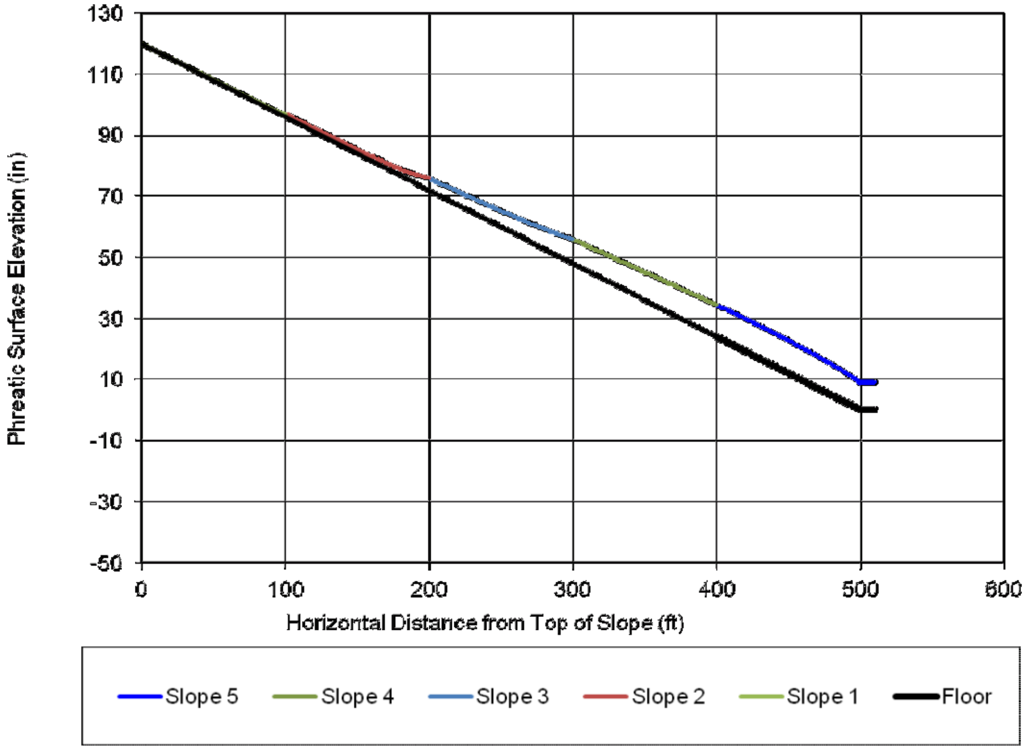


Figure 9. Design Example 6:
Free drain condition is not satisfied

# A-2.4: NTH 2012, Leachate Generation Estimation and Head Calculation

NTH Consultants, Ltd.

# CALCULATION PACKAGE COVER SHEET

**PROJECT NO.:** 13-060921-03 **CALCULATION PACKAGE NO.**

**PROJECT NAME:** WDI MC VI F/G Development

**PREPARED BY:** David R. Lutz / CHRIS W. SUTTON **DATE:** 2/15/11 / REV. 09/14/11

**CHECKED BY:** Robb B. Moore / CORINA M. TROMMER **DATE:** 2/22/11 / Rev. 09/14/11

**QC BY:** Ibraheem Shumar **DATE:** 3/4/11 – 9/16/11

**SUBJECT:** Leachate Generation Estimation and Head Calculation

## CONTENTS

| | DESCRIPTION |
|---|---|
| **PURPOSE:** | To estimate the leachate generation with HELP model and the maximum leachate head on the bottom liner using the Mound Model for the proposed developement. |
| **REFERENCES:** | Qian, X. D. Gray, D.H., and Koerner, R.M. (2004). "Estimation of Maximum Liquid Head over Landfill Barrier." J. Geotechnical & Environmental Engineering 130(5), 488-497. |
| **ASSUMPTIONS:** | See Attached Calculation Package |
| **INPUT DATA:** | See Attached Calculation Package |
| **RELEVANT CPs:** | N/A |
| **RESULTS:** | See Attached Calculation Package |

| | | |
|---|---|---|
| **Job: WDI MC VI-F/G Development** | **Project No.:13-060921-03** | **Page 1** |
| **Subject: Leachate Generation Estimation and** | **By: DRL/CWS** | **Date: 2/15/11 /<br>Rev. 9/14/11** |
| **Head Calculation** | **Chk. by: RBM/CMT** | **Date: 2/22/11 /<br>Rev. 9/14/11** |

## I. PURPOSE

The purpose of this calculation is to estimate leachate generation and maximum leachate head on the liner system. Leachate generation estimation is completed using the HELP model. The maximum leachate head on the bottom liner is estimate using the mound model for the proposed development.

## II. BACKGROUND

The proposed liner system is a double composite liner that consists of the following layers from top down:

1) 12-inch sand layer (with $K \geq 1x10^{-2}$ cm/sec);
2) Double-sided geocomposite;
3) 80-mil textured HDPE primary liner;
4) 5-foot of compacted clay (with $K \leq 1x10^{-7}$ cm/sec);
5) Double-sided geocomposite;
6) 80-mil textured HDPE secondary liner; and
7) 3- foot of compacted clay (with $K \leq 1x10^{-7}$ cm/sec)

The final cover consists of the following components, from the top down: (1) 36-inch vegetative/protective soil layer; (2) Double-sided geocomposite drainage layer; (3) 40-mil HDPE geomembrane liner; and (4) Geosynthetic Clay Liner (GCL).

Per Part 111 Rule 299.9619, "a leachate head of no more than 30 centimeters (12 inches) on the liner" is allowed. The two-layer drainage system, including 1-foot sand layer and 200-mil geocomposite, will convey leachate to the leachate collection piping to maintain less than 1-foot of leachate on the liner.

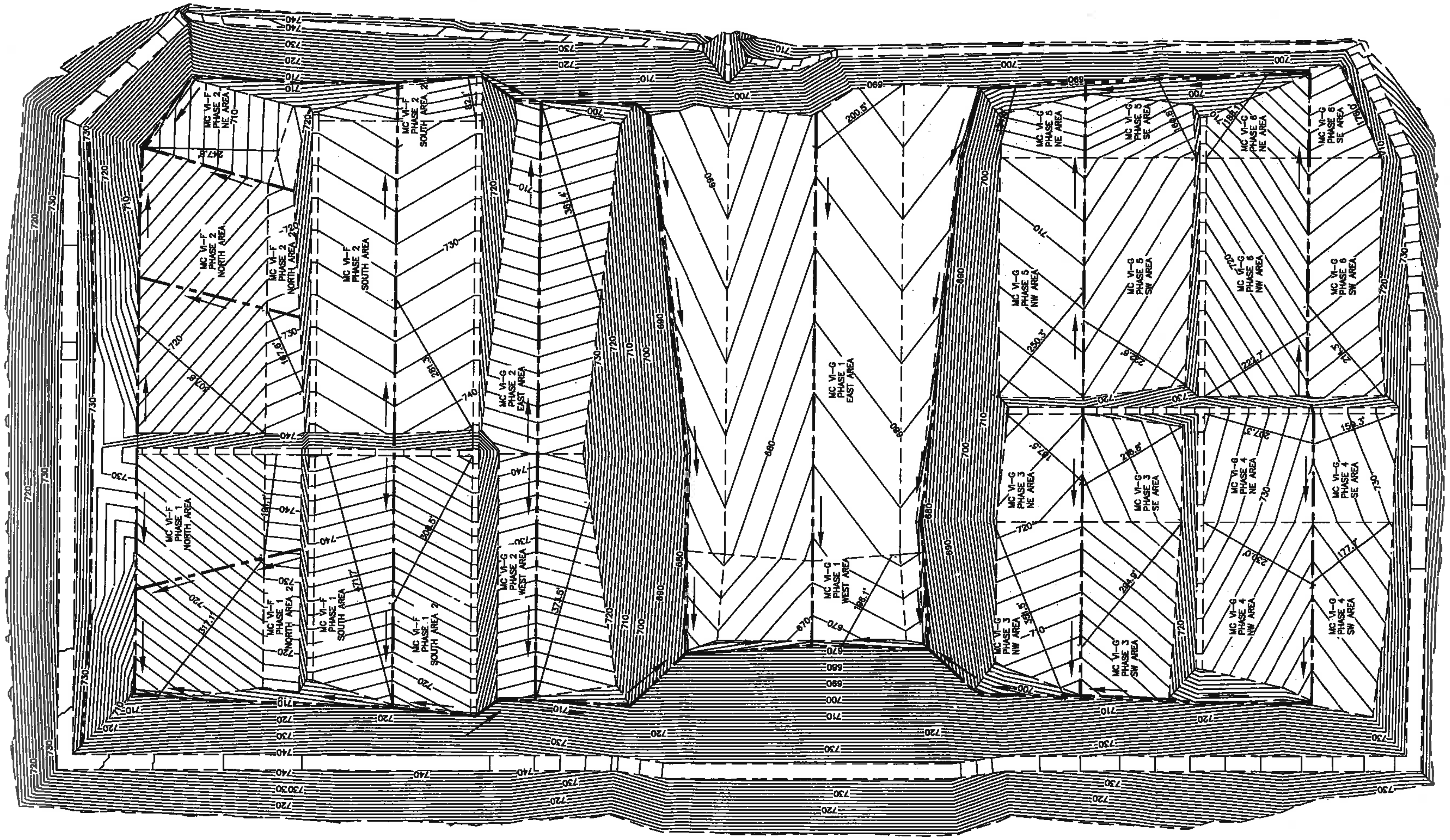
## III. APPROACH

The HELP (Hydrologic Evaluation of Landfill Performance) model was used to estimate the leachate generation collected in the leachate collection system. The proposed development area was divided into several areas as shown on page 2. The floor grades, pipe slope grades, and drainage lengths are summarized on Table 1. The leachate generation during filling operations were analyzed for each area. The most critical areas of the development were analyzed for leachate generation during the post-closure system.

The method presented in Reference 1 (Qian, et al, 2004) was used to perform the leachate head mounding calculation. The leachate generation rate estimated with HELP model for each area was used as vertical inflow rate in the mound calculation.

Pg 2
← N
1"=200'

Rev. 09/14/11



J:\13\13060921\library\6 f-g development\mound model 2-2011.dwg

## TABLE 1
## PROPOSED LANDFILL AREAS

| Area | Base Grade ($S_1$) % | Pipe Grade ($S_2$) % | Composite Floor Slope % | Drainage Length Perpendicular to Slope (L) ft |
|---|---|---|---|---|
| MC VI-F Phase 1 South Area | 2.0% | 7.7% | 8.0% | 472 |
| MC VI-F Phase 1 South Area 2 | 4.0% | 7.7% | 8.7% | 309 |
| MC VI-F Phase 1 North Area | 9.6% | 0.0% | 9.6% | 317 |
| MC VI-F Phase 1 North Area 2 | 7.7% | 0.0% | 7.7% | 191 |
| MC VI-F Phase 2 South Area | 2.0% | 3.4% | 3.9% | 281 |
| MC VI-F Phase 2 South Area 2 | 10.9% | 0.0% | 10.9% | 82 |
| MC VI-F Phase 2 NE Area | 7.4% | 0.0% | 7.4% | 248 |
| MC VI-F Phase 2 North Area | 7.9% | 0.0% | 7.9% | 308 |
| MC VI-F Phase 2 North Area 2 | 5.6% | 0.0% | 5.6% | 168 |
| MC VI-G Phase 1 East Area | 2.0% | 1.5% | 2.5% | 201 |
| MC VI-G Phase 1 West Area | 2.0% | 3.3% | 3.9% | 196 |
| MC VI-G Phase 2 West Area | 2.0% | 7.6% | 7.9% | 374 |
| MC VI-G Phase 2 East Area | 2.0% | 6.6% | 6.9% | 381 |
| MC VI-G Phase 3 NE Area | 2.0% | 1.8% | 2.7% | 188 |
| MC VI-G Phase 3 NW Area | 2.0% | 5.0% | 5.4% | 352 |
| MC VI-G Phase 3 SE Area | 4.0% | 1.8% | 4.4% | 217 |
| MC VI-G Phase 3 SW Area | 4.0% | 5.0% | 6.4% | 295 |
| MC VI-G Phase 4 NE Area | 5.5% | 1.5% | 5.7% | 207 |
| MC VI-G Phase 4 NW Area | 5.5% | 3.1% | 6.3% | 230 |
| MC VI-G Phase 4 SE Area | 4.0% | 1.5% | 4.3% | 177 |
| MC VI-G Phase 4 SW Area | 4.0% | 3.1% | 5.1% | 208 |
| MC VI-G Phase 5 NE Area | 2.0% | 8.0% | 8.2% | 166 |
| MC VI-G Phase 5 NW Area | 2.0% | 2.5% | 3.2% | 250 |
| MC VI-G Phase 5 SE Area | 4.0% | 8.0% | 8.9% | 191 |
| MC VI-G Phase 5 SW Area | 4.0% | 2.5% | 4.7% | 223 |
| MC VI-G Phase 6 NE Area | 5.8% | 6.1% | 8.4% | 180 |
| MC VI-G Phase 6 NW Area | 5.8% | 3.7% | 6.9% | 223 |
| MC VI-G Phase 6 SE Area | 3.0% | 6.1% | 6.8% | 166 |
| MC VI-G Phase 6 SW Area | 3.0% | 3.7% | 4.8% | 258 |

## IV. INPUT DATA

The landfill configurations used in HELP model for filling and post closure cases are listed on Table 2. The input data used in the HELP model is summarized in Table 3. In addition to the data shown on Table 1, a geocomposite with hydraulic conductivity of 12.2 mm/sec was used in the leachate head calculation.

**TABLE 2**
**LANDFILL CONFIGURATION FOR HELP MODEL**

| | | Filling Period | Post Closure |
|---|---|---|---|
| Layer No. | Materials | Thickness (in.) | |
| 1 | Vegetative/Protective Soil | N/A | 36 |
| 2 | Geocomposite | N/A | 0.2 |
| 3 | HDPE Geomembrane | N/A | 0.04 |
| 4 | GCL | N/A | 0.36 |
| 5 | Waste | 120* | 2,005/1,064** |
| 6 | Sand | 12 | 12 |
| 7 | Geocomposite | 0.20 | 0.20 |
| 8 | HDPE Geomembrane | 0.08 | 0.08 |
| 9 | Compacted Clay Liner | 60 | 60 |
| 10 | Geocomposite | 0.20 | 0.20 |
| 11 | HDPE Geomembrane | 0.08 | 0.08 |
| 12 | Compacted Clay Liner | 36 | 36 |

* 10 feet of waste for peak leachate generation

** Maximum Final waste thickness for 4 % area. 2/3 of maximum final waste thickness for 25% area.

TABLE 3
INPUT DATA FOR HELP MODEL

| | Filling Period | Post Closure Period |
|---|---|---|
| Total Area (acre) | 1 | 1 |
| Area Allowing Runoff (%) | 0 | 100 |
| Surface Slope (%) | See Table 1 | 4 / 25 |
| Surface Slope Length (ft) | See Table 1 | 375/250 |
| Surface Condition | Bare Ground | Fair Grass |
| Max. Leaf Area Index | 0 | 4 |
| Evaporative Zone Depth (in.) | 6 | 20 |
| Drainage Length in Liner (ft) | See Table 1 | 200/ 166 |
| Drainage Slope in Liner (%) | See Table 1 | 2.5/ 8.2 |

## V. CALCULATIONS

The results of the HELP model estimated leachate generation are summarized in Table 4. The HELP model output files are attached in Appendix A.

A spreadsheet program was used to estimate the leachate head on the liner. The spreadsheet was developed by Qian based on his methodology presented in Reference 1. The spreadsheets are attached in Appendix B. The estimated leachate head for each area is summarized in Table 5. As shown in Table 5, the maximum leachate head over the liner for each area in the development is less than the 30 cm (12 in.) requirement of R299.9619.

TABLE 4
HELP MODEL SUMMARY TABLE

| Area | Average Peak Daily Leachate Generation (Active Filling) (in) | Average Annual Leachate Generation (Active Filling) (in) | Average Peak Daily Leachate Generation (Post Closure) (in) | Average Annual Leachate Generation (Post Closure) (in) |
|---|---|---|---|---|
| MC VI-F Phase 1 South Area | 0.27 | 15.8 | Insignificant | Insignificant |
| MC VI-F Phase 1 South Area 2 | 0.37 | | | |
| MC VI-F Phase 1 North Area | 0.37 | | | |
| MC VI-F Phase 1 North Area 2 | 0.39 | | | |
| MC VI-F Phase 2 South Area | 0.23 | | | |
| MC VI-F Phase 2 South Area 2 | 0.34 | | | |
| MC VI-F Phase 2 NE Area | 0.37 | | | |
| MC VI-F Phase 2 North Area | 0.36 | | | |
| MC VI-F Phase 2 North Area 2 | 0.38 | | | |
| MC VI-G Phase 1 East Area | 0.21 | | | |
| MC VI-G Phase 1 West Area | 0.32 | | | |
| MC VI-G Phase 2 West Area | 0.33 | | | |
| MC VI-G Phase 2 East Area | 0.29 | | | |
| MC VI-G Phase 3 NE Area | 0.24 | | | |
| MC VI-G Phase 3 NW Area | 0.25 | | | |
| MC VI-G Phase 3 SE Area | 0.31 | | | |
| MC VI-G Phase 3 SW Area | 0.32 | | | |
| MC VI-G Phase 4 NE Area | 0.36 | | | |
| MC VI-G Phase 4 NW Area | 0.36 | | | |
| MC VI-G Phase 4 SE Area | 0.35 | | | |
| MC VI-G Phase 4 SW Area | 0.35 | | | |
| MC VI-G Phase 5 NE Area | 0.36 | | | |
| MC VI-G Phase 5 NW Area | 0.21 | | | |
| MC VI-G Phase 5 SE Area | 0.40 | | | |
| MC VI-G Phase 5 SW Area | 0.32 | | | |
| MC VI-G Phase 6 NE Area | 0.39 | | | |
| MC VI-G Phase 6 NW Area | 0.37 | | | |
| MC VI-G Phase 6 SE Area | 0.38 | | | |
| MC VI-G Phase 6 SW Area | 0.30 | | | |

**TABLE 5**
**LEACHATE HEAD CALCULATION SUMMARY**

| Area | Maximum Head On Liner (in) |
|---|---|
| MC VI-F Phase 1 South Area | 6.6 |
| MC VI-F Phase 1 South Area 2 | 1.3 |
| MC VI-F Phase 1 North Area | 0.8 |
| MC VI-F Phase 1 North Area 2 | 0.3 |
| MC VI-F Phase 2 South Area | 4.8 |
| MC VI-F Phase 2 South Area 2 | 0.1 |
| MC VI-F Phase 2 NE Area | 0.8 |
| MC VI-F Phase 2 North Area | 2.2 |
| MC VI-F Phase 2 North Area 2 | 0.5 |
| MC VI-G Phase 1 East Area | 3.8 |
| MC VI-G Phase 1 West Area | 3.8 |
| MC VI-G Phase 2 West Area | 5.0 |
| MC VI-G Phase 2 East Area | 5.7 |
| MC VI-G Phase 3 NE Area | 3.5 |
| MC VI-G Phase 3 NW Area | 5.7 |
| MC VI-G Phase 3 SE Area | 3.2 |
| MC VI-G Phase 3 SW Area | 2.9 |
| MC VI-G Phase 4 NE Area | 1.2 |
| MC VI-G Phase 4 NW Area | 1.3 |
| MC VI-G Phase 4 SE Area | 2.0 |
| MC VI-G Phase 4 SW Area | 2.2 |
| MC VI-G Phase 5 NE Area | 0.2 |
| MC VI-G Phase 5 NW Area | 4.7 |
| MC VI-G Phase 5 SE Area | 0.3 |
| MC VI-G Phase 5 SW Area | 3.2 |
| MC VI-G Phase 6 NE Area | 0.3 |
| MC VI-G Phase 6 NW Area | 0.7 |
| MC VI-G Phase 6 SE Area | 0.3 |
| MC VI-G Phase 6 SW Area | 4.6 |

Based on R299.9619, a minimum transmissivity (T) of $3.0 * 10^{-5}$ $m^2/s$ for geonet should be utilized. Typical geocomposite has a thickness of 200 mils or 5 mm. As stated earlier, the geocomposite hydraulic conductivity for the proposed development is 12.2 mm/sec. The ultimate hydraulic transmissivity is calculated as:

ultimate hydraulic transmissivity = hydraulic conductivity * thickness

$$= 12.2 \text{ mm/sec} * 5 \text{ mm} * (1 \text{ m}^2 / 1 * 10^6 \text{ mm}^2) = 6.1 * 10^{-5} \text{ m}^2/\text{s} > 3.0 * 10^{-5} \text{ m}^2/\text{s} \ \underline{\text{OK}}.$$

By using the factors of safety of 1.75, 1.5, and 1.5 to account for creep, chemical clogging, and biological clogging, respectively (recommended by Koerner in his book, Design with Geosynthetics), the measured hydraulic transmissivity can be calculated as

$$\text{allowable hydraulic transmissivity} = 6.1*10^{-5}*(1.75*1.5*1.5) = 2.4*10^{-4} \text{ m}^2/\text{s}.$$

Based on NTH's experience with the use of the HELP model to simulate landfill leachate generation, the maximum leachate generation occurs at an approximate waste height of 10 feet. The higher the waste height, the lower the leachate generation rate. Thus, assuming 10 feet of waste and a unit weight of 111 pcf for the waste, the overburden pressure on the drainage layer is:

(111 pcf)(10 ft) = 1,110 psf

## VI. RESULTS & CONCLUSIONS

The results of the HELP modeling indicates that for any area of the development, the maximum estimated peak daily and average annual leachate generation rates during active filling is 0.40 in/day and 15.81 in., respectively. Both the peak daily and average annual leachate generation rate during post closure is estimated to be insignificant. The leachate head calculation estimated that the leachate head on the liner is less than 12 inches for each area of the development. Using a 200 mil geocomposite, with a transmissivity greater than or equal to $2.4*10^{-4}$ $m^2/s$ under a gradient of 2.5% and under an overburden pressure of 1,110 psf.

# APPENDIX A

## Help Model Output Files

```
▯
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP2S-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP2S-F.OUT


TIME:   9:22     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P1 S AREA

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


     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   5
          THICKNESS                    =   120.00   INCHES
          POROSITY                     =     0.4570 VOL/VOL
          FIELD CAPACITY               =     0.1310 VOL/VOL
          WILTING POINT                =     0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT   =     0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
               MATERIAL TEXTURE NUMBER   0
THICKNESS                  =     12.00   INCHES
POROSITY                   =      0.4170 VOL/VOL
FIELD CAPACITY             =      0.0450 VOL/VOL
WILTING POINT              =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999978000E-02 CM/SEC


                         LAYER  3
                         --------

            TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      0.20   INCHES
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.  =   1.22000003000     CM/SEC
SLOPE                      =      8.00   PERCENT
DRAINAGE LENGTH            =    472.0    FEET


                         LAYER  4
                         --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                  =      0.08   INCHES
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.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD


                         LAYER  5
                         --------

              TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                  =     60.00   INCHES
POROSITY                   =      0.4270 VOL/VOL
FIELD CAPACITY             =      0.4180 VOL/VOL
WILTING POINT              =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000001000E-06 CM/SEC


                         LAYER  6
                         --------
```

```
               TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =      0.20    INCHES
 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.    =    1.22000003000     CM/SEC
 SLOPE                        =      8.00    PERCENT
 DRAINAGE LENGTH              =    472.0     FEET


                          LAYER  7
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
 THICKNESS                    =      0.08    INCHES
 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.    =  0.199999996000E-12 CM/SEC
 FML PINHOLE DENSITY          =      1.00    HOLES/ACRE
 FML INSTALLATION DEFECTS     =      1.00    HOLES/ACRE
 FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  8
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
 THICKNESS                    =     36.00    INCHES
 POROSITY                     =      0.4270 VOL/VOL
 FIELD CAPACITY               =      0.4180 VOL/VOL
 WILTING POINT                =      0.3670 VOL/VOL
 INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  8.% AND
          A SLOPE LENGTH OF  472. FEET.

 SCS RUNOFF CURVE NUMBER             =     83.70
 FRACTION OF AREA ALLOWING RUNOFF    =      0.0     PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE  =      1.000   ACRES
 EVAPORATIVE ZONE DEPTH              =      6.0     INCHES
 INITIAL WATER IN EVAPORATIVE ZONE   =      2.742   INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.742   INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =     0.348  INCHES
INITIAL SNOW WATER                  =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =    70.838  INCHES
TOTAL INITIAL WATER                 =    70.838  INCHES
TOTAL SUBSURFACE INFLOW             =     0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DETROIT                MICHIGAN

     STATION LATITUDE                           =  42.40 DEGREES
     MAXIMUM LEAF AREA INDEX                    =   0.00
     START OF GROWING SEASON (JULIAN DATE)      =    121
     END OF GROWING SEASON (JULIAN DATE)        =    286
     EVAPORATIVE ZONE DEPTH                     =   6.0  INCHES
     AVERAGE ANNUAL WIND SPEED                  =  10.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  73.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  71.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  75.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.86         1.69         2.54         3.15         2.77         3.43
  3.10         3.21         2.25         2.12         2.33         2.52


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 23.40        25.80        35.00        47.40        58.10        67.70
 71.90        70.50        63.30        51.90        39.50        28.50


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN
            AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
                                  6FP2S-F
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    5
-------------------------------------------------------------------------------

                             JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                             -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                      1.75     1.67     2.39     4.10     3.71     4.04
                               2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS             0.61     0.62     1.28     1.20     1.61     1.04
                               1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                     0.000    0.000    0.000    0.000    0.000    0.000
                              0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS            0.000    0.000    0.000    0.000    0.000    0.000
                              0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                     0.428    0.393    0.386    1.823    2.687    3.000
                              2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS            0.101    0.092    0.159    0.777    0.797    0.675
                              1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                    0.8809   0.8744   1.0510   2.3689   3.3001   1.7608
                             1.3843   1.0825   1.0390   0.8439   0.6817   0.5273

   STD. DEVIATIONS           0.6165   0.2239   0.5607   1.7222   0.8071   0.6199
                             0.6661   0.1977   0.7371   0.2752   0.0880   0.1668

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                   AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                   0.0244    0.0267    0.0291    0.3593    0.1194    0.0504
                               0.0383    0.0300    0.0297    0.0234    0.0195    0.0146

    STD. DEVIATIONS            0.0171    0.0071    0.0155    0.5742    0.0772    0.0177
                               0.0184    0.0055    0.0211    0.0076    0.0025    0.0046

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                   0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                               0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    STD. DEVIATIONS            0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                               0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                        INCHES            CU. FEET      PERCENT
                                  -------------------  -------------  ---------
 PRECIPITATION                      32.34    (   3.821)    117387.0     100.00

 RUNOFF                              0.000   (  0.0000)         0.00     0.000

 EVAPOTRANSPIRATION                 17.213   (  1.6298)     62481.79    53.227

 LATERAL DRAINAGE COLLECTED         15.79483 (  3.88242)    57335.223   48.84293
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH         0.00003 (  0.00002)        0.101    0.00009
   LAYER  5

 AVERAGE HEAD ON TOP                 0.064 (    0.053)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED          0.00003 (  0.00002)        0.092   0.00008
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH         0.00000 (  0.00000)        0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP                 0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE            -0.669   (  2.0888)     -2430.21    -2.070
*******************************************************************************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******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
  PRECIPITATION                                  2.56        9292.800

  RUNOFF                                         0.000          0.0000

  DRAINAGE COLLECTED FROM LAYER  3               0.27128      984.74115

  PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000004       0.01359

  AVERAGE HEAD ON TOP OF LAYER  4                4.213

  MAXIMUM HEAD ON TOP OF LAYER  4                7.947

  LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                  24.0 FEET

  DRAINAGE COLLECTED FROM LAYER  6               0.00000        0.01345

  PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000       0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                0.182

  LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                   0.0 FEET

  SNOW WATER                                     3.28        11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580


   ***  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.

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



▯
***********************************************************************************

                 FINAL WATER STORAGE AT END OF YEAR    5
------------------------------------------------------------------------
                 LAYER        (INCHES)       (VOL/VOL)
                 -----        --------       ---------
                   1          25.2346         0.2103

                   2           1.2512         0.1043

                   3           0.0104         0.0519
```

```
            4              0.0000            0.0000

            5             25.6200            0.4270

            6              0.0020            0.0100

            7              0.0000            0.0000

            8             15.3720            0.4270

        SNOW WATER         0.000

**********************************************************************************
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```

```
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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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP2S2-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP2S2-F.OUT


TIME:   9:27     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F P1 SOUTH 2

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


     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   5
          THICKNESS                  =    120.00   INCHES
          POROSITY                   =      0.4570 VOL/VOL
          FIELD CAPACITY             =      0.1310 VOL/VOL
          WILTING POINT              =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =       12.00    INCHES
POROSITY                      =        0.4170 VOL/VOL
FIELD CAPACITY                =        0.0450 VOL/VOL
WILTING POINT                 =        0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT    =        0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   0.999999978000E-02 CM/SEC


                         LAYER  3
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =        0.20    INCHES
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.     =    1.22000003000      CM/SEC
SLOPE                         =        8.70    PERCENT
DRAINAGE LENGTH               =      309.0     FEET


                         LAYER  4
                         --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                     =        0.08    INCHES
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.     =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =        1.00    HOLES/ACRE
FML INSTALLATION DEFECTS      =        1.00    HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                         LAYER  5
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                     =       60.00    INCHES
POROSITY                      =        0.4270 VOL/VOL
FIELD CAPACITY                =        0.4180 VOL/VOL
WILTING POINT                 =        0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT    =        0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   0.100000001000E-06 CM/SEC


                         LAYER  6
                         --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                        =       0.20    INCHES
   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.        =    1.22000003000     CM/SEC
   SLOPE                            =       8.70    PERCENT
   DRAINAGE LENGTH                  =     309.0     FEET


                            LAYER  7
                            --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
   THICKNESS                        =       0.08    INCHES
   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.        =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY              =       1.00    HOLES/ACRE
   FML INSTALLATION DEFECTS         =       1.00    HOLES/ACRE
   FML PLACEMENT QUALITY            =  3 - GOOD


                            LAYER  8
                            --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
   THICKNESS                        =      36.00    INCHES
   POROSITY                         =       0.4270 VOL/VOL
   FIELD CAPACITY                   =       0.4180 VOL/VOL
   WILTING POINT                    =       0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT       =       0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.        =  0.100000001000E-06 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  9.% AND
          A SLOPE LENGTH OF  309. FEET.

 SCS RUNOFF CURVE NUMBER              =      84.10
 FRACTION OF AREA ALLOWING RUNOFF     =       0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE   =       1.000  ACRES
 EVAPORATIVE ZONE DEPTH               =       6.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE    =       2.742  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE   =       2.742  INCHES
```

```
      LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
      INITIAL SNOW WATER                  =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
      TOTAL INITIAL WATER                 =     70.838  INCHES
      TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DETROIT                MICHIGAN

         STATION LATITUDE                         = 42.40 DEGREES
         MAXIMUM LEAF AREA INDEX                  =  0.00
         START OF GROWING SEASON (JULIAN DATE)    =   121
         END OF GROWING SEASON (JULIAN DATE)      =   286
         EVAPORATIVE ZONE DEPTH                   =  6.0  INCHES
         AVERAGE ANNUAL WIND SPEED                = 10.20 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY    = 73.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY    = 67.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY    = 71.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY    = 75.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT             MICHIGAN

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
      1.86        1.69        2.54        3.15        2.77        3.43
      3.10        3.21        2.25        2.12        2.33        2.52


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT             MICHIGAN

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
     23.40       25.80       35.00       47.40       58.10       67.70
     71.90       70.50       63.30       51.90       39.50       28.50


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT             MICHIGAN
                  AND STATION LATITUDE  =  42.40 DEGREES




*******************************************************************************
```

```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                              JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                              -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                       1.75     1.67     2.39     4.10     3.71     4.04
                                2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS              0.61     0.62     1.28     1.20     1.61     1.04
                                1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                       0.000    0.000    0.000    0.000    0.000    0.000
                                0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS              0.000    0.000    0.000    0.000    0.000    0.000
                                0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                       0.428    0.393    0.386    1.823    2.687    3.000
                                2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS              0.101    0.092    0.159    0.777    0.797    0.675
                                1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                       0.8857   0.8756   1.0577   2.3821   3.2897   1.7535
                                1.3828   1.0849   1.0350   0.8429   0.6802   0.5255

   STD. DEVIATIONS              0.6170   0.2241   0.5657   1.7042   0.7918   0.6342
                                0.6643   0.2034   0.7360   0.2720   0.0871   0.1734

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                    AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0148   0.0161   0.0177   0.0468   0.0549   0.0302
                              0.0231   0.0181   0.0178   0.0141   0.0117   0.0088

    STD. DEVIATIONS           0.0103   0.0043   0.0094   0.0418   0.0132   0.0109
                              0.0111   0.0034   0.0127   0.0045   0.0015   0.0029

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET       PERCENT
                                -------------------  -------------    ---------
 PRECIPITATION                   32.34    (   3.821)    117387.0       100.00

 RUNOFF                           0.000   (  0.0000)         0.00        0.000

 EVAPOTRANSPIRATION              17.213   (  1.6298)     62481.79       53.227

 LATERAL DRAINAGE COLLECTED      15.79552 (  3.88690)    57337.754    48.84508
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)        0.048      0.00004
   LAYER  5

 AVERAGE HEAD ON TOP              0.023 (    0.006)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00001 (  0.00000)        0.039     0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.009      0.00001
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.670   (  2.0890)     -2432.65      -2.072
*******************************************************************************


□
******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                (INCHES)     (CU. FT.)
                                               ----------  -------------
  PRECIPITATION                                  2.56        9292.800

  RUNOFF                                         0.000          0.0000

  DRAINAGE COLLECTED FROM LAYER  3               0.36814     1336.35925

  PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000001       0.00356

  AVERAGE HEAD ON TOP OF LAYER  4                1.047

  MAXIMUM HEAD ON TOP OF LAYER  4                1.880

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                    5.4 FEET

  DRAINAGE COLLECTED FROM LAYER  6               0.00000        0.00222

  PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000       0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                0.046

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                    0.0 FEET

  SNOW WATER                                     3.28       11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580

   ***  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.

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



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

               FINAL WATER STORAGE AT END OF YEAR    5
------------------------------------------------------------------------
                LAYER        (INCHES)        (VOL/VOL)
                -----        --------        ---------
                  1           25.2346          0.2103

                  2            1.2512          0.1043

                  3            0.0070          0.0351
```

```
                 4            0.0000          0.0000

                 5           25.6200          0.4270

                 6            0.0020          0.0100

                 7            0.0000          0.0000

                 8           15.3720          0.4270

            SNOW WATER        0.000

***************************************************************************
***************************************************************************
```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP2N-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP2N-F.OUT


TIME:   9:32     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F P1 N Area

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


     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   5
          THICKNESS                    =     120.00   INCHES
          POROSITY                     =       0.4570 VOL/VOL
          FIELD CAPACITY               =       0.1310 VOL/VOL
          WILTING POINT                =       0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4170 VOL/VOL
FIELD CAPACITY               =       0.0450 VOL/VOL
WILTING POINT                =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                         LAYER  3
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.20    INCHES
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.    =   1.22000003000      CM/SEC
SLOPE                        =       9.60    PERCENT
DRAINAGE LENGTH              =     317.0     FEET


                         LAYER  4
                         --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.08    INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                         LAYER  5
                         --------

                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
THICKNESS                    =      60.00    INCHES
POROSITY                     =       0.4270 VOL/VOL
FIELD CAPACITY               =       0.4180 VOL/VOL
WILTING POINT                =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                         LAYER  6
                         --------
```

```
                  TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER  0
      THICKNESS                   =      0.20   INCHES
      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.   =    1.22000003000     CM/SEC
      SLOPE                       =      9.60   PERCENT
      DRAINAGE LENGTH             =     317.0   FEET


                             LAYER  7
                             --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
      THICKNESS                   =      0.08   INCHES
      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.   =  0.199999996000E-12 CM/SEC
      FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
      FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
      FML PLACEMENT QUALITY       =  3 - GOOD


                             LAYER  8
                             --------

                  TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
      THICKNESS                   =     36.00   INCHES
      POROSITY                    =      0.4270 VOL/VOL
      FIELD CAPACITY              =      0.4180 VOL/VOL
      WILTING POINT               =      0.3670 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
            GROUND CONDITIONS, A SURFACE SLOPE OF 10.% AND
            A SLOPE LENGTH OF  317. FEET.

    SCS RUNOFF CURVE NUMBER              =    84.10
    FRACTION OF AREA ALLOWING RUNOFF     =     0.0    PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE   =     1.000  ACRES
    EVAPORATIVE ZONE DEPTH               =     6.0    INCHES
    INITIAL WATER IN EVAPORATIVE ZONE    =     2.742  INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE   =     2.742  INCHES
```

```
      LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
      INITIAL SNOW WATER                  =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
      TOTAL INITIAL WATER                 =     70.838  INCHES
      TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DETROIT               MICHIGAN

           STATION LATITUDE                         =  42.40 DEGREES
           MAXIMUM LEAF AREA INDEX                  =   0.00
           START OF GROWING SEASON (JULIAN DATE)    =    121
           END OF GROWING SEASON (JULIAN DATE)      =    286
           EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
           AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT             MICHIGAN

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
      1.86        1.69        2.54        3.15        2.77        3.43
      3.10        3.21        2.25        2.12        2.33        2.52


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT             MICHIGAN

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
     23.40       25.80       35.00       47.40       58.10       67.70
     71.90       70.50       63.30       51.90       39.50       28.50


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT             MICHIGAN
                  AND STATION LATITUDE  =  42.40 DEGREES



 *******************************************************************************
```

```
                              6FP2N-F
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                           2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                           1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                 0.8862   0.8757   1.0584   2.3835   3.2887   1.7526
                          1.3826   1.0852   1.0345   0.8428   0.6801   0.5253

   STD. DEVIATIONS        0.6171   0.2241   0.5661   1.7025   0.7902   0.6356
                          0.6641   0.2040   0.7358   0.2716   0.0870   0.1741

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                    AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  ------------------------------------
    AVERAGES                  0.0138   0.0150   0.0165   0.0383   0.0511   0.0281
                              0.0215   0.0169   0.0166   0.0131   0.0109   0.0082

    STD. DEVIATIONS           0.0096   0.0040   0.0088   0.0273   0.0123   0.0102
                              0.0103   0.0032   0.0118   0.0042   0.0014   0.0027

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  ------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET        PERCENT
                              ------------------    ------------     ---------
 PRECIPITATION                32.34     (   3.821)    117387.0        100.00

 RUNOFF                        0.000    (  0.0000)         0.00         0.000

 EVAPOTRANSPIRATION           17.213    (  1.6298)     62481.79        53.227

 LATERAL DRAINAGE COLLECTED   15.79559 (  3.88737)     57337.984     48.84528
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH   0.00001 (  0.00000)         0.045      0.00004
   LAYER  5

 AVERAGE HEAD ON TOP           0.021 (     0.005)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED    0.00001 (  0.00000)         0.036     0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH   0.00000 (  0.00000)         0.009      0.00001
   LAYER  8

 AVERAGE HEAD ON TOP           0.000 (     0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE      -0.670    (  2.0890)     -2432.90       -2.073
*******************************************************************************


□
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```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                (INCHES)    (CU. FT.)
                                               ----------  -------------
  PRECIPITATION                                  2.56        9292.800

  RUNOFF                                         0.000          0.0000

  DRAINAGE COLLECTED FROM LAYER  3               0.37150     1348.55627

  PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000000       0.00077

  AVERAGE HEAD ON TOP OF LAYER  4                0.179

  MAXIMUM HEAD ON TOP OF LAYER  4                0.358

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                    0.0 FEET

  DRAINAGE COLLECTED FROM LAYER  6               0.00000        0.00064

  PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000       0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                0.024

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                    0.0 FEET

  SNOW WATER                                     3.28       11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580

   ***  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    5
----------------------------------------------------------------------
                LAYER        (INCHES)       (VOL/VOL)
                -----        --------       ---------
                  1          25.2346         0.2103

                  2           1.2512         0.1043

                  3           0.0067         0.0334
```

```
           4              0.0000            0.0000

           5             25.6200            0.4270

           6              0.0020            0.0100

           7              0.0000            0.0000

           8             15.3720            0.4270

      SNOW WATER          0.000
******************************************************************************
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```

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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:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP2N2-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP2N2-F.OUT


TIME:   9:34     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F P1 NORTH 2

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


     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   5
          THICKNESS                   =   120.00   INCHES
          POROSITY                    =     0.4570 VOL/VOL
          FIELD CAPACITY              =     0.1310 VOL/VOL
          WILTING POINT               =     0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT  =     0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      12.00   INCHES
POROSITY                      =       0.4170 VOL/VOL
FIELD CAPACITY                =       0.0450 VOL/VOL
WILTING POINT                 =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                         LAYER  3
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =       0.20   INCHES
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.     =   1.22000003000      CM/SEC
SLOPE                         =       7.70   PERCENT
DRAINAGE LENGTH               =     191.0    FEET


                         LAYER  4
                         --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                     =       0.08   INCHES
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.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                         LAYER  5
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                     =      60.00   INCHES
POROSITY                      =       0.4270 VOL/VOL
FIELD CAPACITY                =       0.4180 VOL/VOL
WILTING POINT                 =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


                         LAYER  6
                         --------
```

```
                 TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
    THICKNESS                  =      0.20   INCHES
    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.  =    1.22000003000     CM/SEC
    SLOPE                      =      7.70   PERCENT
    DRAINAGE LENGTH            =    191.0    FEET


                           LAYER  7
                           --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
    THICKNESS                  =      0.08   INCHES
    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.  =  0.199999996000E-12 CM/SEC
    FML PINHOLE DENSITY        =      1.00   HOLES/ACRE
    FML INSTALLATION DEFECTS   =      1.00   HOLES/ACRE
    FML PLACEMENT QUALITY      =  3 - GOOD


                           LAYER  8
                           --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
    THICKNESS                  =     36.00   INCHES
    POROSITY                   =      0.4270 VOL/VOL
    FIELD CAPACITY             =      0.4180 VOL/VOL
    WILTING POINT              =      0.3670 VOL/VOL
    INITIAL SOIL WATER CONTENT =      0.4270 VOL/VOL
    EFFECTIVE SAT. HYD. COND.  =  0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  8.% AND
           A SLOPE LENGTH OF  191. FEET.

   SCS RUNOFF CURVE NUMBER             =     84.50
   FRACTION OF AREA ALLOWING RUNOFF    =      0.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE  =      1.000   ACRES
   EVAPORATIVE ZONE DEPTH              =      6.0     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE   =      2.742   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.742   INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.348  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =     70.838  INCHES
TOTAL INITIAL WATER                  =     70.838  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           DETROIT                MICHIGAN

       STATION LATITUDE                         =  42.40 DEGREES
       MAXIMUM LEAF AREA INDEX                  =   0.00
       START OF GROWING SEASON (JULIAN DATE)    =    121
       END OF GROWING SEASON (JULIAN DATE)      =    286
       EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
       AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT              MICHIGAN

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.86         1.69         2.54         3.15         2.77         3.43
  3.10         3.21         2.25         2.12         2.33         2.52


  NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT              MICHIGAN

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 23.40        25.80        35.00        47.40        58.10        67.70
 71.90        70.50        63.30        51.90        39.50        28.50


  NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT              MICHIGAN
             AND STATION LATITUDE  =  42.40 DEGREES



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```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                           2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                           1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                 0.8879   0.8760   1.0605   2.3888   3.2852   1.7497
                          1.3819   1.0864   1.0329   0.8424   0.6796   0.5246

   STD. DEVIATIONS        0.6171   0.2243   0.5673   1.6965   0.7849   0.6401
                          0.6631   0.2060   0.7351   0.2705   0.0867   0.1765

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

------------------------------------------------------------------------------
```

```
                AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                 0.0103   0.0112   0.0123   0.0287   0.0382   0.0210
                             0.0161   0.0126   0.0124   0.0098   0.0082   0.0061

    STD. DEVIATIONS          0.0072   0.0030   0.0066   0.0204   0.0091   0.0077
                             0.0077   0.0024   0.0088   0.0031   0.0010   0.0021

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                               -------------------  -------------   ---------
 PRECIPITATION                   32.34    (   3.821)    117387.0     100.00

 RUNOFF                           0.000   (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION              17.213   (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED      15.79583 (  3.88894)    57338.855   48.84602
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)        0.037     0.00003
   LAYER  5

 AVERAGE HEAD ON TOP              0.016 (    0.004)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00001 (  0.00000)        0.028    0.00002
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.670   (  2.0890)     -2433.74     -2.073
*******************************************************************************


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```

```
                                6FP2N2-F
                PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
----------------------------------------------------------------------------
                                                   (INCHES)      (CU. FT.)
                                                  ----------   -------------
    PRECIPITATION                                   2.56         9292.800

    RUNOFF                                          0.000           0.0000

    DRAINAGE COLLECTED FROM LAYER  3                0.39109      1419.66760

    PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000000        0.00062

    AVERAGE HEAD ON TOP OF LAYER  4                 0.141

    MAXIMUM HEAD ON TOP OF LAYER  4                 0.280

    LOCATION OF MAXIMUM HEAD IN LAYER  3
          (DISTANCE FROM DRAIN)                     0.2 FEET

    DRAINAGE COLLECTED FROM LAYER  6                0.00000         0.00051

    PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000        0.00002

    AVERAGE HEAD ON TOP OF LAYER  7                 0.000

    MAXIMUM HEAD ON TOP OF LAYER  7                 0.015

    LOCATION OF MAXIMUM HEAD IN LAYER  6
          (DISTANCE FROM DRAIN)                     0.0 FEET

    SNOW WATER                                      3.28        11902.9795


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                       0.4570

    MINIMUM VEG. SOIL WATER (VOL/VOL)                       0.0580


     ***  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    5
----------------------------------------------------------------------
                 LAYER        (INCHES)        (VOL/VOL)
                 -----        --------        ---------
                   1          25.2346          0.2103

                   2           1.2512          0.1043

                   3           0.0055          0.0276
```

```
                4              0.0000         0.0000
                5             25.6200         0.4270
                6              0.0020         0.0100
                7              0.0000         0.0000
                8             15.3720         0.4270
           SNOW WATER          0.000
**********************************************************************************
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```

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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:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP1S-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP1S-F.OUT


TIME:   8:19     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F PH 2 SOUTH

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


     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   5
           THICKNESS                   =   120.00   INCHES
           POROSITY                    =     0.4570 VOL/VOL
           FIELD CAPACITY              =     0.1310 VOL/VOL
           WILTING POINT               =     0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                         =     12.00   INCHES
POROSITY                          =      0.4170 VOL/VOL
FIELD CAPACITY                    =      0.0450 VOL/VOL
WILTING POINT                     =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT        =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.         =  0.999999978000E-02 CM/SEC


                           LAYER  3
                           --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                         =      0.20   INCHES
POROSITY                          =      0.8500 VOL/VOL
FIELD CAPACITY                    =      0.0100 VOL/VOL
WILTING POINT                     =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT        =      0.0102 VOL/VOL
EFFECTIVE SAT. HYD. COND.         =   1.22000003000     CM/SEC
SLOPE                             =      3.90   PERCENT
DRAINAGE LENGTH                   =    281.0    FEET


                           LAYER  4
                           --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                         =      0.08   INCHES
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.         =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY               =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS          =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY             =  3 - GOOD


                           LAYER  5
                           --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                         =     60.00   INCHES
POROSITY                          =      0.4270 VOL/VOL
FIELD CAPACITY                    =      0.4180 VOL/VOL
WILTING POINT                     =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT        =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.         =  0.100000001000E-06 CM/SEC


                           LAYER  6
                           --------
```

```
             TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
 THICKNESS                     =      0.20   INCHES
 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.     =    1.22000003000     CM/SEC
 SLOPE                         =      3.90   PERCENT
 DRAINAGE LENGTH               =    281.0    FEET


                      LAYER  7
                      --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
 THICKNESS                     =      0.08   INCHES
 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.     =  0.199999996000E-12 CM/SEC
 FML PINHOLE DENSITY           =      1.00   HOLES/ACRE
 FML INSTALLATION DEFECTS      =      1.00   HOLES/ACRE
 FML PLACEMENT QUALITY         =  3 - GOOD


                      LAYER  8
                      --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
 THICKNESS                     =     36.00   INCHES
 POROSITY                      =      0.4270 VOL/VOL
 FIELD CAPACITY                =      0.4180 VOL/VOL
 WILTING POINT                 =      0.3670 VOL/VOL
 INITIAL SOIL WATER CONTENT    =      0.4270 VOL/VOL
 EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  4.% AND
          A SLOPE LENGTH OF  281. FEET.

 SCS RUNOFF CURVE NUMBER            =     83.80
 FRACTION OF AREA ALLOWING RUNOFF   =      0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
 EVAPORATIVE ZONE DEPTH             =      6.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE  =      2.742  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE =      2.742  INCHES
```

```
   LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
   INITIAL SNOW WATER                  =       0.000  INCHES
   INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
   TOTAL INITIAL WATER                 =      70.838  INCHES
   TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             DETROIT               MICHIGAN

        STATION LATITUDE                          =  42.40 DEGREES
        MAXIMUM LEAF AREA INDEX                   =   0.00
        START OF GROWING SEASON (JULIAN DATE)     =    121
        END OF GROWING SEASON (JULIAN DATE)       =    286
        EVAPORATIVE ZONE DEPTH                    =   6.0  INCHES
        AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT              MICHIGAN

             NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
   1.86         1.69         2.54         3.15         2.77         3.43
   3.10         3.21         2.25         2.12         2.33         2.52


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT              MICHIGAN

        NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
  23.40        25.80        35.00        47.40        58.10        67.70
  71.90        70.50        63.30        51.90        39.50        28.50


    NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT              MICHIGAN
               AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                    1.75     1.67     2.39     4.10     3.71     4.04
                             2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS           0.61     0.62     1.28     1.20     1.61     1.04
                             1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                    0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS           0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    0.428    0.393    0.386    1.823    2.687    3.000
                             2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS           0.101    0.092    0.159    0.777    0.797    0.675
                             1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                    0.8782   0.8738   1.0470   2.3490   3.3190   1.7646
                             1.3850   1.0815   1.0410   0.8444   0.6826   0.5282

   STD. DEVIATIONS           0.6160   0.2239   0.5574   1.7425   0.8318   0.6118
                             0.6668   0.1947   0.7372   0.2770   0.0884   0.1633

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                    AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0296   0.0324   0.0403   0.6390   0.3073   0.0614
                              0.0466   0.0364   0.0362   0.0284   0.0237   0.0178

    STD. DEVIATIONS           0.0207   0.0086   0.0259   1.1537   0.4546   0.0213
                              0.0224   0.0066   0.0256   0.0093   0.0031   0.0055

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET     PERCENT
                                -------------------   -------------  ---------
 PRECIPITATION                   32.34     (   3.821)    117387.0     100.00

 RUNOFF                           0.000    (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION              17.213    (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED      15.79443 (  3.88001)     57333.793   48.84171
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00004 (  0.00003)         0.156    0.00013
   LAYER  5

 AVERAGE HEAD ON TOP              0.108 (    0.105)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00004 (  0.00003)         0.147    0.00012
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.669    (  2.0887)     -2428.80     -2.069
*******************************************************************************


□
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```

```
          PEAK DAILY VALUES FOR YEARS     1 THROUGH    5
------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------   -------------
  PRECIPITATION                                  2.56         9292.800

  RUNOFF                                         0.000           0.0000

  DRAINAGE COLLECTED FROM LAYER  3               0.22798       827.56445

  PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000004        0.01537

  AVERAGE HEAD ON TOP OF LAYER  4                4.819

  MAXIMUM HEAD ON TOP OF LAYER  4                8.305

  LOCATION OF MAXIMUM HEAD IN LAYER  3
       (DISTANCE FROM DRAIN)                    38.5 FEET

  DRAINAGE COLLECTED FROM LAYER  6               0.00000         0.01528

  PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000        0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                0.000

  LOCATION OF MAXIMUM HEAD IN LAYER  6
       (DISTANCE FROM DRAIN)                     0.0 FEET

  SNOW WATER                                     3.28        11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                          0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                          0.0580


   ***  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    5
----------------------------------------------------------------------
              LAYER        (INCHES)      (VOL/VOL)
              -----        --------      ---------
                1           25.2346       0.2103

                2            1.2512       0.1043

                3            0.0123       0.0617
```

```
                  4            0.0000          0.0000

                  5           25.6200          0.4270

                  6            0.0020          0.0100

                  7            0.0000          0.0000

                  8           15.3720          0.4270

             SNOW WATER        0.000

******************************************************************************
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```

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▯
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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                **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP1S2-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP1S2-F.OUT


TIME:   8:46     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F PH 2 SOUTH2

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


     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   5
           THICKNESS                  =   120.00   INCHES
           POROSITY                   =     0.4570 VOL/VOL
           FIELD CAPACITY             =     0.1310 VOL/VOL
           WILTING POINT              =     0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.2393 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4170 VOL/VOL
FIELD CAPACITY               =       0.0450 VOL/VOL
WILTING POINT                =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0942 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

             TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.20    INCHES
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.    =   1.22000003000      CM/SEC
SLOPE                        =      10.90    PERCENT
DRAINAGE LENGTH              =      82.0     FEET


                          LAYER  4
                          --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.08    INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  5
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                    =      60.00    INCHES
POROSITY                     =       0.4270 VOL/VOL
FIELD CAPACITY               =       0.4180 VOL/VOL
WILTING POINT                =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                  TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =       0.20    INCHES
     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.    =    1.22000003000      CM/SEC
     SLOPE                        =      10.90    PERCENT
     DRAINAGE LENGTH              =      82.0     FEET


                             LAYER  7
                             --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
     THICKNESS                    =       0.08    INCHES
     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.    =  0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
     FML INSTALLATION DEFECTS     =       1.00    HOLES/ACRE
     FML PLACEMENT QUALITY        =  3 - GOOD


                             LAYER  8
                             --------

                    TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
     THICKNESS                    =      36.00    INCHES
     POROSITY                     =       0.4270 VOL/VOL
     FIELD CAPACITY               =       0.4180 VOL/VOL
     WILTING POINT                =       0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
            GROUND CONDITIONS, A SURFACE SLOPE OF 11.% AND
            A SLOPE LENGTH OF   82. FEET.

  SCS RUNOFF CURVE NUMBER              =     85.30
  FRACTION OF AREA ALLOWING RUNOFF     =      0.0     PERCENT
  AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
  EVAPORATIVE ZONE DEPTH               =      6.0     INCHES
  INITIAL WATER IN EVAPORATIVE ZONE    =      2.742   INCHES
  UPPER LIMIT OF EVAPORATIVE STORAGE   =      2.742   INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     70.839  INCHES
TOTAL INITIAL WATER                 =     70.839  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           DETROIT               MICHIGAN

       STATION LATITUDE                        =  42.40 DEGREES
       MAXIMUM LEAF AREA INDEX                 =   0.00
       START OF GROWING SEASON (JULIAN DATE)   =    121
       END OF GROWING SEASON (JULIAN DATE)     =    286
       EVAPORATIVE ZONE DEPTH                  =   6.0  INCHES
       AVERAGE ANNUAL WIND SPEED               =  10.20 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  73.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  67.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  71.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  75.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


  NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


  NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN
             AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.428    0.393    0.386    1.819    2.677    3.012
                            2.297    2.273    1.287    1.044    0.980    0.563

   STD. DEVIATIONS          0.101    0.092    0.159    0.778    0.793    0.654
                            1.043    0.530    0.893    0.346    0.368    0.174

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                   0.8799   0.8910   1.0723   2.3498   3.2569   1.7811
                            1.3827   1.0947   1.0664   0.8402   0.6913   0.5237

   STD. DEVIATIONS          0.6137   0.2326   0.5704   1.6829   0.7650   0.6444
                            0.6830   0.2155   0.7511   0.2701   0.0978   0.1417

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
          AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                 0.0031   0.0035   0.0038   0.0086   0.0116   0.0065
                             0.0049   0.0039   0.0039   0.0030   0.0025   0.0019

    STD. DEVIATIONS          0.0022   0.0009   0.0020   0.0062   0.0027   0.0024
                             0.0024   0.0008   0.0028   0.0010   0.0004   0.0005

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET     PERCENT
                                -------------------  -------------  ---------
 PRECIPITATION                   32.34    (   3.821)    117387.0     100.00

 RUNOFF                           0.000   (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION              17.160   (  1.6079)     62290.70     53.064

 LATERAL DRAINAGE COLLECTED      15.82985 (  3.93131)    57462.359   48.95123
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)        0.018     0.00002
   LAYER  5

 AVERAGE HEAD ON TOP              0.005 (    0.001)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00000 (  0.00000)        0.016    0.00001
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.003     0.00000
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.652   (  2.0945)     -2366.12     -2.016
*******************************************************************************


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```

```
            PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
    PRECIPITATION                                 2.56          9292.800

    RUNOFF                                        0.000            0.0000

    DRAINAGE COLLECTED FROM LAYER  3              0.34460       1250.90259

    PERCOLATION/LEAKAGE THROUGH LAYER  5          0.000000         0.00020

    AVERAGE HEAD ON TOP OF LAYER  4               0.038

    MAXIMUM HEAD ON TOP OF LAYER  4               0.074

    LOCATION OF MAXIMUM HEAD IN LAYER  3
          (DISTANCE FROM DRAIN)                   0.6 FEET

    DRAINAGE COLLECTED FROM LAYER  6              0.00000          0.00019

    PERCOLATION/LEAKAGE THROUGH LAYER  8          0.000000         0.00001

    AVERAGE HEAD ON TOP OF LAYER  7               0.000

    MAXIMUM HEAD ON TOP OF LAYER  7               0.003

    LOCATION OF MAXIMUM HEAD IN LAYER  6
          (DISTANCE FROM DRAIN)                   0.0 FEET

    SNOW WATER                                    3.28         11902.9795


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

    MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580


     ***  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    5
----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          25.3244         0.2110

                2           1.2585         0.1049

                3           0.0031         0.0156
```

```
                       4           0.0000         0.0000
                       5          25.6200         0.4270
                       6           0.0020         0.0100
                       7           0.0000         0.0000
                       8          15.3720         0.4270
                  SNOW WATER       0.000
*******************************************************************************
*******************************************************************************
```

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□
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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP1NE-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP1NE-F.OUT


TIME:   8:54     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F P2 NE Area

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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   5
          THICKNESS                    =     120.00    INCHES
          POROSITY                     =       0.4570 VOL/VOL
          FIELD CAPACITY               =       0.1310 VOL/VOL
          WILTING POINT                =       0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                      =       12.00   INCHES
POROSITY                       =       0.4170 VOL/VOL
FIELD CAPACITY                 =       0.0450 VOL/VOL
WILTING POINT                  =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                      =        0.20   INCHES
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.      =   1.22000003000      CM/SEC
SLOPE                          =        7.40   PERCENT
DRAINAGE LENGTH                =      248.0    FEET


                          LAYER  4
                          --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                      =        0.08   INCHES
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.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =        1.00   HOLES/ACRE
FML INSTALLATION DEFECTS       =        1.00   HOLES/ACRE
FML PLACEMENT QUALITY          =  3 - GOOD


                          LAYER  5
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                      =       60.00   INCHES
POROSITY                       =       0.4270 VOL/VOL
FIELD CAPACITY                 =       0.4180 VOL/VOL
WILTING POINT                  =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                    TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER   0
      THICKNESS                   =       0.20    INCHES
      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.   =    1.22000003000      CM/SEC
      SLOPE                       =       7.40    PERCENT
      DRAINAGE LENGTH             =     248.0     FEET


                                  LAYER  7
                                  --------

                    TYPE 4 - FLEXIBLE MEMBRANE LINER
                     MATERIAL TEXTURE NUMBER  35
      THICKNESS                   =       0.08    INCHES
      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.   =  0.199999996000E-12 CM/SEC
      FML PINHOLE DENSITY         =       1.00    HOLES/ACRE
      FML INSTALLATION DEFECTS    =       1.00    HOLES/ACRE
      FML PLACEMENT QUALITY       =  3 - GOOD


                                  LAYER  8
                                  --------

                       TYPE 3 - BARRIER SOIL LINER
                     MATERIAL TEXTURE NUMBER  16
      THICKNESS                   =      36.00    INCHES
      POROSITY                    =       0.4270 VOL/VOL
      FIELD CAPACITY              =       0.4180 VOL/VOL
      WILTING POINT               =       0.3670 VOL/VOL
      INITIAL SOIL WATER CONTENT  =       0.4270 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

    NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
             SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
             GROUND CONDITIONS, A SURFACE SLOPE OF  7.% AND
             A SLOPE LENGTH OF  248. FEET.

   SCS RUNOFF CURVE NUMBER            =    84.20
   FRACTION OF AREA ALLOWING RUNOFF   =     0.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE =     1.000   ACRES
   EVAPORATIVE ZONE DEPTH             =     6.0     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE  =     2.742   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE =     2.742   INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
INITIAL SNOW WATER                  =       0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
TOTAL INITIAL WATER                 =      70.838  INCHES
TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DETROIT                MICHIGAN

     STATION LATITUDE                        =  42.40 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   0.00
     START OF GROWING SEASON (JULIAN DATE)   =    121
     END OF GROWING SEASON (JULIAN DATE)     =    286
     EVAPORATIVE ZONE DEPTH                  =   6.0  INCHES
     AVERAGE ANNUAL WIND SPEED               =  10.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  73.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  71.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  75.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN
            AND STATION LATITUDE  =  42.40 DEGREES




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```

```
                              6FP1NE-F
      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                            JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                            -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                     1.75     1.67     2.39     4.10     3.71     4.04
                              2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS            0.61     0.62     1.28     1.20     1.61     1.04
                              1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                     0.000    0.000    0.000    0.000    0.000    0.000
                              0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS            0.000    0.000    0.000    0.000    0.000    0.000
                              0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                     0.428    0.393    0.386    1.823    2.687    3.000
                              2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS            0.101    0.092    0.159    0.777    0.797    0.675
                              1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                     0.8861   0.8757   1.0583   2.3833   3.2889   1.7528
                              1.3827   1.0852   1.0346   0.8428   0.6801   0.5253

   STD. DEVIATIONS            0.6171   0.2241   0.5660   1.7027   0.7905   0.6354
                              0.6641   0.2039   0.7358   0.2717   0.0870   0.1740

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES                0.0139   0.0152   0.0166   0.0387   0.0517   0.0285
                           0.0217   0.0171   0.0168   0.0132   0.0110   0.0083

   STD. DEVIATIONS         0.0097   0.0040   0.0089   0.0277   0.0124   0.0103
                           0.0104   0.0032   0.0119   0.0043   0.0014   0.0027

 DAILY AVERAGE HEAD ON TOP OF LAYER  7
 -------------------------------------
   AVERAGES                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES             CU. FEET      PERCENT
                                ------------------    ------------   ---------
 PRECIPITATION                   32.34    (   3.821)     117387.0     100.00

 RUNOFF                           0.000   (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION              17.213   (  1.6298)      62481.79     53.227

 LATERAL DRAINAGE COLLECTED      15.79558 (  3.88730)     57337.937   48.84524
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)         0.046    0.00004
   LAYER  5

 AVERAGE HEAD ON TOP              0.021 (    0.005)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00001 (  0.00000)         0.037   0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.670   (  2.0890)      -2432.86    -2.073
*******************************************************************************


□
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```

```
            PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                 (INCHES)     (CU. FT.)
                                                ----------  -------------
  PRECIPITATION                                   2.56         9292.800

  RUNOFF                                          0.000           0.0000

  DRAINAGE COLLECTED FROM LAYER  3                0.37065      1345.47253

  PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000000        0.00077

  AVERAGE HEAD ON TOP OF LAYER  4                 0.181

  MAXIMUM HEAD ON TOP OF LAYER  4                 0.358

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                     0.6 FEET

  DRAINAGE COLLECTED FROM LAYER  6                0.00000         0.00064

  PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000        0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                 0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                 0.022

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                     0.0 FEET

  SNOW WATER                                      3.28        11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580


   ***  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    5
----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          25.2346         0.2103

                2           1.2512         0.1043

                3           0.0067         0.0336
```

```
           4                  0.0000            0.0000
           5                 25.6200            0.4270
           6                  0.0020            0.0100
           7                  0.0000            0.0000
           8                 15.3720            0.4270
      SNOW WATER              0.000
***********************************************************************************
***********************************************************************************
```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FP1N-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FP1N-F.OUT


TIME:   8:57     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F P2 N Area

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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   5
           THICKNESS                      =    120.00    INCHES
           POROSITY                       =      0.4570 VOL/VOL
           FIELD CAPACITY                 =      0.1310 VOL/VOL
           WILTING POINT                  =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT     =      0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       12.00    INCHES
POROSITY                     =        0.4170 VOL/VOL
FIELD CAPACITY               =        0.0450 VOL/VOL
WILTING POINT                =        0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =        0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.999999978000E-02 CM/SEC


                        LAYER  3
                        --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =        0.20    INCHES
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.    =    1.22000003000       CM/SEC
SLOPE                        =        7.90    PERCENT
DRAINAGE LENGTH              =      308.0     FEET


                        LAYER  4
                        --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
THICKNESS                    =        0.08    INCHES
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.    =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =        1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =        1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                        LAYER  5
                        --------

                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
THICKNESS                    =       60.00    INCHES
POROSITY                     =        0.4270 VOL/VOL
FIELD CAPACITY               =        0.4180 VOL/VOL
WILTING POINT                =        0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC


                        LAYER  6
                        --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =        0.20    INCHES
     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.    =     1.22000003000      CM/SEC
     SLOPE                        =        7.90    PERCENT
     DRAINAGE LENGTH              =      308.0     FEET


                           LAYER  7
                           --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
     THICKNESS                    =        0.08    INCHES
     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.    =   0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY          =        1.00    HOLES/ACRE
     FML INSTALLATION DEFECTS     =        1.00    HOLES/ACRE
     FML PLACEMENT QUALITY        =   3 - GOOD


                           LAYER  8
                           --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
     THICKNESS                    =       36.00    INCHES
     POROSITY                     =        0.4270 VOL/VOL
     FIELD CAPACITY               =        0.4180 VOL/VOL
     WILTING POINT                =        0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC


             GENERAL DESIGN AND EVAPORATIVE ZONE DATA
             ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  8.% AND
           A SLOPE LENGTH OF  308. FEET.

   SCS RUNOFF CURVE NUMBER            =      84.10
   FRACTION OF AREA ALLOWING RUNOFF   =       0.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE =       1.000   ACRES
   EVAPORATIVE ZONE DEPTH             =       6.0     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE  =       2.742   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE =       2.742   INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
INITIAL SNOW WATER                  =       0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
TOTAL INITIAL WATER                 =      70.838  INCHES
TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         DETROIT              MICHIGAN

       STATION LATITUDE                           =  42.40 DEGREES
       MAXIMUM LEAF AREA INDEX                    =   0.00
       START OF GROWING SEASON (JULIAN DATE)      =    121
       END OF GROWING SEASON (JULIAN DATE)        =    286
       EVAPORATIVE ZONE DEPTH                     =   6.0  INCHES
       AVERAGE ANNUAL WIND SPEED                  =  10.20 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  73.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  67.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  71.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  75.00 %


NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
         COEFFICIENTS FOR    DETROIT             MICHIGAN

         NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
         COEFFICIENTS FOR    DETROIT             MICHIGAN

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
         COEFFICIENTS FOR    DETROIT             MICHIGAN
           AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                            JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                            -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                     1.75     1.67     2.39     4.10     3.71     4.04
                              2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS            0.61     0.62     1.28     1.20     1.61     1.04
                              1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                    0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS           0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    0.428    0.393    0.386    1.823    2.687    3.000
                             2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS           0.101    0.092    0.159    0.777    0.797    0.675
                             1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                   0.8850   0.8754   1.0568   2.3802   3.2911   1.7546
                            1.3831   1.0845   1.0356   0.8430   0.6804   0.5258

   STD. DEVIATIONS          0.6170   0.2240   0.5651   1.7067   0.7939   0.6322
                            0.6646   0.2025   0.7362   0.2724   0.0872   0.1725

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER   4
  -------------------------------------
    AVERAGES                  0.0162   0.0177   0.0193   0.0568   0.0602   0.0332
                              0.0253   0.0198   0.0196   0.0154   0.0129   0.0096

    STD. DEVIATIONS           0.0113   0.0047   0.0103   0.0579   0.0145   0.0120
                              0.0122   0.0037   0.0139   0.0050   0.0016   0.0032

  DAILY AVERAGE HEAD ON TOP OF LAYER   7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH   5
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET      PERCENT
                               -------------------  -------------   ---------
 PRECIPITATION                   32.34    (   3.821)   117387.0      100.00

 RUNOFF                           0.000   (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION              17.213   (  1.6298)    62481.79      53.227

 LATERAL DRAINAGE COLLECTED      15.79543 (  3.88625)   57337.406    48.84478
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)       0.052      0.00004
   LAYER  5

 AVERAGE HEAD ON TOP              0.025 (     0.008)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00001 (  0.00000)       0.043     0.00004
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)       0.009      0.00001
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (     0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.670    (  2.0890)   -2432.30      -2.072
*******************************************************************************


□
******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS     1 THROUGH     5
-----------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
   PRECIPITATION                                  2.56         9292.800

   RUNOFF                                         0.000           0.0000

   DRAINAGE COLLECTED FROM LAYER  3               0.36088      1309.99597

   PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000002        0.00651

   AVERAGE HEAD ON TOP OF LAYER  4                1.970

   MAXIMUM HEAD ON TOP OF LAYER  4                3.594

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                   11.7 FEET

   DRAINAGE COLLECTED FROM LAYER  6               0.00000         0.00374

   PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000        0.00002

   AVERAGE HEAD ON TOP OF LAYER  7                0.000

   MAXIMUM HEAD ON TOP OF LAYER  7                0.063

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                    0.0 FEET

   SNOW WATER                                     3.28        11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580


    ***  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.

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


▯
*******************************************************************************

                FINAL WATER STORAGE AT END OF YEAR     5
----------------------------------------------------------------------
              LAYER          (INCHES)        (VOL/VOL)
              -----          --------        ---------
                1            25.2346          0.2103

                2             1.2512          0.1043

                3             0.0075          0.0374
```

```
                      4            0.0000         0.0000
                      5           25.6200         0.4270
                      6            0.0020         0.0100
                      7            0.0000         0.0000
                      8           15.3720         0.4270
                  SNOW WATER       0.000
********************************************************************************
********************************************************************************
```

```
▯
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:        S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FP1N2-F.D10
OUTPUT DATA FILE:             S:\WASTE\ENGINE~1\HELP3.07\6FP1N2-F.OUT


TIME:    8:59     DATE:    8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-F P2 NORTH 2

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


     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   5
          THICKNESS                  =    120.00   INCHES
          POROSITY                   =      0.4570 VOL/VOL
          FIELD CAPACITY             =      0.1310 VOL/VOL
          WILTING POINT              =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      12.00   INCHES
POROSITY                     =       0.4170 VOL/VOL
FIELD CAPACITY               =       0.0450 VOL/VOL
WILTING POINT                =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.20   INCHES
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.    =   1.22000003000      CM/SEC
SLOPE                        =       5.60   PERCENT
DRAINAGE LENGTH              =     168.0    FEET


                          LAYER  4
                          --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.08   INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  5
                          --------

                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
THICKNESS                    =      60.00   INCHES
POROSITY                     =       0.4270 VOL/VOL
FIELD CAPACITY               =       0.4180 VOL/VOL
WILTING POINT                =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
  THICKNESS                     =      0.20   INCHES
  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.     =   1.22000003000     CM/SEC
  SLOPE                         =      5.60   PERCENT
  DRAINAGE LENGTH               =    168.0    FEET


                         LAYER  7
                         --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
  THICKNESS                     =      0.08   INCHES
  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.     =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY           =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS      =      1.00   HOLES/ACRE
  FML PLACEMENT QUALITY         =  3 - GOOD


                         LAYER  8
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
  THICKNESS                     =     36.00   INCHES
  POROSITY                      =      0.4270 VOL/VOL
  FIELD CAPACITY                =      0.4180 VOL/VOL
  WILTING POINT                 =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT    =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  6.% AND
          A SLOPE LENGTH OF  168. FEET.

 SCS RUNOFF CURVE NUMBER              =     84.40
 FRACTION OF AREA ALLOWING RUNOFF     =      0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
 EVAPORATIVE ZONE DEPTH               =      6.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE    =      2.742  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE   =      2.742  INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.348  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     70.838  INCHES
TOTAL INITIAL WATER                =     70.838  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           DETROIT                MICHIGAN

      STATION LATITUDE                           = 42.40 DEGREES
      MAXIMUM LEAF AREA INDEX                    =  0.00
      START OF GROWING SEASON (JULIAN DATE)      =   121
      END OF GROWING SEASON (JULIAN DATE)        =   286
      EVAPORATIVE ZONE DEPTH                     =  6.0  INCHES
      AVERAGE ANNUAL WIND SPEED                  = 10.20 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY      = 73.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY      = 67.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY      = 71.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY      = 75.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.86         1.69         2.54         3.15         2.77         3.43
  3.10         3.21         2.25         2.12         2.33         2.52


  NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

      NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 23.40        25.80        35.00        47.40        58.10        67.70
 71.90        70.50        63.30        51.90        39.50        28.50


  NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN
             AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
                              6FP1N2-F
      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.428    0.393    0.386    1.823    2.687    3.000
                            2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS          0.101    0.092    0.159    0.777    0.797    0.675
                            1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                   0.8868   0.8758   1.0592   2.3855   3.2873   1.7515
                            1.3824   1.0857   1.0339   0.8427   0.6799   0.5250

   STD. DEVIATIONS          0.6171   0.2242   0.5666   1.7002   0.7882   0.6374
                            0.6637   0.2048   0.7355   0.2712   0.0869   0.1751

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
           AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0124   0.0136   0.0149   0.0346   0.0461   0.0254
                              0.0194   0.0152   0.0150   0.0118   0.0099   0.0074

    STD. DEVIATIONS           0.0087   0.0036   0.0080   0.0247   0.0111   0.0092
                              0.0093   0.0029   0.0107   0.0038   0.0013   0.0025

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                -------------------   ------------   ---------
 PRECIPITATION                    32.34    (   3.821)   117387.0      100.00

 RUNOFF                            0.000   (  0.0000)        0.00      0.000

 EVAPOTRANSPIRATION               17.213   (  1.6298)    62481.79     53.227

 LATERAL DRAINAGE COLLECTED       15.79568 (  3.88797)   57338.324    48.84557
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00001 (  0.00000)       0.042     0.00004
   LAYER  5

 AVERAGE HEAD ON TOP               0.019 (    0.005)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00001 (  0.00000)       0.033    0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)       0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.670   (  2.0890)    -2433.22     -2.073
*******************************************************************************


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```

```
           PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                 (INCHES)    (CU. FT.)
                                                ----------  -------------
  PRECIPITATION                                   2.56        9292.800

  RUNOFF                                          0.000          0.0000

  DRAINAGE COLLECTED FROM LAYER  3                0.37896     1375.63538

  PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000000       0.00071

  AVERAGE HEAD ON TOP OF LAYER  4                 0.165

  MAXIMUM HEAD ON TOP OF LAYER  4                 0.325

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                     1.9 FEET

  DRAINAGE COLLECTED FROM LAYER  6                0.00000        0.00058

  PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000       0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                 0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                 0.016

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                     0.0 FEET

  SNOW WATER                                      3.28       11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580


   ***  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    5
----------------------------------------------------------------------
              LAYER         (INCHES)       (VOL/VOL)
              -----         --------       ---------
                1            25.2346        0.2103

                2             1.2512        0.1043

                3             0.0062        0.0311
```

```
             4            0.0000          0.0000

             5           25.6200          0.4270

             6            0.0020          0.0100

             7            0.0000          0.0000

             8           15.3720          0.4270

          SNOW WATER      0.000

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP1E~1.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP1E-F1.OUT


TIME:   9:38     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P1 EAST

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


     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   5
          THICKNESS                  =    120.00   INCHES
          POROSITY                   =      0.4570 VOL/VOL
          FIELD CAPACITY             =      0.1310 VOL/VOL
          WILTING POINT              =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
               MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      12.00   INCHES
POROSITY                      =       0.4170 VOL/VOL
FIELD CAPACITY                =       0.0450 VOL/VOL
WILTING POINT                 =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                         LAYER  3
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                     =       0.20   INCHES
POROSITY                      =       0.8500 VOL/VOL
FIELD CAPACITY                =       0.0100 VOL/VOL
WILTING POINT                 =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.0103 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   1.22000003000      CM/SEC
SLOPE                         =       2.50   PERCENT
DRAINAGE LENGTH               =     201.0    FEET


                         LAYER  4
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                     =       0.08   INCHES
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.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                         LAYER  5
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                     =      60.00   INCHES
POROSITY                      =       0.4270 VOL/VOL
FIELD CAPACITY                =       0.4180 VOL/VOL
WILTING POINT                 =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


                         LAYER  6
                         --------
```

```
                   TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =        0.20    INCHES
     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.    =     1.22000003000      CM/SEC
     SLOPE                        =        2.50    PERCENT
     DRAINAGE LENGTH              =      201.0     FEET


                              LAYER  7
                              --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                     MATERIAL TEXTURE NUMBER  35
     THICKNESS                    =        0.08    INCHES
     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.    =  0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY          =        1.00    HOLES/ACRE
     FML INSTALLATION DEFECTS     =        1.00    HOLES/ACRE
     FML PLACEMENT QUALITY        =  3 - GOOD


                              LAYER  8
                              --------

                    TYPE 3 - BARRIER SOIL LINER
                     MATERIAL TEXTURE NUMBER  16
     THICKNESS                    =       36.00    INCHES
     POROSITY                     =        0.4270 VOL/VOL
     FIELD CAPACITY               =        0.4180 VOL/VOL
     WILTING POINT                =        0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
           A SLOPE LENGTH OF  201. FEET.

 SCS RUNOFF CURVE NUMBER               =      83.90
 FRACTION OF AREA ALLOWING RUNOFF      =       0.0     PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE    =       1.000   ACRES
 EVAPORATIVE ZONE DEPTH                =       6.0     INCHES
 INITIAL WATER IN EVAPORATIVE ZONE     =       2.742   INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE    =       2.742   INCHES
```

```
     LOWER LIMIT OF EVAPORATIVE STORAGE =        0.348  INCHES
     INITIAL SNOW WATER                 =        0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS   =       70.838  INCHES
     TOTAL INITIAL WATER                =       70.838  INCHES
     TOTAL SUBSURFACE INFLOW            =        0.00   INCHES/YEAR


                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               DETROIT               MICHIGAN

          STATION LATITUDE                          =  42.40 DEGREES
          MAXIMUM LEAF AREA INDEX                   =   0.00
          START OF GROWING SEASON (JULIAN DATE)     =    121
          END OF GROWING SEASON (JULIAN DATE)       =    286
          EVAPORATIVE ZONE DEPTH                    =   6.0  INCHES
          AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT             MICHIGAN

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     1.86        1.69        2.54        3.15        2.77        3.43
     3.10        3.21        2.25        2.12        2.33        2.52


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT             MICHIGAN

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    23.40       25.80       35.00       47.40       58.10       67.70
    71.90       70.50       63.30       51.90       39.50       28.50


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT             MICHIGAN
                 AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    5
------------------------------------------------------------------------------

                              JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                              -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
     TOTALS                     1.75     1.67     2.39     4.10     3.71     4.04
                                2.70     3.30     1.70     0.95     2.88     3.17

     STD. DEVIATIONS            0.61     0.62     1.28     1.20     1.61     1.04
                                1.31     1.70     0.93     0.37     1.23     0.94

  RUNOFF
  ------
     TOTALS                     0.000    0.000    0.000    0.000    0.000    0.000
                                0.000    0.000    0.000    0.000    0.000    0.000

     STD. DEVIATIONS            0.000    0.000    0.000    0.000    0.000    0.000
                                0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
     TOTALS                     0.428    0.393    0.386    1.823    2.687    3.000
                                2.315    2.279    1.309    1.049    0.980    0.563

     STD. DEVIATIONS            0.101    0.092    0.159    0.777    0.797    0.675
                                1.039    0.522    0.900    0.348    0.370    0.175

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
     TOTALS                     0.8765   0.8735   1.0442   2.3220   3.3454   1.7671
                                1.3854   1.0811   1.0422   0.8447   0.6832   0.5288

     STD. DEVIATIONS            0.6157   0.2241   0.5551   1.7192   0.8271   0.6066
                                0.6672   0.1929   0.7370   0.2781   0.0887   0.1611

  PERCOLATION/LEAKAGE THROUGH LAYER  5
  ------------------------------------
     TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

     STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  LATERAL DRAINAGE COLLECTED FROM LAYER  6
  ----------------------------------------
     TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

     STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER  8
  ------------------------------------
     TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

     STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

------------------------------------------------------------------------------
```

```
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0329   0.0361   0.0492   0.8098   0.4976   0.0685
                              0.0520   0.0406   0.0404   0.0317   0.0265   0.0198

    STD. DEVIATIONS           0.0231   0.0096   0.0368   1.5176   0.7157   0.0235
                              0.0250   0.0072   0.0286   0.0104   0.0034   0.0060

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                -------------------   -------------  ---------
 PRECIPITATION                    32.34   (   3.821)    117387.0     100.00

 RUNOFF                            0.000  (  0.0000)         0.00     0.000

 EVAPOTRANSPIRATION               17.213  (  1.6298)     62481.79    53.227

 LATERAL DRAINAGE COLLECTED       15.79416 (  3.87846)    57332.812   48.84087
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00005 (  0.00004)        0.196     0.00017
   LAYER  5

 AVERAGE HEAD ON TOP               0.142 (    0.136)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00005 (  0.00004)        0.187    0.00016
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)        0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.669  (  2.0886)     -2427.86     -2.068
*******************************************************************************


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```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
  PRECIPITATION                                 2.56         9292.800

  RUNOFF                                        0.000           0.0000

  DRAINAGE COLLECTED FROM LAYER  3              0.20808       755.33795

  PERCOLATION/LEAKAGE THROUGH LAYER  5          0.000005        0.01685

  AVERAGE HEAD ON TOP OF LAYER  4               5.328

  MAXIMUM HEAD ON TOP OF LAYER  4               8.275

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                  44.8 FEET

  DRAINAGE COLLECTED FROM LAYER  6              0.00000         0.01679

  PERCOLATION/LEAKAGE THROUGH LAYER  8          0.000000        0.00002

  AVERAGE HEAD ON TOP OF LAYER  7               0.000

  MAXIMUM HEAD ON TOP OF LAYER  7               0.001

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                   0.0 FEET

  SNOW WATER                                    3.28        11902.9795

  MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580

   ***  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    5
----------------------------------------------------------------------
                LAYER        (INCHES)       (VOL/VOL)
                -----       ---------      ---------
                  1          25.2346         0.2103

                  2           1.2512         0.1043

                  3           0.0137         0.0684
```

```
              4             0.0000          0.0000

              5            25.6200          0.4270

              6             0.0020          0.0100

              7             0.0000          0.0000

              8            15.3720          0.4270

          SNOW WATER        0.000

****************************************************************************
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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:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP1W~1.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP1W-F1.OUT


TIME:   9:41     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P1 WEST

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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   5
          THICKNESS                    =    120.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.1310 VOL/VOL
          WILTING POINT                =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       12.00    INCHES
POROSITY                     =        0.4170 VOL/VOL
FIELD CAPACITY               =        0.0450 VOL/VOL
WILTING POINT                =        0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =        0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.999999978000E-02 CM/SEC


                        LAYER  3
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =        0.20    INCHES
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.    =    1.22000003000      CM/SEC
SLOPE                        =        3.90    PERCENT
DRAINAGE LENGTH              =      196.0     FEET


                        LAYER  4
                        --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                    =        0.08    INCHES
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.    =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =        1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =        1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                        LAYER  5
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                    =       60.00    INCHES
POROSITY                     =        0.4270 VOL/VOL
FIELD CAPACITY               =        0.4180 VOL/VOL
WILTING POINT                =        0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC


                        LAYER  6
                        --------
```

```
               TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
   THICKNESS                     =       0.20   INCHES
   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.     =    1.22000003000     CM/SEC
   SLOPE                         =       3.90   PERCENT
   DRAINAGE LENGTH               =     196.0    FEET


                          LAYER  7
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
   THICKNESS                     =       0.08   INCHES
   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.     =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY           =       1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS      =       1.00   HOLES/ACRE
   FML PLACEMENT QUALITY         =  3 - GOOD


                          LAYER  8
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
   THICKNESS                     =      36.00   INCHES
   POROSITY                      =       0.4270 VOL/VOL
   FIELD CAPACITY                =       0.4180 VOL/VOL
   WILTING POINT                 =       0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT    =       0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  4.% AND
          A SLOPE LENGTH OF  196. FEET.

 SCS RUNOFF CURVE NUMBER              =      84.10
 FRACTION OF AREA ALLOWING RUNOFF     =       0.0     PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE   =       1.000   ACRES
 EVAPORATIVE ZONE DEPTH               =       6.0     INCHES
 INITIAL WATER IN EVAPORATIVE ZONE    =       2.742   INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE   =       2.742   INCHES
```

```
  LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
  INITIAL SNOW WATER                  =      0.000  INCHES
  INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
  TOTAL INITIAL WATER                 =     70.838  INCHES
  TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

   NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
            DETROIT              MICHIGAN

       STATION LATITUDE                         =  42.40 DEGREES
       MAXIMUM LEAF AREA INDEX                  =   0.00
       START OF GROWING SEASON (JULIAN DATE)    =    121
       END OF GROWING SEASON (JULIAN DATE)      =    286
       EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
       AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


   NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    DETROIT              MICHIGAN

            NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.86         1.69         2.54         3.15         2.77         3.43
  3.10         3.21         2.25         2.12         2.33         2.52


   NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    DETROIT              MICHIGAN

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 23.40        25.80        35.00        47.40        58.10        67.70
 71.90        70.50        63.30        51.90        39.50        28.50


   NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    DETROIT              MICHIGAN
              AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                    1.75     1.67     2.39     4.10     3.71     4.04
                             2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS           0.61     0.62     1.28     1.20     1.61     1.04
                             1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.428    0.393    0.386    1.823    2.687    3.000
                            2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS          0.101    0.092    0.159    0.777    0.797    0.675
                            1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                  0.8827   0.8749   1.0537   2.3746   3.2953   1.7581
                           1.3838   1.0833   1.0375   0.8435   0.6811   0.5267

   STD. DEVIATIONS         0.6167   0.2239   0.5628   1.7146   0.8002   0.6255
                           0.6655   0.1998   0.7368   0.2739   0.0876   0.1693

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

------------------------------------------------------------------------------
```

```
                    AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0207   0.0227   0.0247   0.1824   0.0774   0.0426
                              0.0325   0.0254   0.0252   0.0198   0.0165   0.0124

    STD. DEVIATIONS           0.0145   0.0060   0.0132   0.2870   0.0188   0.0152
                              0.0156   0.0047   0.0179   0.0064   0.0021   0.0040

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET      PERCENT
                                   -------------------  ------------  ---------
 PRECIPITATION                       32.34    (   3.821)   117387.0     100.00

 RUNOFF                               0.000   (  0.0000)        0.00      0.000

 EVAPOTRANSPIRATION                  17.213   (  1.6298)    62481.79     53.227

 LATERAL DRAINAGE COLLECTED          15.79511 (  3.88415)   57336.250   48.84380
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH          0.00002 (  0.00001)       0.074     0.00006
   LAYER  5

 AVERAGE HEAD ON TOP                  0.042 (    0.028)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED           0.00002 (  0.00001)       0.065    0.00006
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH          0.00000 (  0.00000)       0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP                  0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE             -0.670    (  2.0889)    -2431.17     -2.071
*******************************************************************************


□
******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
----------------------------------------------------------------------------
                                                 (INCHES)     (CU. FT.)
                                                ----------   -------------
   PRECIPITATION                                   2.56        9292.800

   RUNOFF                                          0.000          0.0000

   DRAINAGE COLLECTED FROM LAYER  3                0.31594     1146.87036

   PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000003       0.01252

   AVERAGE HEAD ON TOP OF LAYER  4                 3.850

   MAXIMUM HEAD ON TOP OF LAYER  4                 6.549

   LOCATION OF MAXIMUM HEAD IN LAYER  3
          (DISTANCE FROM DRAIN)                   29.1 FEET

   DRAINAGE COLLECTED FROM LAYER  6                0.00000        0.01187

   PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000       0.00002

   AVERAGE HEAD ON TOP OF LAYER  7                 0.000

   MAXIMUM HEAD ON TOP OF LAYER  7                 0.007

   LOCATION OF MAXIMUM HEAD IN LAYER  6
          (DISTANCE FROM DRAIN)                    0.0 FEET

   SNOW WATER                                      3.28       11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                        0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                        0.0580


    ***  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.

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



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

                FINAL WATER STORAGE AT END OF YEAR    5
----------------------------------------------------------------------
               LAYER         (INCHES)        (VOL/VOL)
               -----         --------        ---------
                 1            25.2346          0.2103

                 2             1.2512          0.1043

                 3             0.0091          0.0453
```

```
                 4           0.0000          0.0000
                 5          25.6200          0.4270
                 6           0.0020          0.0100
                 7           0.0000          0.0000
                 8          15.3720          0.4270
           SNOW WATER        0.000
*******************************************************************************
*******************************************************************************
```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP2-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP2-F.OUT


TIME:   9:47     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G PHASE 2 W

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


     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   5
          THICKNESS                    =   120.00   INCHES
          POROSITY                     =     0.4570 VOL/VOL
          FIELD CAPACITY               =     0.1310 VOL/VOL
          WILTING POINT                =     0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT   =     0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4170 VOL/VOL
FIELD CAPACITY               =       0.0450 VOL/VOL
WILTING POINT                =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                       LAYER  3
                       --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.20    INCHES
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.    =   1.22000003000      CM/SEC
SLOPE                        =       7.90    PERCENT
DRAINAGE LENGTH              =     374.0     FEET


                       LAYER  4
                       --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.08    INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                       LAYER  5
                       --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
THICKNESS                    =      60.00    INCHES
POROSITY                     =       0.4270 VOL/VOL
FIELD CAPACITY               =       0.4180 VOL/VOL
WILTING POINT                =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                       LAYER  6
                       --------
```

```
                 TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
    THICKNESS                   =       0.20   INCHES
    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.   =    1.22000003000     CM/SEC
    SLOPE                       =       7.90   PERCENT
    DRAINAGE LENGTH             =     374.0    FEET


                              LAYER  7
                              --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
    THICKNESS                   =       0.08   INCHES
    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.   =  0.199999996000E-12 CM/SEC
    FML PINHOLE DENSITY         =       1.00   HOLES/ACRE
    FML INSTALLATION DEFECTS    =       1.00   HOLES/ACRE
    FML PLACEMENT QUALITY       =  3 - GOOD


                              LAYER  8
                              --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
    THICKNESS                   =      36.00   INCHES
    POROSITY                    =       0.4270 VOL/VOL
    FIELD CAPACITY              =       0.4180 VOL/VOL
    WILTING POINT               =       0.3670 VOL/VOL
    INITIAL SOIL WATER CONTENT  =       0.4270 VOL/VOL
    EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  8.% AND
           A SLOPE LENGTH OF  374. FEET.

   SCS RUNOFF CURVE NUMBER             =      83.90
   FRACTION OF AREA ALLOWING RUNOFF    =       0.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE  =       1.000  ACRES
   EVAPORATIVE ZONE DEPTH              =       6.0    INCHES
   INITIAL WATER IN EVAPORATIVE ZONE   =       2.742  INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE  =       2.742  INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
TOTAL INITIAL WATER                 =     70.838  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           DETROIT                MICHIGAN

       STATION LATITUDE                          =  42.40 DEGREES
       MAXIMUM LEAF AREA INDEX                   =   0.00
       START OF GROWING SEASON (JULIAN DATE)     =    121
       END OF GROWING SEASON (JULIAN DATE)       =    286
       EVAPORATIVE ZONE DEPTH                    =   6.0  INCHES
       AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.86         1.69         2.54         3.15         2.77         3.43
  3.10         3.21         2.25         2.12         2.33         2.52


  NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 23.40        25.80        35.00        47.40        58.10        67.70
 71.90        70.50        63.30        51.90        39.50        28.50


  NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN
             AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.428    0.393    0.386    1.823    2.687    3.000
                            2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS          0.101    0.092    0.159    0.777    0.797    0.675
                            1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                  0.8833   0.8750   1.0545   2.3757   3.2944   1.7572
                           1.3836   1.0835   1.0371   0.8434   0.6810   0.5265

   STD. DEVIATIONS         0.6168   0.2239   0.5634   1.7128   0.7989   0.6272
                           0.6653   0.2005   0.7367   0.2736   0.0875   0.1701

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0196   0.0214   0.0234   0.1201   0.0732   0.0403
                              0.0307   0.0241   0.0238   0.0187   0.0156   0.0117

    STD. DEVIATIONS           0.0137   0.0057   0.0125   0.1845   0.0177   0.0144
                              0.0148   0.0045   0.0169   0.0061   0.0020   0.0038

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                         INCHES            CU. FEET     PERCENT
                                   -------------------  -------------  ---------
 PRECIPITATION                      32.34    (   3.821)     117387.0    100.00

 RUNOFF                              0.000   (  0.0000)         0.00     0.000

 EVAPOTRANSPIRATION                 17.213   (  1.6298)     62481.79    53.227

 LATERAL DRAINAGE COLLECTED         15.79518 (  3.88467)    57336.516   48.84402
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH         0.00002 (  0.00001)        0.066    0.00006
   LAYER  5

 AVERAGE HEAD ON TOP                 0.035 (    0.019)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED          0.00002 (  0.00001)        0.057   0.00005
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH         0.00000 (  0.00000)        0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP                 0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE            -0.670   (  2.0889)     -2431.45    -2.071
*******************************************************************************


▯
******************************************************************************
```

```
           PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
  PRECIPITATION                                   2.56         9292.800

  RUNOFF                                          0.000           0.0000

  DRAINAGE COLLECTED FROM LAYER  3                0.32267      1171.30908

  PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000003        0.00959

  AVERAGE HEAD ON TOP OF LAYER  4                 2.934

  MAXIMUM HEAD ON TOP OF LAYER  4                 5.557

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                    17.4 FEET

  DRAINAGE COLLECTED FROM LAYER  6                0.00000         0.00767

  PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000        0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                 0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                 0.110

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                     0.0 FEET

  SNOW WATER                                      3.28        11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                       0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                       0.0580


   ***  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    5
----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1           25.2346         0.2103

                2            1.2512         0.1043

                3            0.0087         0.0433
```

```
                4              0.0000          0.0000

                5             25.6200          0.4270

                6              0.0020          0.0100

                7              0.0000          0.0000

                8             15.3720          0.4270

           SNOW WATER          0.000

*******************************************************************************
*******************************************************************************
```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP3-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP3-F.OUT


TIME:   9:56     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G PHASE 2 E

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


     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   5
          THICKNESS                      =    120.00   INCHES
          POROSITY                       =      0.4570 VOL/VOL
          FIELD CAPACITY                 =      0.1310 VOL/VOL
          WILTING POINT                  =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT     =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                MATERIAL TEXTURE NUMBER   0
THICKNESS                      =     12.00    INCHES
POROSITY                       =      0.4170 VOL/VOL
FIELD CAPACITY                 =      0.0450 VOL/VOL
WILTING POINT                  =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC


                             LAYER  3
                             --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                      =      0.20    INCHES
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.      =   1.22000003000      CM/SEC
SLOPE                          =      6.90    PERCENT
DRAINAGE LENGTH                =    381.0     FEET


                             LAYER  4
                             --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                      =      0.08    INCHES
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.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =      1.00    HOLES/ACRE
FML INSTALLATION DEFECTS       =      1.00    HOLES/ACRE
FML PLACEMENT QUALITY          = 3 - GOOD


                             LAYER  5
                             --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
THICKNESS                      =     60.00    INCHES
POROSITY                       =      0.4270 VOL/VOL
FIELD CAPACITY                 =      0.4180 VOL/VOL
WILTING POINT                  =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


                             LAYER  6
                             --------
```

```
                 TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =       0.20   INCHES
   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.       =     1.22000003000      CM/SEC
   SLOPE                           =       6.90   PERCENT
   DRAINAGE LENGTH                 =     381.0    FEET


                            LAYER  7
                            --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
   THICKNESS                       =       0.08   INCHES
   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.       =   0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY             =       1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS        =       1.00   HOLES/ACRE
   FML PLACEMENT QUALITY           =   3 - GOOD


                            LAYER  8
                            --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
   THICKNESS                       =      36.00   INCHES
   POROSITY                        =       0.4270 VOL/VOL
   FIELD CAPACITY                  =       0.4180 VOL/VOL
   WILTING POINT                   =       0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT      =       0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =   0.100000001000E-06 CM/SEC


               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  7.% AND
           A SLOPE LENGTH OF  381. FEET.

 SCS RUNOFF CURVE NUMBER             =      83.80
 FRACTION OF AREA ALLOWING RUNOFF    =       0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE  =       1.000  ACRES
 EVAPORATIVE ZONE DEPTH              =       6.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE   =       2.742  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE  =       2.742  INCHES
```

```
       LOWER LIMIT OF EVAPORATIVE STORAGE  =        0.348  INCHES
       INITIAL SNOW WATER                  =        0.000  INCHES
       INITIAL WATER IN LAYER MATERIALS    =       70.838  INCHES
       TOTAL INITIAL WATER                 =       70.838  INCHES
       TOTAL SUBSURFACE INFLOW             =        0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                 DETROIT               MICHIGAN

            STATION LATITUDE                         =  42.40 DEGREES
            MAXIMUM LEAF AREA INDEX                  =   0.00
            START OF GROWING SEASON (JULIAN DATE)    =    121
            END OF GROWING SEASON (JULIAN DATE)      =    286
            EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
            AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


        NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT             MICHIGAN

                 NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       1.86        1.69        2.54        3.15        2.77        3.43
       3.10        3.21        2.25        2.12        2.33        2.52


        NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT             MICHIGAN

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
      23.40       25.80       35.00       47.40       58.10       67.70
      71.90       70.50       63.30       51.90       39.50       28.50


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT             MICHIGAN
                   AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
                              6GP3-F
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                  1.75     1.67     2.39     4.10     3.71     4.04
                           2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS         0.61     0.62     1.28     1.20     1.61     1.04
                           1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                           2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                           1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                  0.8817   0.8746   1.0522   2.3729   3.2965   1.7596
                           1.3841   1.0828   1.0384   0.8437   0.6815   0.5271

   STD. DEVIATIONS         0.6166   0.2239   0.5616   1.7177   0.8023   0.6223
                           0.6658   0.1986   0.7370   0.2747   0.0878   0.1679

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES                 0.0228    0.0250    0.0272    0.2821    0.0909    0.0470
                            0.0358    0.0280    0.0278    0.0218    0.0182    0.0136

   STD. DEVIATIONS          0.0160    0.0066    0.0145    0.4401    0.0294    0.0166
                            0.0172    0.0051    0.0197    0.0071    0.0023    0.0043

 DAILY AVERAGE HEAD ON TOP OF LAYER  7
 -------------------------------------
   AVERAGES                 0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                            0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

   STD. DEVIATIONS          0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                            0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                     INCHES             CU. FEET       PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  32.34    (   3.821)     117387.0      100.00

 RUNOFF                          0.000   (  0.0000)          0.00       0.000

 EVAPOTRANSPIRATION             17.213   (  1.6298)      62481.79      53.227

 LATERAL DRAINAGE COLLECTED     15.79495 (  3.88317)     57335.676    48.84331
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00002 (  0.00001)         0.088     0.00008
   LAYER  5

 AVERAGE HEAD ON TOP             0.053 (    0.041)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED      0.00002 (  0.00001)         0.079    0.00007
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP             0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE        -0.670   (  2.0889)      -2430.63      -2.071
*******************************************************************************


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```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------
                                               (INCHES)     (CU. FT.)
                                              ----------   -------------
   PRECIPITATION                                 2.56        9292.800

   RUNOFF                                        0.000          0.0000

   DRAINAGE COLLECTED FROM LAYER  3              0.28825     1046.36450

   PERCOLATION/LEAKAGE THROUGH LAYER  5          0.000004       0.01299

   AVERAGE HEAD ON TOP OF LAYER  4               4.009

   MAXIMUM HEAD ON TOP OF LAYER  4               7.453

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                  25.2 FEET

   DRAINAGE COLLECTED FROM LAYER  6              0.00000        0.01292

   PERCOLATION/LEAKAGE THROUGH LAYER  8          0.000000       0.00002

   AVERAGE HEAD ON TOP OF LAYER  7               0.000

   MAXIMUM HEAD ON TOP OF LAYER  7               0.026

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                   0.0 FEET

   SNOW WATER                                    3.28       11902.9795

   MAXIMUM VEG. SOIL WATER (VOL/VOL)                         0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                         0.0580

    ***  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    5
-------------------------------------------------------------------
                  LAYER        (INCHES)        (VOL/VOL)
                  -----        --------        ---------
                    1           25.2346          0.2103

                    2            1.2512          0.1043

                    3            0.0098          0.0490
```

```
                      4             0.0000         0.0000

                      5            25.6200         0.4270

                      6             0.0020         0.0100

                      7             0.0000         0.0000

                      8            15.3720         0.4270

                  SNOW WATER        0.000

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


PRECIPITATION DATA FILE:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:        S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6GP4NE-F.D10
OUTPUT DATA FILE:             S:\WASTE\ENGINE~1\HELP3.07\6GP4NE-1.OUT


TIME:  10: 1      DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P3 NE AREA

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


     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   5
          THICKNESS                  =    120.00    INCHES
          POROSITY                   =      0.4570 VOL/VOL
          FIELD CAPACITY             =      0.1310 VOL/VOL
          WILTING POINT              =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                      =       12.00   INCHES
POROSITY                       =       0.4170 VOL/VOL
FIELD CAPACITY                 =       0.0450 VOL/VOL
WILTING POINT                  =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =   0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                      =       0.20    INCHES
POROSITY                       =       0.8500 VOL/VOL
FIELD CAPACITY                 =       0.0100 VOL/VOL
WILTING POINT                  =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0101 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =    1.22000003000      CM/SEC
SLOPE                          =       2.70    PERCENT
DRAINAGE LENGTH                =     188.0     FEET


                          LAYER  4
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                      =       0.08    INCHES
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.      =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS       =       1.00    HOLES/ACRE
FML PLACEMENT QUALITY          =   3 - GOOD


                          LAYER  5
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                      =      60.00    INCHES
POROSITY                       =       0.4270 VOL/VOL
FIELD CAPACITY                 =       0.4180 VOL/VOL
WILTING POINT                  =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =   0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                 TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =        0.20   INCHES
   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.    =     1.22000003000     CM/SEC
   SLOPE                        =        2.70   PERCENT
   DRAINAGE LENGTH              =      188.0    FEET


                            LAYER  7
                            --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
   THICKNESS                    =        0.08   INCHES
   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.    =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY          =        1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS     =        1.00   HOLES/ACRE
   FML PLACEMENT QUALITY        =  3 - GOOD


                            LAYER  8
                            --------

                    TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
   THICKNESS                    =       36.00   INCHES
   POROSITY                     =        0.4270 VOL/VOL
   FIELD CAPACITY               =        0.4180 VOL/VOL
   WILTING POINT                =        0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  3.% AND
          A SLOPE LENGTH OF  188. FEET.

 SCS RUNOFF CURVE NUMBER              =      84.00
 FRACTION OF AREA ALLOWING RUNOFF     =       0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE   =       1.000  ACRES
 EVAPORATIVE ZONE DEPTH               =       6.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE    =       2.742  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE   =       2.742  INCHES
```

```
      LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
      INITIAL SNOW WATER                  =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
      TOTAL INITIAL WATER                 =     70.838  INCHES
      TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DETROIT               MICHIGAN

           STATION LATITUDE                         =  42.40 DEGREES
           MAXIMUM LEAF AREA INDEX                  =   0.00
           START OF GROWING SEASON (JULIAN DATE)    =    121
           END OF GROWING SEASON (JULIAN DATE)      =    286
           EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
           AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT              MICHIGAN

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL       FEB/AUG       MAR/SEP       APR/OCT       MAY/NOV       JUN/DEC
   -------       -------       -------       -------       -------       -------
     1.86          1.69          2.54          3.15          2.77          3.43
     3.10          3.21          2.25          2.12          2.33          2.52


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT              MICHIGAN

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL       FEB/AUG       MAR/SEP       APR/OCT       MAY/NOV       JUN/DEC
   -------       -------       -------       -------       -------       -------
    23.40         25.80         35.00         47.40         58.10         67.70
    71.90         70.50         63.30         51.90         39.50         28.50


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT              MICHIGAN
                  AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                    1.75     1.67     2.39     4.10     3.71     4.04
                             2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS           0.61     0.62     1.28     1.20     1.61     1.04
                             1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                    0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS           0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    0.428    0.393    0.386    1.823    2.687    3.000
                             2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS           0.101    0.092    0.159    0.777    0.797    0.675
                             1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                    0.8788   0.8739   1.0478   2.3528   3.3154   1.7639
                             1.3849   1.0817   1.0406   0.8443   0.6825   0.5280

   STD. DEVIATIONS           0.6161   0.2239   0.5581   1.7390   0.8273   0.6134
                             0.6666   0.1953   0.7372   0.2766   0.0883   0.1640

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                  AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES                  0.0286    0.0313    0.0391    0.5814    0.2656    0.0592
                             0.0450    0.0352    0.0349    0.0274    0.0229    0.0172

   STD. DEVIATIONS           0.0200    0.0083    0.0253    1.0308    0.3694    0.0206
                             0.0217    0.0063    0.0248    0.0090    0.0030    0.0053

 DAILY AVERAGE HEAD ON TOP OF LAYER  7
 -------------------------------------
   AVERAGES                  0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                             0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

   STD. DEVIATIONS           0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                             0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    32.34     (   3.821)    117387.0    100.00

 RUNOFF                            0.000    (  0.0000)        0.00     0.000

 EVAPOTRANSPIRATION               17.213    (  1.6298)     62481.79    53.227

 LATERAL DRAINAGE COLLECTED       15.79451 (  3.88049)     57334.090  48.84196
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00004 (  0.00003)        0.144    0.00012
   LAYER  5

 AVERAGE HEAD ON TOP               0.099 (    0.094)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00004 (  0.00003)        0.135   0.00012
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)        0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.669    (  2.0887)     -2429.08    -2.069
*******************************************************************************


*******************************************************************************
```

```
           PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
  PRECIPITATION                                  2.56          9292.800

  RUNOFF                                         0.000            0.0000

  DRAINAGE COLLECTED FROM LAYER  3               0.23508        853.32965

  PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000004         0.01500

  AVERAGE HEAD ON TOP OF LAYER  4                4.693

  MAXIMUM HEAD ON TOP OF LAYER  4                7.430

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                   39.1 FEET

  DRAINAGE COLLECTED FROM LAYER  6               0.00000          0.01491

  PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000         0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                0.007

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                    0.0 FEET

  SNOW WATER                                     3.28         11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580


   ***  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.

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



□
*************************************************************************

            FINAL WATER STORAGE AT END OF YEAR    5
----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          25.2346         0.2103

                2           1.2512         0.1043

                3           0.0120         0.0598
```

```
                       4            0.0000         0.0000
                       5           25.6200         0.4270
                       6            0.0020         0.0100
                       7            0.0000         0.0000
                       8           15.3720         0.4270
                  SNOW WATER        0.000
********************************************************************************
********************************************************************************
```

```
▯
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP4NW-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP4NW-1.OUT


TIME:  10: 6     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P3 NW AREA

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


     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   5
          THICKNESS                  =    120.00   INCHES
          POROSITY                   =      0.4570 VOL/VOL
          FIELD CAPACITY             =      0.1310 VOL/VOL
          WILTING POINT              =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00    INCHES
POROSITY                     =      0.4170 VOL/VOL
FIELD CAPACITY               =      0.0450 VOL/VOL
WILTING POINT                =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                      LAYER  3
                      --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20    INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0101 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   1.22000003000      CM/SEC
SLOPE                        =      5.40    PERCENT
DRAINAGE LENGTH              =    352.0     FEET


                      LAYER  4
                      --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.08    INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =      1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                      LAYER  5
                      --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                    =     60.00    INCHES
POROSITY                     =      0.4270 VOL/VOL
FIELD CAPACITY               =      0.4180 VOL/VOL
WILTING POINT                =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                      LAYER  6
                      --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.20   INCHES
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.    =     1.22000003000     CM/SEC
SLOPE                        =       5.40   PERCENT
DRAINAGE LENGTH              =     352.0    FEET


                          LAYER  7
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.08   INCHES
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.    =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                          LAYER  8
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                    =      36.00   INCHES
POROSITY                     =       0.4270 VOL/VOL
FIELD CAPACITY               =       0.4180 VOL/VOL
WILTING POINT                =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  5.% AND
           A SLOPE LENGTH OF  352. FEET.

SCS RUNOFF CURVE NUMBER             =     83.80
FRACTION OF AREA ALLOWING RUNOFF    =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      6.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.742  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.742  INCHES
```

```
   LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
   INITIAL SNOW WATER                  =       0.000  INCHES
   INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
   TOTAL INITIAL WATER                 =      70.838  INCHES
   TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             DETROIT                MICHIGAN

        STATION LATITUDE                         =  42.40 DEGREES
        MAXIMUM LEAF AREA INDEX                  =   0.00
        START OF GROWING SEASON (JULIAN DATE)    =    121
        END OF GROWING SEASON (JULIAN DATE)      =    286
        EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
        AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT             MICHIGAN

             NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
   1.86         1.69         2.54         3.15         2.77         3.43
   3.10         3.21         2.25         2.12         2.33         2.52


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT             MICHIGAN

        NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
  23.40        25.80        35.00        47.40        58.10        67.70
  71.90        70.50        63.30        51.90        39.50        28.50


    NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT             MICHIGAN
               AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
                                  6GP4NW-1
          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH     5
-------------------------------------------------------------------------------

                              JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                              -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                       1.75     1.67     2.39     4.10     3.71     4.04
                                2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS              0.61     0.62     1.28     1.20     1.61     1.04
                                1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                      0.000    0.000    0.000    0.000    0.000    0.000
                               0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS             0.000    0.000    0.000    0.000    0.000    0.000
                               0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                      0.428    0.393    0.386    1.823    2.687    3.000
                               2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS             0.101    0.092    0.159    0.777    0.797    0.675
                               1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                     0.8796   0.8741   1.0491   2.3598   3.3088   1.7626
                              1.3846   1.0820   1.0400   0.8441   0.6822   0.5278

   STD. DEVIATIONS            0.6163   0.2239   0.5592   1.7318   0.8185   0.6161
                              0.6664   0.1963   0.7372   0.2760   0.0882   0.1651

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                   0.0268   0.0294   0.0370   0.4909   0.1980   0.0555
                               0.0422   0.0330   0.0328   0.0257   0.0215   0.0161

    STD. DEVIATIONS            0.0188   0.0078   0.0243   0.8387   0.2322   0.0194
                               0.0203   0.0060   0.0232   0.0084   0.0028   0.0050

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES             CU. FEET       PERCENT
                                -------------------   -------------   ---------
 PRECIPITATION                    32.34     (   3.821)    117387.0     100.00

 RUNOFF                            0.000    (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION               17.213    (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED       15.79465 (  3.88130)     57334.562    48.84236
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00003 (  0.00003)         0.126     0.00011
   LAYER  5

 AVERAGE HEAD ON TOP               0.084 (     0.077)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00003 (  0.00003)         0.117    0.00010
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)         0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (     0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.669    (  2.0888)     -2429.56     -2.070
*******************************************************************************


□
******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
   PRECIPITATION                                2.56        9292.800

   RUNOFF                                       0.000          0.0000

   DRAINAGE COLLECTED FROM LAYER  3             0.24889      903.46655

   PERCOLATION/LEAKAGE THROUGH LAYER  5         0.000004       0.01444

   AVERAGE HEAD ON TOP OF LAYER  4              4.501

   MAXIMUM HEAD ON TOP OF LAYER  4              8.153

   LOCATION OF MAXIMUM HEAD IN LAYER  3
          (DISTANCE FROM DRAIN)                32.3 FEET

   DRAINAGE COLLECTED FROM LAYER  6             0.00000        0.01432

   PERCOLATION/LEAKAGE THROUGH LAYER  8         0.000000       0.00002

   AVERAGE HEAD ON TOP OF LAYER  7              0.000

   MAXIMUM HEAD ON TOP OF LAYER  7              0.000

   LOCATION OF MAXIMUM HEAD IN LAYER  6
          (DISTANCE FROM DRAIN)                 0.0 FEET

   SNOW WATER                                   3.28        11902.9795

   MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0580

    ***  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    5
----------------------------------------------------------------------
                   LAYER        (INCHES)        (VOL/VOL)
                   -----        --------        ---------
                     1           25.2346         0.2103

                     2            1.2512         0.1043

                     3            0.0113         0.0564
```

```
                      4            0.0000         0.0000
                      5           25.6200         0.4270
                      6            0.0020         0.0100
                      7            0.0000         0.0000
                      8           15.3720         0.4270
                  SNOW WATER       0.000
*******************************************************************************
*******************************************************************************
```

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


PRECIPITATION DATA FILE:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:        S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6GP4SE-F.D10
OUTPUT DATA FILE:             S:\WASTE\ENGINE~1\HELP3.07\6GP4SE-1.OUT


TIME:  10: 9     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P3 SE AREA

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


     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   5
           THICKNESS                    =   120.00   INCHES
           POROSITY                     =     0.4570 VOL/VOL
           FIELD CAPACITY               =     0.1310 VOL/VOL
           WILTING POINT                =     0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.4170 VOL/VOL
FIELD CAPACITY               =      0.0450 VOL/VOL
WILTING POINT                =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                         LAYER  3
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
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.    =   1.22000003000     CM/SEC
SLOPE                        =      4.40   PERCENT
DRAINAGE LENGTH              =    217.0    FEET


                         LAYER  4
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.08   INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                         LAYER  5
                         --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
THICKNESS                    =     60.00   INCHES
POROSITY                     =      0.4270 VOL/VOL
FIELD CAPACITY               =      0.4180 VOL/VOL
WILTING POINT                =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                         LAYER  6
                         --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
      THICKNESS                      =        0.20    INCHES
      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.      =     1.22000003000      CM/SEC
      SLOPE                          =        4.40    PERCENT
      DRAINAGE LENGTH                =      217.0     FEET


                          LAYER  7
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
      THICKNESS                      =        0.08    INCHES
      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.      =  0.199999996000E-12 CM/SEC
      FML PINHOLE DENSITY            =        1.00    HOLES/ACRE
      FML INSTALLATION DEFECTS       =        1.00    HOLES/ACRE
      FML PLACEMENT QUALITY          =  3 - GOOD


                          LAYER  8
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
      THICKNESS                      =       36.00    INCHES
      POROSITY                       =        0.4270 VOL/VOL
      FIELD CAPACITY                 =        0.4180 VOL/VOL
      WILTING POINT                  =        0.3670 VOL/VOL
      INITIAL SOIL WATER CONTENT     =        0.4270 VOL/VOL
      EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
              GROUND CONDITIONS, A SURFACE SLOPE OF  4.% AND
              A SLOPE LENGTH OF  217. FEET.

    SCS RUNOFF CURVE NUMBER                 =      84.10
    FRACTION OF AREA ALLOWING RUNOFF        =       0.0     PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE      =       1.000   ACRES
    EVAPORATIVE ZONE DEPTH                  =       6.0     INCHES
    INITIAL WATER IN EVAPORATIVE ZONE       =       2.742   INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE      =       2.742   INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
TOTAL INITIAL WATER                 =     70.838  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DETROIT               MICHIGAN

     STATION LATITUDE                          =  42.40 DEGREES
     MAXIMUM LEAF AREA INDEX                   =   0.00
     START OF GROWING SEASON (JULIAN DATE)     =    121
     END OF GROWING SEASON (JULIAN DATE)       =    286
     EVAPORATIVE ZONE DEPTH                    =    6.0  INCHES
     AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.86         1.69         2.54         3.15         2.77         3.43
  3.10         3.21         2.25         2.12         2.33         2.52


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 23.40        25.80        35.00        47.40        58.10        67.70
 71.90        70.50        63.30        51.90        39.50        28.50


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN
            AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                           2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                           1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                 0.8829   0.8749   1.0540   2.3753   3.2947   1.7578
                          1.3837   1.0834   1.0374   0.8435   0.6811   0.5266

   STD. DEVIATIONS        0.6168   0.2239   0.5630   1.7137   0.7994   0.6261
                          0.6654   0.2000   0.7368   0.2738   0.0876   0.1696

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------

  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                    0.0203   0.0222   0.0243   0.1632   0.0759   0.0419
                                0.0319   0.0250   0.0247   0.0194   0.0162   0.0121

    STD. DEVIATIONS             0.0142   0.0059   0.0130   0.2458   0.0184   0.0149
                                0.0153   0.0046   0.0175   0.0063   0.0021   0.0039

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                     INCHES             CU. FEET        PERCENT
                               -------------------   -------------    ---------
 PRECIPITATION                  32.34     (   3.821)    117387.0       100.00

 RUNOFF                          0.000    (  0.0000)         0.00        0.000

 EVAPOTRANSPIRATION             17.213    (  1.6298)     62481.79       53.227

 LATERAL DRAINAGE COLLECTED     15.79513 (  3.88431)     57336.332    48.84387
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00002 (  0.00001)         0.071      0.00006
   LAYER  5

 AVERAGE HEAD ON TOP             0.040 (    0.024)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED      0.00002 (  0.00001)         0.062     0.00005
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.009      0.00001
   LAYER  8

 AVERAGE HEAD ON TOP             0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE        -0.670    (  2.0889)     -2431.26      -2.071
*******************************************************************************


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```

```
              PEAK DAILY VALUES FOR YEARS     1 THROUGH     5
-------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
  PRECIPITATION                                    2.56         9292.800

  RUNOFF                                           0.000           0.0000

  DRAINAGE COLLECTED FROM LAYER  3                 0.31084      1128.33765

  PERCOLATION/LEAKAGE THROUGH LAYER  5             0.000003        0.00957

  AVERAGE HEAD ON TOP OF LAYER  4                  2.929

  MAXIMUM HEAD ON TOP OF LAYER  4                  5.201

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                     23.7 FEET

  DRAINAGE COLLECTED FROM LAYER  6                 0.00000         0.00948

  PERCOLATION/LEAKAGE THROUGH LAYER  8             0.000000        0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                  0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                  0.000

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                      0.0 FEET

  SNOW WATER                                       3.28        11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                       0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                       0.0580


   ***  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    5
---------------------------------------------------------------------
                LAYER        (INCHES)      (VOL/VOL)
                -----        --------      ---------
                  1          25.2346         0.2103

                  2           1.2512         0.1043

                  3           0.0089         0.0446
```

```
                 4            0.0000          0.0000
                 5           25.6200          0.4270
                 6            0.0020          0.0100
                 7            0.0000          0.0000
                 8           15.3720          0.4270
            SNOW WATER        0.000
******************************************************************************
******************************************************************************
```

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


PRECIPITATION DATA FILE:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:        S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6GP4SW-F.D10
OUTPUT DATA FILE:             S:\WASTE\ENGINE~1\HELP3.07\6GP4SW-1.OUT


TIME:  10:19     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P3 SW AREA

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


     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   5
          THICKNESS                    =    120.00    INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.1310 VOL/VOL
          WILTING POINT                =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      12.00   INCHES
POROSITY                      =       0.4170 VOL/VOL
FIELD CAPACITY                =       0.0450 VOL/VOL
WILTING POINT                 =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =       0.20   INCHES
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.     =   1.22000003000      CM/SEC
SLOPE                         =       4.27   PERCENT
DRAINAGE LENGTH               =     205.0    FEET


                          LAYER  4
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                     =       0.08   INCHES
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.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                          LAYER  5
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                     =      60.00   INCHES
POROSITY                      =       0.4270 VOL/VOL
FIELD CAPACITY                =       0.4180 VOL/VOL
WILTING POINT                 =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
               TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =        0.20   INCHES
 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.    =     1.22000003000     CM/SEC
 SLOPE                        =        4.27   PERCENT
 DRAINAGE LENGTH              =      205.0    FEET


                          LAYER  7
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
 THICKNESS                    =        0.08   INCHES
 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.    =   0.199999996000E-12 CM/SEC
 FML PINHOLE DENSITY          =        1.00   HOLES/ACRE
 FML INSTALLATION DEFECTS     =        1.00   HOLES/ACRE
 FML PLACEMENT QUALITY        =   3 - GOOD


                          LAYER  8
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
 THICKNESS                    =      36.00   INCHES
 POROSITY                     =       0.4270 VOL/VOL
 FIELD CAPACITY               =       0.4180 VOL/VOL
 WILTING POINT                =       0.3670 VOL/VOL
 INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  4.% AND
           A SLOPE LENGTH OF  205. FEET.

 SCS RUNOFF CURVE NUMBER               =     84.10
 FRACTION OF AREA ALLOWING RUNOFF      =      0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE    =      1.000  ACRES
 EVAPORATIVE ZONE DEPTH                =      6.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE     =      2.742  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE    =      2.742  INCHES
```

```
     LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
     INITIAL SNOW WATER                  =       0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
     TOTAL INITIAL WATER                 =      70.838  INCHES
     TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               DETROIT                MICHIGAN

          STATION LATITUDE                        =  42.40 DEGREES
          MAXIMUM LEAF AREA INDEX                 =   0.00
          START OF GROWING SEASON (JULIAN DATE)   =    121
          END OF GROWING SEASON (JULIAN DATE)     =    286
          EVAPORATIVE ZONE DEPTH                  =   6.0  INCHES
          AVERAGE ANNUAL WIND SPEED               =  10.20 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  73.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  67.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  71.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  75.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT             MICHIGAN

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    1.86        1.69        2.54        3.15        2.77        3.43
    3.10        3.21        2.25        2.12        2.33        2.52


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT             MICHIGAN

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   23.40       25.80       35.00       47.40       58.10       67.70
   71.90       70.50       63.30       51.90       39.50       28.50


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT             MICHIGAN
                AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                    1.75     1.67     2.39     4.10     3.71     4.04
                             2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS           0.61     0.62     1.28     1.20     1.61     1.04
                             1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                    0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS           0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    0.428    0.393    0.386    1.823    2.687    3.000
                             2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS           0.101    0.092    0.159    0.777    0.797    0.675
                             1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                    0.8832   0.8750   1.0543   2.3755   3.2946   1.7574
                             1.3837   1.0835   1.0371   0.8434   0.6810   0.5265

   STD. DEVIATIONS           0.6168   0.2239   0.5633   1.7131   0.7992   0.6269
                             0.6653   0.2003   0.7367   0.2736   0.0876   0.1700

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

------------------------------------------------------------------------------
```

```
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0198   0.0216   0.0237   0.1266   0.0739   0.0407
                              0.0310   0.0243   0.0240   0.0189   0.0158   0.0118

    STD. DEVIATIONS           0.0138   0.0057   0.0126   0.1983   0.0179   0.0145
                              0.0149   0.0045   0.0171   0.0061   0.0020   0.0038

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    32.34    (   3.821)    117387.0     100.00

 RUNOFF                            0.000   (  0.0000)         0.00     0.000

 EVAPOTRANSPIRATION               17.213   (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED       15.79517 (  3.88458)    57336.465   48.84398
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00002 (  0.00001)        0.067    0.00006
   LAYER  5

 AVERAGE HEAD ON TOP               0.036 (    0.020)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00002 (  0.00001)        0.058   0.00005
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)        0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.670   (  2.0889)     -2431.40    -2.071
*******************************************************************************


□
******************************************************************************
```

```
               PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
   PRECIPITATION                                  2.56           9292.800

   RUNOFF                                         0.000            0.0000

   DRAINAGE COLLECTED FROM LAYER  3               0.31863        1156.62695

   PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000003           0.00959

   AVERAGE HEAD ON TOP OF LAYER  4                2.934

   MAXIMUM HEAD ON TOP OF LAYER  4                5.161

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                   23.7 FEET

   DRAINAGE COLLECTED FROM LAYER  6               0.00000            0.00767

   PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000           0.00002

   AVERAGE HEAD ON TOP OF LAYER  7                0.000

   MAXIMUM HEAD ON TOP OF LAYER  7                0.004

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                    0.0 FEET

   SNOW WATER                                     3.28          11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580

    ***  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.

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


▯
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR    5
-----------------------------------------------------------------------
                LAYER          (INCHES)        (VOL/VOL)
                -----          --------        ---------
                  1            25.2346          0.2103

                  2             1.2512          0.1043

                  3             0.0087          0.0437
```

```
                    4              0.0000          0.0000

                    5             25.6200          0.4270

                    6              0.0020          0.0100

                    7              0.0000          0.0000

                    8             15.3720          0.4270

               SNOW WATER          0.000

******************************************************************************
******************************************************************************
```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP5NE-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP5NE-1.OUT


TIME:  10:21     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P4 NE AREA

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


     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   5
           THICKNESS                 =    120.00   INCHES
           POROSITY                  =      0.4570 VOL/VOL
           FIELD CAPACITY            =      0.1310 VOL/VOL
           WILTING POINT             =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     12.00   INCHES
POROSITY                      =      0.4170 VOL/VOL
FIELD CAPACITY                =      0.0450 VOL/VOL
WILTING POINT                 =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.20   INCHES
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.     =   1.22000003000      CM/SEC
SLOPE                         =      5.70   PERCENT
DRAINAGE LENGTH               =    207.0    FEET


                          LAYER  4
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                     =      0.08   INCHES
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.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                          LAYER  5
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
THICKNESS                     =     60.00   INCHES
POROSITY                      =      0.4270 VOL/VOL
FIELD CAPACITY                =      0.4180 VOL/VOL
WILTING POINT                 =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
     THICKNESS                   =        0.20   INCHES
     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.   =     1.22000003000      CM/SEC
     SLOPE                       =        5.70   PERCENT
     DRAINAGE LENGTH             =      207.0    FEET


                            LAYER  7
                            --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
     THICKNESS                   =        0.08   INCHES
     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.   =  0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY         =        1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS    =        1.00   HOLES/ACRE
     FML PLACEMENT QUALITY       =  3 - GOOD


                            LAYER  8
                            --------

                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
     THICKNESS                   =       36.00   INCHES
     POROSITY                    =        0.4270 VOL/VOL
     FIELD CAPACITY              =        0.4180 VOL/VOL
     WILTING POINT               =        0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT  =        0.4270 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
            GROUND CONDITIONS, A SURFACE SLOPE OF  6.% AND
            A SLOPE LENGTH OF  207. FEET.

   SCS RUNOFF CURVE NUMBER               =     84.30
   FRACTION OF AREA ALLOWING RUNOFF      =      0.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE    =      1.000   ACRES
   EVAPORATIVE ZONE DEPTH                =      6.0     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE     =      2.742   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE    =      2.742   INCHES
```

```
   LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
   INITIAL SNOW WATER                  =       0.000  INCHES
   INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
   TOTAL INITIAL WATER                 =      70.838  INCHES
   TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             DETROIT              MICHIGAN

        STATION LATITUDE                          =  42.40 DEGREES
        MAXIMUM LEAF AREA INDEX                   =   0.00
        START OF GROWING SEASON (JULIAN DATE)     =    121
        END OF GROWING SEASON (JULIAN DATE)       =    286
        EVAPORATIVE ZONE DEPTH                    =   6.0  INCHES
        AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT             MICHIGAN

             NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    1.86        1.69        2.54        3.15        2.77        3.43
    3.10        3.21        2.25        2.12        2.33        2.52


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT             MICHIGAN

        NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   23.40       25.80       35.00       47.40       58.10       67.70
   71.90       70.50       63.30       51.90       39.50       28.50


    NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DETROIT             MICHIGAN
               AND STATION LATITUDE  =  42.40 DEGREES



***********************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.428    0.393    0.386    1.823    2.687    3.000
                            2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS          0.101    0.092    0.159    0.777    0.797    0.675
                            1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                   0.8855   0.8756   1.0576   2.3817   3.2900   1.7537
                            1.3829   1.0848   1.0351   0.8429   0.6802   0.5256

   STD. DEVIATIONS          0.6170   0.2241   0.5656   1.7047   0.7922   0.6338
                            0.6644   0.2032   0.7360   0.2720   0.0871   0.1733

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                 0.0150   0.0164   0.0180   0.0475   0.0559   0.0308
                             0.0235   0.0184   0.0182   0.0143   0.0119   0.0089

    STD. DEVIATIONS          0.0105   0.0044   0.0096   0.0423   0.0135   0.0111
                             0.0113   0.0035   0.0129   0.0046   0.0015   0.0029

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                    INCHES             CU. FEET        PERCENT
                              -------------------   -------------    ---------
 PRECIPITATION                 32.34     (   3.821)   117387.0       100.00

 RUNOFF                         0.000    (  0.0000)        0.00        0.000

 EVAPOTRANSPIRATION            17.213    (  1.6298)     62481.79      53.227

 LATERAL DRAINAGE COLLECTED    15.79550 (  3.88678)     57337.672    48.84501
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH    0.00001 (  0.00000)         0.049      0.00004
   LAYER  5

 AVERAGE HEAD ON TOP            0.023 (    0.007)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED     0.00001 (  0.00000)         0.040     0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)         0.009      0.00001
   LAYER  8

 AVERAGE HEAD ON TOP            0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE       -0.670    (  2.0890)     -2432.59      -2.072
*******************************************************************************


******************************************************************************
```

```
            PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
----------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
   PRECIPITATION                                  2.56         9292.800

   RUNOFF                                         0.000           0.0000

   DRAINAGE COLLECTED FROM LAYER  3               0.36522      1325.76208

   PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000001        0.00357

   AVERAGE HEAD ON TOP OF LAYER  4                1.051

   MAXIMUM HEAD ON TOP OF LAYER  4                1.864

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                    8.9 FEET

   DRAINAGE COLLECTED FROM LAYER  6               0.00000         0.00221

   PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000        0.00002

   AVERAGE HEAD ON TOP OF LAYER  7                0.000

   MAXIMUM HEAD ON TOP OF LAYER  7                0.039

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                    0.0 FEET

   SNOW WATER                                     3.28        11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580


    ***  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.

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



□
*******************************************************************************

              FINAL WATER STORAGE AT END OF YEAR    5
----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          25.2346         0.2103

                2           1.2512         0.1043

                3           0.0071         0.0355
```

```
                      4            0.0000          0.0000
                      5           25.6200          0.4270
                      6            0.0020          0.0100
                      7            0.0000          0.0000
                      8           15.3720          0.4270
                  SNOW WATER       0.000
******************************************************************************
******************************************************************************
```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP5NW-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP5NW-1.OUT


TIME:  10:23     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P4 NW AREA

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


     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   5
           THICKNESS                     =     120.00    INCHES
           POROSITY                      =       0.4570 VOL/VOL
           FIELD CAPACITY                =       0.1310 VOL/VOL
           WILTING POINT                 =       0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT    =       0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       12.00    INCHES
POROSITY                     =        0.4170 VOL/VOL
FIELD CAPACITY               =        0.0450 VOL/VOL
WILTING POINT                =        0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =        0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =    0.999999978000E-02 CM/SEC


                         LAYER  3
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =        0.20    INCHES
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.    =     1.22000003000      CM/SEC
SLOPE                        =        6.30    PERCENT
DRAINAGE LENGTH              =      230.0     FEET


                         LAYER  4
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                    =        0.08    INCHES
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.    =    0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =        1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =        1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =    3 - GOOD


                         LAYER  5
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                    =       60.00    INCHES
POROSITY                     =        0.4270 VOL/VOL
FIELD CAPACITY               =        0.4180 VOL/VOL
WILTING POINT                =        0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =    0.100000001000E-06 CM/SEC


                         LAYER  6
                         --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                   =       0.20   INCHES
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.   =     1.22000003000     CM/SEC
SLOPE                       =       6.30   PERCENT
DRAINAGE LENGTH             =     230.0    FEET


                          LAYER  7
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                   =       0.08   INCHES
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.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                          LAYER  8
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
THICKNESS                   =      36.00   INCHES
POROSITY                    =       0.4270 VOL/VOL
FIELD CAPACITY              =       0.4180 VOL/VOL
WILTING POINT               =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  6.% AND
          A SLOPE LENGTH OF  230. FEET.

SCS RUNOFF CURVE NUMBER            =      84.20
FRACTION OF AREA ALLOWING RUNOFF   =       0.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =       1.000   ACRES
EVAPORATIVE ZONE DEPTH             =       6.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =       2.742   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =       2.742   INCHES
```

```
        LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
        INITIAL SNOW WATER                  =       0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
        TOTAL INITIAL WATER                 =      70.838  INCHES
        TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  DETROIT                MICHIGAN

             STATION LATITUDE                         =  42.40 DEGREES
             MAXIMUM LEAF AREA INDEX                  =   0.00
             START OF GROWING SEASON (JULIAN DATE)    =    121
             END OF GROWING SEASON (JULIAN DATE)      =    286
             EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
             AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
             AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
             AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
             AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
             AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DETROIT              MICHIGAN

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
      -------      -------      -------      -------      -------      -------
        1.86         1.69         2.54         3.15         2.77         3.43
        3.10         3.21         2.25         2.12         2.33         2.52


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DETROIT              MICHIGAN

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
      -------      -------      -------      -------      -------      -------
       23.40        25.80        35.00        47.40        58.10        67.70
       71.90        70.50        63.30        51.90        39.50        28.50


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DETROIT              MICHIGAN
                    AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    5
------------------------------------------------------------------------------

                              JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                              -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                       1.75     1.67     2.39     4.10     3.71     4.04
                                2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS              0.61     0.62     1.28     1.20     1.61     1.04
                                1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                       0.000    0.000    0.000    0.000    0.000    0.000
                                0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS              0.000    0.000    0.000    0.000    0.000    0.000
                                0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                       0.428    0.393    0.386    1.823    2.687    3.000
                                2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS              0.101    0.092    0.159    0.777    0.797    0.675
                                1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                       0.8855   0.8756   1.0575   2.3816   3.2901   1.7537
                                1.3829   1.0848   1.0351   0.8429   0.6803   0.5256

   STD. DEVIATIONS              0.6170   0.2241   0.5655   1.7049   0.7923   0.6337
                                0.6644   0.2031   0.7360   0.2721   0.0871   0.1732

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

------------------------------------------------------------------------------
```

```
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------

  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                 0.0151   0.0165   0.0181   0.0478   0.0562   0.0310
                             0.0236   0.0185   0.0183   0.0144   0.0120   0.0090

    STD. DEVIATIONS          0.0105   0.0044   0.0097   0.0425   0.0135   0.0112
                             0.0114   0.0035   0.0130   0.0047   0.0015   0.0030

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET     PERCENT
                                  -------------------  -------------  ---------
 PRECIPITATION                     32.34    (   3.821)    117387.0     100.00

 RUNOFF                             0.000   (  0.0000)        0.00      0.000

 EVAPOTRANSPIRATION                17.213   (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED        15.79550 (  3.88673)    57337.652   48.84499
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH        0.00001 (  0.00000)        0.049     0.00004
   LAYER  5

 AVERAGE HEAD ON TOP                0.023 (    0.007)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED         0.00001 (  0.00000)        0.040    0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH        0.00000 (  0.00000)        0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP                0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE           -0.670   (  2.0890)     -2432.56     -2.072
*******************************************************************************


□
*******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
  PRECIPITATION                                    2.56        9292.800

  RUNOFF                                           0.000          0.0000

  DRAINAGE COLLECTED FROM LAYER  3                 0.36425     1322.21655

  PERCOLATION/LEAKAGE THROUGH LAYER  5             0.000001       0.00357

  AVERAGE HEAD ON TOP OF LAYER  4                  1.052

  MAXIMUM HEAD ON TOP OF LAYER  4                  1.884

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                      8.3 FEET

  DRAINAGE COLLECTED FROM LAYER  6                 0.00000        0.00220

  PERCOLATION/LEAKAGE THROUGH LAYER  8             0.000000       0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                  0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                  0.041

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                      0.0 FEET

  SNOW WATER                                       3.28       11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580


   ***  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.

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


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

                FINAL WATER STORAGE AT END OF YEAR    5
------------------------------------------------------------------------
                 LAYER        (INCHES)      (VOL/VOL)
                 -----        --------      ---------
                   1          25.2346        0.2103

                   2           1.2512        0.1043

                   3           0.0071        0.0357
```

```
                  4          0.0000          0.0000
                  5         25.6200          0.4270
                  6          0.0020          0.0100
                  7          0.0000          0.0000
                  8         15.3720          0.4270
              SNOW WATER     0.000
********************************************************************************
********************************************************************************
```

```
□
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP5SE-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP5SE-1.OUT


TIME:  10:24     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P4 SE AREA

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


     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   5
          THICKNESS                   =   120.00   INCHES
          POROSITY                    =     0.4570 VOL/VOL
          FIELD CAPACITY              =     0.1310 VOL/VOL
          WILTING POINT               =     0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT  =     0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      12.00   INCHES
POROSITY                   =       0.4170 VOL/VOL
FIELD CAPACITY             =       0.0450 VOL/VOL
WILTING POINT              =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999978000E-02 CM/SEC


                        LAYER  3
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                  =       0.20   INCHES
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.  =   1.22000003000      CM/SEC
SLOPE                      =       4.30   PERCENT
DRAINAGE LENGTH            =     177.0    FEET


                        LAYER  4
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                  =       0.08   INCHES
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.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD


                        LAYER  5
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                  =      60.00   INCHES
POROSITY                   =       0.4270 VOL/VOL
FIELD CAPACITY             =       0.4180 VOL/VOL
WILTING POINT              =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000001000E-06 CM/SEC


                        LAYER  6
                        --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                      =        0.20    INCHES
  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.      =     1.22000003000      CM/SEC
  SLOPE                          =        4.30    PERCENT
  DRAINAGE LENGTH                =      177.0     FEET


                           LAYER  7
                           --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
  THICKNESS                      =        0.08    INCHES
  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.      =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY            =        1.00    HOLES/ACRE
  FML INSTALLATION DEFECTS       =        1.00    HOLES/ACRE
  FML PLACEMENT QUALITY          =  3 - GOOD


                           LAYER  8
                           --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
  THICKNESS                      =       36.00    INCHES
  POROSITY                       =        0.4270 VOL/VOL
  FIELD CAPACITY                 =        0.4180 VOL/VOL
  WILTING POINT                  =        0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT     =        0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


             GENERAL DESIGN AND EVAPORATIVE ZONE DATA
             ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  4.% AND
          A SLOPE LENGTH OF  177. FEET.

 SCS RUNOFF CURVE NUMBER             =      84.30
 FRACTION OF AREA ALLOWING RUNOFF    =       0.0     PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE  =       1.000   ACRES
 EVAPORATIVE ZONE DEPTH              =       6.0     INCHES
 INITIAL WATER IN EVAPORATIVE ZONE   =       2.742   INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE  =       2.742   INCHES
```

```
     LOWER LIMIT OF EVAPORATIVE STORAGE =        0.348  INCHES
     INITIAL SNOW WATER                 =        0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS   =       70.838  INCHES
     TOTAL INITIAL WATER                =       70.838  INCHES
     TOTAL SUBSURFACE INFLOW            =        0.00   INCHES/YEAR


               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               DETROIT                MICHIGAN

          STATION LATITUDE                        =  42.40 DEGREES
          MAXIMUM LEAF AREA INDEX                 =   0.00
          START OF GROWING SEASON (JULIAN DATE)   =    121
          END OF GROWING SEASON (JULIAN DATE)     =    286
          EVAPORATIVE ZONE DEPTH                  =   6.0  INCHES
          AVERAGE ANNUAL WIND SPEED               =  10.20 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  73.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  67.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  71.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  75.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT                MICHIGAN

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     1.86        1.69        2.54        3.15        2.77        3.43
     3.10        3.21        2.25        2.12        2.33        2.52


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT                MICHIGAN

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    23.40       25.80       35.00       47.40       58.10       67.70
    71.90       70.50       63.30       51.90       39.50       28.50


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DETROIT                MICHIGAN
                 AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
                              6GP5SE-1
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                    1.75     1.67     2.39     4.10     3.71     4.04
                             2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS           0.61     0.62     1.28     1.20     1.61     1.04
                             1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                    0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS           0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    0.428    0.393    0.386    1.823    2.687    3.000
                             2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS           0.101    0.092    0.159    0.777    0.797    0.675
                             1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                    0.8846   0.8753   1.0563   2.3791   3.2919   1.7552
                             1.3832   1.0842   1.0359   0.8431   0.6805   0.5260

   STD. DEVIATIONS           0.6169   0.2240   0.5647   1.7081   0.7951   0.6310
                             0.6648   0.2020   0.7363   0.2727   0.0873   0.1719

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0170   0.0186   0.0203   0.0591   0.0633   0.0349
                              0.0266   0.0209   0.0206   0.0162   0.0135   0.0101

    STD. DEVIATIONS           0.0119   0.0049   0.0109   0.0598   0.0153   0.0125
                              0.0128   0.0039   0.0146   0.0052   0.0017   0.0033

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                       INCHES             CU. FEET      PERCENT
                                 -------------------   -------------   ---------
 PRECIPITATION                    32.34     (   3.821)   117387.0      100.00

 RUNOFF                            0.000    (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION               17.213    (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED       15.79537 (  3.88588)     57337.184   48.84459
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00001 (  0.00000)         0.054     0.00005
   LAYER  5

 AVERAGE HEAD ON TOP               0.027 (    0.008)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00001 (  0.00000)         0.045    0.00004
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)         0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.670    (  2.0890)     -2432.10     -2.072
*******************************************************************************


▯
******************************************************************************
```

```
                 PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
   PRECIPITATION                                2.56          9292.800

   RUNOFF                                       0.000            0.0000

   DRAINAGE COLLECTED FROM LAYER  3             0.35007       1270.76208

   PERCOLATION/LEAKAGE THROUGH LAYER  5         0.000002         0.00656

   AVERAGE HEAD ON TOP OF LAYER  4              1.985

   MAXIMUM HEAD ON TOP OF LAYER  4              3.480

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                 17.2 FEET

   DRAINAGE COLLECTED FROM LAYER  6             0.00000          0.00367

   PERCOLATION/LEAKAGE THROUGH LAYER  8         0.000000         0.00002

   AVERAGE HEAD ON TOP OF LAYER  7              0.000

   MAXIMUM HEAD ON TOP OF LAYER  7              0.049

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                  0.0 FEET

   SNOW WATER                                   3.28         11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0580


    ***  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.

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


0
**********************************************************************************

             FINAL WATER STORAGE AT END OF YEAR    5
------------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          25.2346         0.2103

                2           1.2512         0.1043

                3           0.0078         0.0388
```

```
              4            0.0000          0.0000

              5           25.6200          0.4270

              6            0.0020          0.0100

              7            0.0000          0.0000

              8           15.3720          0.4270

          SNOW WATER       0.000

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


PRECIPITATION DATA FILE:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:        S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6GP5SW-F.D10
OUTPUT DATA FILE:             S:\WASTE\ENGINE~1\HELP3.07\6GP5SW-1.OUT


TIME:  10:26     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P4 SW AREA

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


     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    5
          THICKNESS                      =    120.00    INCHES
          POROSITY                       =      0.4570 VOL/VOL
          FIELD CAPACITY                 =      0.1310 VOL/VOL
          WILTING POINT                  =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT     =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4170 VOL/VOL
FIELD CAPACITY               =       0.0450 VOL/VOL
WILTING POINT                =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.20    INCHES
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.    =   1.22000003000      CM/SEC
SLOPE                        =       5.10    PERCENT
DRAINAGE LENGTH              =     208.0     FEET


                          LAYER  4
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.08    INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  5
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
THICKNESS                    =      60.00    INCHES
POROSITY                     =       0.4270 VOL/VOL
FIELD CAPACITY               =       0.4180 VOL/VOL
WILTING POINT                =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =        0.20    INCHES
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.    =    1.22000003000      CM/SEC
SLOPE                        =        5.10    PERCENT
DRAINAGE LENGTH              =      208.0     FEET


                          LAYER  7
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                    =        0.08    INCHES
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.    =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =        1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =        1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                          LAYER  8
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                    =       36.00    INCHES
POROSITY                     =        0.4270 VOL/VOL
FIELD CAPACITY               =        0.4180 VOL/VOL
WILTING POINT                =        0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  5.% AND
           A SLOPE LENGTH OF  208. FEET.

SCS RUNOFF CURVE NUMBER              =      84.20
FRACTION OF AREA ALLOWING RUNOFF     =       0.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =       1.000   ACRES
EVAPORATIVE ZONE DEPTH               =       6.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =       2.742   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =       2.742   INCHES
```

```
        LOWER LIMIT OF EVAPORATIVE STORAGE  =     0.348  INCHES
        INITIAL SNOW WATER                  =     0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS    =    70.838  INCHES
        TOTAL INITIAL WATER                 =    70.838  INCHES
        TOTAL SUBSURFACE INFLOW             =     0.00   INCHES/YEAR


              EVAPOTRANSPIRATION AND WEATHER DATA
              -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                 DETROIT                MICHIGAN

           STATION LATITUDE                         =  42.40 DEGREES
           MAXIMUM LEAF AREA INDEX                  =   0.00
           START OF GROWING SEASON (JULIAN DATE)    =    121
           END OF GROWING SEASON (JULIAN DATE)      =    286
           EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
           AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT              MICHIGAN

                 NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        1.86        1.69        2.54        3.15        2.77        3.43
        3.10        3.21        2.25        2.12        2.33        2.52


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT              MICHIGAN

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       23.40       25.80       35.00       47.40       58.10       67.70
       71.90       70.50       63.30       51.90       39.50       28.50


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT              MICHIGAN
                  AND STATION LATITUDE  =  42.40 DEGREES


****************************************************************************
```

```
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.428    0.393    0.386    1.823    2.687    3.000
                            2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS          0.101    0.092    0.159    0.777    0.797    0.675
                            1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                   0.8846   0.8754   1.0564   2.3793   3.2918   1.7551
                            1.3832   1.0843   1.0359   0.8431   0.6805   0.5259

   STD. DEVIATIONS          0.6170   0.2240   0.5647   1.7079   0.7949   0.6312
                            0.6648   0.2021   0.7363   0.2726   0.0873   0.1720

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

------------------------------------------------------------------------------
```

```
                AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                    0.0169    0.0184    0.0201    0.0587    0.0628    0.0346
                                0.0264    0.0207    0.0204    0.0161    0.0134    0.0100

    STD. DEVIATIONS             0.0118    0.0049    0.0108    0.0594    0.0152    0.0124
                                0.0127    0.0039    0.0145    0.0052    0.0017    0.0033

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                                0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    STD. DEVIATIONS             0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
                                0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH   5
-------------------------------------------------------------------------------
                                     INCHES             CU. FEET        PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  32.34     (   3.821)    117387.0      100.00

 RUNOFF                          0.000    (  0.0000)         0.00       0.000

 EVAPOTRANSPIRATION             17.213    (  1.6298)     62481.79      53.227

 LATERAL DRAINAGE COLLECTED     15.79538 (  3.88594)     57337.227    48.84463
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00001 (  0.00000)         0.054     0.00005
   LAYER  5

 AVERAGE HEAD ON TOP             0.027 (    0.008)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED      0.00001 (  0.00000)         0.045    0.00004
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP             0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE        -0.670    (  2.0890)     -2432.14      -2.072
*******************************************************************************



******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS     1 THROUGH    5
------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
   PRECIPITATION                                  2.56          9292.800

   RUNOFF                                         0.000            0.0000

   DRAINAGE COLLECTED FROM LAYER  3               0.35190       1277.38477

   PERCOLATION/LEAKAGE THROUGH LAYER  5           0.000002         0.00655

   AVERAGE HEAD ON TOP OF LAYER  4                1.982

   MAXIMUM HEAD ON TOP OF LAYER  4                3.539

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                  16.0 FEET

   DRAINAGE COLLECTED FROM LAYER  6               0.00000          0.00368

   PERCOLATION/LEAKAGE THROUGH LAYER  8           0.000000         0.00002

   AVERAGE HEAD ON TOP OF LAYER  7                0.000

   MAXIMUM HEAD ON TOP OF LAYER  7                0.053

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                    0.0 FEET

   SNOW WATER                                     3.28         11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580


    ***  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    5
----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          25.2346         0.2103

                2           1.2512         0.1043

                3           0.0077         0.0386
```

```
          4             0.0000          0.0000

          5            25.6200          0.4270

          6             0.0020          0.0100

          7             0.0000          0.0000

          8            15.3720          0.4270

      SNOW WATER        0.000

******************************************************************************
******************************************************************************
```

```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP6NE-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP6NE-1.OUT


TIME:  10:28     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P5 NE AREA

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


     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   5
           THICKNESS                      =   120.00    INCHES
           POROSITY                       =     0.4570 VOL/VOL
           FIELD CAPACITY                 =     0.1310 VOL/VOL
           WILTING POINT                  =     0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT     =     0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                       =      12.00   INCHES
POROSITY                        =       0.4170 VOL/VOL
FIELD CAPACITY                  =       0.0450 VOL/VOL
WILTING POINT                   =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT      =       0.0933 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =   0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                       =       0.20   INCHES
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.       =    1.22000003000     CM/SEC
SLOPE                           =       8.20   PERCENT
DRAINAGE LENGTH                 =     166.0    FEET


                          LAYER  4
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                       =       0.08   INCHES
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.       =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY             =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS        =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY           =   3 - GOOD


                          LAYER  5
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
THICKNESS                       =      60.00   INCHES
POROSITY                        =       0.4270 VOL/VOL
FIELD CAPACITY                  =       0.4180 VOL/VOL
WILTING POINT                   =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT      =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =   0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
   THICKNESS                      =      0.20    INCHES
   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.      =   1.22000003000      CM/SEC
   SLOPE                          =      8.20    PERCENT
   DRAINAGE LENGTH                =    166.0     FEET


                           LAYER  7
                           --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
   THICKNESS                      =      0.08    INCHES
   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.      =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY            =      1.00    HOLES/ACRE
   FML INSTALLATION DEFECTS       =      1.00    HOLES/ACRE
   FML PLACEMENT QUALITY          =  3 - GOOD


                           LAYER  8
                           --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
   THICKNESS                      =     36.00    INCHES
   POROSITY                       =      0.4270 VOL/VOL
   FIELD CAPACITY                 =      0.4180 VOL/VOL
   WILTING POINT                  =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT     =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  8.% AND
          A SLOPE LENGTH OF  166. FEET.

 SCS RUNOFF CURVE NUMBER                =     84.60
 FRACTION OF AREA ALLOWING RUNOFF       =      0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE     =      1.000  ACRES
 EVAPORATIVE ZONE DEPTH                 =      6.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE      =      2.742  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE     =      2.742  INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     70.812  INCHES
TOTAL INITIAL WATER                 =     70.812  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DETROIT               MICHIGAN

     STATION LATITUDE                        =  42.40 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   0.00
     START OF GROWING SEASON (JULIAN DATE)   =    121
     END OF GROWING SEASON (JULIAN DATE)     =    286
     EVAPORATIVE ZONE DEPTH                  =   6.0  INCHES
     AVERAGE ANNUAL WIND SPEED               =  10.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  73.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  71.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  75.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN
            AND STATION LATITUDE  =  42.40 DEGREES


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```
                              6GP6NE-1
       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.831    2.676    3.005
                           2.308    2.275    1.307    1.048    0.979    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.787    0.794    0.659
                           1.019    0.521    0.898    0.348    0.365    0.174

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                 0.8753   0.8793   1.0626   2.3590   3.2841   1.7746
                          1.3670   1.0971   1.0466   0.8438   0.6850   0.5236

   STD. DEVIATIONS        0.6177   0.2281   0.5700   1.6659   0.7586   0.6422
                          0.6665   0.2127   0.7401   0.2736   0.0869   0.1531

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------

  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                 0.0083   0.0092   0.0101   0.0232   0.0312   0.0174
                             0.0130   0.0104   0.0103   0.0080   0.0067   0.0050

    STD. DEVIATIONS          0.0059   0.0025   0.0054   0.0164   0.0072   0.0063
                             0.0063   0.0020   0.0073   0.0026   0.0009   0.0015

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET     PERCENT
                                ------------------    ------------  ---------
 PRECIPITATION                   32.34    (   3.821)    117387.0     100.00

 RUNOFF                           0.000   (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION              17.199   (  1.6204)     62432.09     53.185

 LATERAL DRAINAGE COLLECTED      15.79809 (  3.92089)    57347.051   48.85300
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)        0.032     0.00003
   LAYER  5

 AVERAGE HEAD ON TOP              0.013 (    0.003)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00001 (  0.00000)        0.023    0.00002
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.659   (  2.0963)    -2392.22     -2.038
*******************************************************************************


□
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```

```
              PEAK DAILY VALUES FOR YEARS     1 THROUGH    5
-----------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------   -------------
   PRECIPITATION                                2.56         9292.800

   RUNOFF                                       0.000           0.0000

   DRAINAGE COLLECTED FROM LAYER  3             0.36279      1316.93005

   PERCOLATION/LEAKAGE THROUGH LAYER  5         0.000000        0.00048

   AVERAGE HEAD ON TOP OF LAYER  4              0.107

   MAXIMUM HEAD ON TOP OF LAYER  4              0.212

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                  0.1 FEET

   DRAINAGE COLLECTED FROM LAYER  6             0.00000         0.00041

   PERCOLATION/LEAKAGE THROUGH LAYER  8         0.000000        0.00002

   AVERAGE HEAD ON TOP OF LAYER  7              0.000

   MAXIMUM HEAD ON TOP OF LAYER  7              0.011

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                  0.0 FEET

   SNOW WATER                                   3.28        11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0580


    ***  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    5
----------------------------------------------------------------------
                LAYER        (INCHES)       (VOL/VOL)
                -----        --------       ---------
                  1           25.2668         0.2106

                  2            1.2516         0.1043

                  3            0.0048         0.0242
```

```
                      4            0.0000          0.0000

                      5           25.6200          0.4270

                      6            0.0020          0.0100

                      7            0.0000          0.0000

                      8           15.3720          0.4270

                  SNOW WATER       0.000

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP6NW-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP6NW-1.OUT


TIME:  10:29     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P5 NW AREA

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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   5
           THICKNESS                     =    120.00   INCHES
           POROSITY                      =      0.4570 VOL/VOL
           FIELD CAPACITY                =      0.1310 VOL/VOL
           WILTING POINT                 =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT    =      0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      12.00   INCHES
POROSITY                   =       0.4170 VOL/VOL
FIELD CAPACITY             =       0.0450 VOL/VOL
WILTING POINT              =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999978000E-02 CM/SEC


                      LAYER  3
                      --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =       0.20   INCHES
POROSITY                   =       0.8500 VOL/VOL
FIELD CAPACITY             =       0.0100 VOL/VOL
WILTING POINT              =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0103 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   1.22000003000     CM/SEC
SLOPE                      =       3.20   PERCENT
DRAINAGE LENGTH            =     250.0    FEET


                      LAYER  4
                      --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                  =       0.08   INCHES
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.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD


                      LAYER  5
                      --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                  =      60.00   INCHES
POROSITY                   =       0.4270 VOL/VOL
FIELD CAPACITY             =       0.4180 VOL/VOL
WILTING POINT              =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000001000E-06 CM/SEC


                      LAYER  6
                      --------
```

```
                  TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
   THICKNESS                      =      0.20    INCHES
   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.      =   1.22000003000      CM/SEC
   SLOPE                          =      3.20    PERCENT
   DRAINAGE LENGTH                =    250.0     FEET


                             LAYER  7
                             --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
   THICKNESS                      =      0.08    INCHES
   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.      =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY            =      1.00    HOLES/ACRE
   FML INSTALLATION DEFECTS       =      1.00    HOLES/ACRE
   FML PLACEMENT QUALITY          =  3 - GOOD


                             LAYER  8
                             --------

                    TYPE 3 - BARRIER SOIL LINER
                     MATERIAL TEXTURE NUMBER  16
   THICKNESS                      =     36.00    INCHES
   POROSITY                       =      0.4270 VOL/VOL
   FIELD CAPACITY                 =      0.4180 VOL/VOL
   WILTING POINT                  =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT     =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
           GROUND CONDITIONS, A SURFACE SLOPE OF  3.% AND
           A SLOPE LENGTH OF  250. FEET.

 SCS RUNOFF CURVE NUMBER                =     83.90
 FRACTION OF AREA ALLOWING RUNOFF       =      0.0     PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE     =      1.000   ACRES
 EVAPORATIVE ZONE DEPTH                 =      6.0     INCHES
 INITIAL WATER IN EVAPORATIVE ZONE      =      2.742   INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE     =      2.742   INCHES
```

```
    LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
    INITIAL SNOW WATER                  =      0.000  INCHES
    INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
    TOTAL INITIAL WATER                 =     70.838  INCHES
    TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              DETROIT                MICHIGAN

         STATION LATITUDE                         = 42.40 DEGREES
         MAXIMUM LEAF AREA INDEX                  =  0.00
         START OF GROWING SEASON (JULIAN DATE)    =   121
         END OF GROWING SEASON (JULIAN DATE)      =   286
         EVAPORATIVE ZONE DEPTH                   =  6.0  INCHES
         AVERAGE ANNUAL WIND SPEED                = 10.20 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY    = 73.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY    = 67.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY    = 71.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY    = 75.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DETROIT             MICHIGAN

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
   1.86         1.69         2.54         3.15         2.77         3.43
   3.10         3.21         2.25         2.12         2.33         2.52


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DETROIT             MICHIGAN

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
  23.40        25.80        35.00        47.40        58.10        67.70
  71.90        70.50        63.30        51.90        39.50        28.50


     NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DETROIT             MICHIGAN
                AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    5
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                  1.75     1.67     2.39     4.10     3.71     4.04
                           2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS         0.61     0.62     1.28     1.20     1.61     1.04
                           1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                           2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                           1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                  0.8770   0.8736   1.0450   2.3322   3.3354   1.7664
                           1.3853   1.0812   1.0419   0.8446   0.6831   0.5286

   STD. DEVIATIONS         0.6158   0.2240   0.5558   1.7323   0.8320   0.6080
                           0.6671   0.1934   0.7370   0.2778   0.0886   0.1617

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
          AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0320   0.0351   0.0481   0.7694   0.4424   0.0666
                              0.0505   0.0394   0.0393   0.0308   0.0257   0.0193

    STD. DEVIATIONS           0.0225   0.0093   0.0363   1.4321   0.6402   0.0229
                              0.0243   0.0071   0.0278   0.0101   0.0033   0.0059

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                     INCHES             CU. FEET       PERCENT
                                -------------------   -------------   ---------
 PRECIPITATION                    32.34     (   3.821)     117387.0     100.00

 RUNOFF                            0.000    (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION               17.213    (  1.6298)      62481.79     53.227

 LATERAL DRAINAGE COLLECTED       15.79424 (   3.87888)     57333.082   48.84110
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00005 (  0.00004)          0.186    0.00016
   LAYER  5

 AVERAGE HEAD ON TOP               0.133 (    0.129)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00005 (  0.00004)          0.177    0.00015
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)          0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.669    (  2.0887)      -2428.12     -2.068
*******************************************************************************


▯
******************************************************************************
```

```
               PEAK DAILY VALUES FOR YEARS     1 THROUGH    5
-------------------------------------------------------------------------
                                                (INCHES)    (CU. FT.)
                                               ----------  -------------
  PRECIPITATION                                   2.56       9292.800

  RUNOFF                                          0.000         0.0000

  DRAINAGE COLLECTED FROM LAYER  3                0.21298     773.11560

  PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000005      0.01642

  AVERAGE HEAD ON TOP OF LAYER  4                 5.180

  MAXIMUM HEAD ON TOP OF LAYER  4                 8.574

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                    42.9 FEET

  DRAINAGE COLLECTED FROM LAYER  6                0.00000       0.01635

  PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000      0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                 0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                 0.010

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                     0.0 FEET

  SNOW WATER                                      3.28      11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                        0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                        0.0580


   ***  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.

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


▯
*****************************************************************************

                 FINAL WATER STORAGE AT END OF YEAR    5
-------------------------------------------------------------------------
                  LAYER        (INCHES)       (VOL/VOL)
                  -----        --------       ---------
                    1          25.2346         0.2103

                    2           1.2512         0.1043

                    3           0.0133         0.0666
```

```
                    4           0.0000           0.0000

                    5          25.6200           0.4270

                    6           0.0020           0.0100

                    7           0.0000           0.0000

                    8          15.3720           0.4270

               SNOW WATER       0.000

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```

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□
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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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP6SE-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP6SE-1.OUT


TIME:  10:33     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P5 SE AREA

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


     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   5
           THICKNESS                    =   120.00    INCHES
           POROSITY                     =     0.4570 VOL/VOL
           FIELD CAPACITY               =     0.1310 VOL/VOL
           WILTING POINT                =     0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                    MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      12.00   INCHES
POROSITY                      =       0.4170 VOL/VOL
FIELD CAPACITY                =       0.0450 VOL/VOL
WILTING POINT                 =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
THICKNESS                     =       0.20   INCHES
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.     =   1.22000003000      CM/SEC
SLOPE                         =       8.90   PERCENT
DRAINAGE LENGTH               =     191.0    FEET


                          LAYER  4
                          --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
THICKNESS                     =       0.08   INCHES
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.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                          LAYER  5
                          --------

                   TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER  16
THICKNESS                     =      60.00   INCHES
POROSITY                      =       0.4270 VOL/VOL
FIELD CAPACITY                =       0.4180 VOL/VOL
WILTING POINT                 =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                        =       0.20    INCHES
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.        =    1.22000003000     CM/SEC
SLOPE                            =       8.90    PERCENT
DRAINAGE LENGTH                  =     191.0     FEET


                             LAYER  7
                             --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
THICKNESS                        =       0.08    INCHES
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.        =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY              =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS         =       1.00    HOLES/ACRE
FML PLACEMENT QUALITY            =  3 - GOOD


                             LAYER  8
                             --------

                  TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
THICKNESS                        =      36.00    INCHES
POROSITY                         =       0.4270 VOL/VOL
FIELD CAPACITY                   =       0.4180 VOL/VOL
WILTING POINT                    =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT       =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =  0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  9.% AND
          A SLOPE LENGTH OF  191. FEET.

SCS RUNOFF CURVE NUMBER              =      84.50
FRACTION OF AREA ALLOWING RUNOFF     =       0.0      PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =       1.000    ACRES
EVAPORATIVE ZONE DEPTH               =       6.0      INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =       2.742    INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =       2.742    INCHES
```

```
       LOWER LIMIT OF EVAPORATIVE STORAGE =       0.348  INCHES
       INITIAL SNOW WATER                 =       0.000  INCHES
       INITIAL WATER IN LAYER MATERIALS   =      70.838  INCHES
       TOTAL INITIAL WATER                =      70.838  INCHES
       TOTAL SUBSURFACE INFLOW            =       0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                 DETROIT                MICHIGAN

          STATION LATITUDE                         =  42.40 DEGREES
          MAXIMUM LEAF AREA INDEX                  =   0.00
          START OF GROWING SEASON (JULIAN DATE)    =    121
          END OF GROWING SEASON (JULIAN DATE)      =    286
          EVAPORATIVE ZONE DEPTH                   =    6.0  INCHES
          AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


        NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT              MICHIGAN

                 NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        1.86        1.69        2.54        3.15        2.77        3.43
        3.10        3.21        2.25        2.12        2.33        2.52


        NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT              MICHIGAN

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       23.40       25.80       35.00       47.40       58.10       67.70
       71.90       70.50       63.30       51.90       39.50       28.50


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT              MICHIGAN
                   AND STATION LATITUDE  =  42.40 DEGREES



***********************************************************************
```

```
         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                           2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                           1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                 0.8886   0.8761   1.0614   2.3911   3.2837   1.7485
                          1.3815   1.0869   1.0323   0.8423   0.6794   0.5243

   STD. DEVIATIONS        0.6172   0.2243   0.5678   1.6941   0.7827   0.6418
                          0.6626   0.2068   0.7348   0.2700   0.0866   0.1775

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                  AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0090   0.0097   0.0107   0.0249   0.0331   0.0182
                              0.0139   0.0110   0.0108   0.0085   0.0071   0.0053

    STD. DEVIATIONS           0.0062   0.0026   0.0057   0.0177   0.0079   0.0067
                              0.0067   0.0021   0.0077   0.0027   0.0009   0.0018

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                    INCHES             CU. FEET        PERCENT
                              -------------------    -------------    ---------
 PRECIPITATION                 32.34     (   3.821)     117387.0      100.00

 RUNOFF                         0.000    (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION            17.213    (  1.6298)      62481.79     53.227

 LATERAL DRAINAGE COLLECTED    15.79592 (  3.88956)      57339.187    48.84630
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH    0.00001 (  0.00000)          0.033     0.00003
   LAYER  5

 AVERAGE HEAD ON TOP            0.014 (    0.003)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED     0.00001 (  0.00000)          0.025    0.00002
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)          0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP            0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE       -0.671    (  2.0891)      -2434.07     -2.074
*******************************************************************************


□
******************************************************************************
```

```
              PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
   PRECIPITATION                                   2.56          9292.800

   RUNOFF                                          0.000            0.0000

   DRAINAGE COLLECTED FROM LAYER  3                0.39905       1448.55737

   PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000000         0.00055

   AVERAGE HEAD ON TOP OF LAYER  4                 0.125

   MAXIMUM HEAD ON TOP OF LAYER  4                 0.248

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                     0.0 FEET

   DRAINAGE COLLECTED FROM LAYER  6                0.00000          0.00046

   PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000         0.00002

   AVERAGE HEAD ON TOP OF LAYER  7                 0.000

   MAXIMUM HEAD ON TOP OF LAYER  7                 0.013

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                     0.0 FEET

   SNOW WATER                                      3.28         11902.9795


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                       0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                       0.0580


    ***  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    5
----------------------------------------------------------------------
               LAYER        (INCHES)      (VOL/VOL)
               -----        --------      ---------
                 1          25.2346        0.2103

                 2           1.2512        0.1043

                 3           0.0051        0.0253
```

```
                 4             0.0000          0.0000

                 5            25.6200          0.4270

                 6             0.0020          0.0100

                 7             0.0000          0.0000

                 8            15.3720          0.4270

          SNOW WATER           0.000

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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:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP6SW-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP6SW-1.OUT


TIME:  10:43     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P5 SW AREA

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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   5
           THICKNESS                  =    120.00   INCHES
           POROSITY                   =      0.4570 VOL/VOL
           FIELD CAPACITY             =      0.1310 VOL/VOL
           WILTING POINT              =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                 LAYER  2
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                      =       12.00   INCHES
POROSITY                       =       0.4170 VOL/VOL
FIELD CAPACITY                 =       0.0450 VOL/VOL
WILTING POINT                  =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                      =        0.20   INCHES
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.      =   1.22000003000     CM/SEC
SLOPE                          =        4.70   PERCENT
DRAINAGE LENGTH                =      223.0    FEET


                          LAYER  4
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                      =        0.08   INCHES
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.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =        1.00   HOLES/ACRE
FML INSTALLATION DEFECTS       =        1.00   HOLES/ACRE
FML PLACEMENT QUALITY          =  3 - GOOD


                          LAYER  5
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                      =       60.00   INCHES
POROSITY                       =       0.4270 VOL/VOL
FIELD CAPACITY                 =       0.4180 VOL/VOL
WILTING POINT                  =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
               TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
     THICKNESS                   =     0.20   INCHES
     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.   =   1.22000003000     CM/SEC
     SLOPE                       =     4.70   PERCENT
     DRAINAGE LENGTH             =    223.0    FEET


                           LAYER  7
                           --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
     THICKNESS                   =     0.08   INCHES
     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.   =  0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY         =     1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS    =     1.00   HOLES/ACRE
     FML PLACEMENT QUALITY       =  3 - GOOD


                           LAYER  8
                           --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
     THICKNESS                   =    36.00   INCHES
     POROSITY                    =     0.4270 VOL/VOL
     FIELD CAPACITY              =     0.4180 VOL/VOL
     WILTING POINT               =     0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT  =     0.4270 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
            GROUND CONDITIONS, A SURFACE SLOPE OF  5.% AND
            A SLOPE LENGTH OF  223. FEET.

  SCS RUNOFF CURVE NUMBER            =     84.10
  FRACTION OF AREA ALLOWING RUNOFF   =      0.0    PERCENT
  AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
  EVAPORATIVE ZONE DEPTH             =      6.0    INCHES
  INITIAL WATER IN EVAPORATIVE ZONE  =      2.742  INCHES
  UPPER LIMIT OF EVAPORATIVE STORAGE =      2.742  INCHES
```

```
        LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
        INITIAL SNOW WATER                  =      0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
        TOTAL INITIAL WATER                 =     70.838  INCHES
        TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


              EVAPOTRANSPIRATION AND WEATHER DATA
              -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                 DETROIT                MICHIGAN

             STATION LATITUDE                         =  42.40 DEGREES
             MAXIMUM LEAF AREA INDEX                  =   0.00
             START OF GROWING SEASON (JULIAN DATE)    =    121
             END OF GROWING SEASON (JULIAN DATE)      =    286
             EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
             AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
             AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
             AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
             AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
             AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


        NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT             MICHIGAN

                 NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

     JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
     -------      -------      -------      -------      -------      -------
       1.86         1.69         2.54         3.15         2.77         3.43
       3.10         3.21         2.25         2.12         2.33         2.52


        NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT             MICHIGAN

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

     JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
     -------      -------      -------      -------      -------      -------
      23.40        25.80        35.00        47.40        58.10        67.70
      71.90        70.50        63.30        51.90        39.50        28.50


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DETROIT             MICHIGAN
                   AND STATION LATITUDE  =  42.40 DEGREES



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```

```
      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH     5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS          0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.428    0.393    0.386    1.823    2.687    3.000
                            2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS          0.101    0.092    0.159    0.777    0.797    0.675
                            1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                   0.8833   0.8750   1.0545   2.3758   3.2944   1.7572
                            1.3836   1.0836   1.0371   0.8434   0.6809   0.5265

   STD. DEVIATIONS          0.6168   0.2239   0.5634   1.7127   0.7988   0.6272
                            0.6653   0.2005   0.7367   0.2736   0.0875   0.1701

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                 0.0196   0.0214   0.0234   0.1200   0.0731   0.0403
                             0.0307   0.0240   0.0238   0.0187   0.0156   0.0117

    STD. DEVIATIONS          0.0137   0.0057   0.0125   0.1843   0.0177   0.0144
                             0.0148   0.0044   0.0169   0.0061   0.0020   0.0038

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH   5
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    32.34    (   3.821)    117387.0    100.00

 RUNOFF                            0.000   (  0.0000)         0.00     0.000

 EVAPOTRANSPIRATION               17.213   (  1.6298)     62481.79    53.227

 LATERAL DRAINAGE COLLECTED       15.79519 (  3.88468)    57336.547   48.84405
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00002 (  0.00001)        0.066    0.00006
   LAYER  5

 AVERAGE HEAD ON TOP               0.035 (    0.019)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00002 (  0.00001)        0.057   0.00005
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)        0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.670   (  2.0889)     -2431.46    -2.071
*******************************************************************************


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```

```
              PEAK DAILY VALUES FOR YEARS     1 THROUGH    5
------------------------------------------------------------------------
                                             (INCHES)      (CU. FT.)
                                            ----------   -------------
  PRECIPITATION                               2.56          9292.800

  RUNOFF                                      0.000            0.0000

  DRAINAGE COLLECTED FROM LAYER  3            0.32309       1172.80627

  PERCOLATION/LEAKAGE THROUGH LAYER  5        0.000003         0.00959

  AVERAGE HEAD ON TOP OF LAYER  4             2.933

  MAXIMUM HEAD ON TOP OF LAYER  4             5.245

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)               22.9 FEET

  DRAINAGE COLLECTED FROM LAYER  6            0.00000          0.00767

  PERCOLATION/LEAKAGE THROUGH LAYER  8        0.000000         0.00002

  AVERAGE HEAD ON TOP OF LAYER  7             0.000

  MAXIMUM HEAD ON TOP OF LAYER  7             0.009

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                 0.0 FEET

  SNOW WATER                                  3.28         11902.9795


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0580


   ***  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    5
------------------------------------------------------------------------
                LAYER       (INCHES)       (VOL/VOL)
                -----       --------       ---------
                  1          25.2346         0.2103

                  2           1.2512         0.1043

                  3           0.0087         0.0433
```

```
          4              0.0000          0.0000
          5             25.6200          0.4270
          6              0.0020          0.0100
          7              0.0000          0.0000
          8             15.3720          0.4270
      SNOW WATER         0.000
******************************************************************************
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```

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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:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP7NE-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP7NE-1.OUT


TIME:  10:46     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P6 NE AREA

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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   5
           THICKNESS                  =    120.00   INCHES
           POROSITY                   =      0.4570 VOL/VOL
           FIELD CAPACITY             =      0.1310 VOL/VOL
           WILTING POINT              =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                  LAYER  2
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
              MATERIAL TEXTURE NUMBER   0
THICKNESS                      =     12.00    INCHES
POROSITY                       =      0.4170 VOL/VOL
FIELD CAPACITY                 =      0.0450 VOL/VOL
WILTING POINT                  =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                      =      0.20    INCHES
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.      =   1.22000003000      CM/SEC
SLOPE                          =      8.40    PERCENT
DRAINAGE LENGTH                =    211.0     FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                      =      0.08    INCHES
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.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =      1.00    HOLES/ACRE
FML INSTALLATION DEFECTS       =      1.00    HOLES/ACRE
FML PLACEMENT QUALITY          =  3 - GOOD


                        LAYER  5
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                      =     60.00    INCHES
POROSITY                       =      0.4270 VOL/VOL
FIELD CAPACITY                 =      0.4180 VOL/VOL
WILTING POINT                  =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


                        LAYER  6
                        --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =        0.20    INCHES
 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.    =     1.22000003000     CM/SEC
 SLOPE                        =        8.40    PERCENT
 DRAINAGE LENGTH              =      211.0     FEET


                          LAYER  7
                          --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
 THICKNESS                    =        0.08    INCHES
 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.    =   0.199999996000E-12 CM/SEC
 FML PINHOLE DENSITY          =        1.00    HOLES/ACRE
 FML INSTALLATION DEFECTS     =        1.00    HOLES/ACRE
 FML PLACEMENT QUALITY        =    3 - GOOD


                          LAYER  8
                          --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
 THICKNESS                    =       36.00    INCHES
 POROSITY                     =        0.4270 VOL/VOL
 FIELD CAPACITY               =        0.4180 VOL/VOL
 WILTING POINT                =        0.3670 VOL/VOL
 INITIAL SOIL WATER CONTENT   =        0.4270 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
         GROUND CONDITIONS, A SURFACE SLOPE OF  8.% AND
         A SLOPE LENGTH OF  211. FEET.

SCS RUNOFF CURVE NUMBER              =     84.40
FRACTION OF AREA ALLOWING RUNOFF     =      0.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
EVAPORATIVE ZONE DEPTH               =      6.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      2.742   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      2.742   INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.348  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     70.838  INCHES
TOTAL INITIAL WATER                =     70.838  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR


          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DETROIT             MICHIGAN

     STATION LATITUDE                         = 42.40 DEGREES
     MAXIMUM LEAF AREA INDEX                  =  0.00
     START OF GROWING SEASON (JULIAN DATE)    =   121
     END OF GROWING SEASON (JULIAN DATE)      =   286
     EVAPORATIVE ZONE DEPTH                   =  6.0  INCHES
     AVERAGE ANNUAL WIND SPEED                = 10.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    = 73.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    = 67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    = 71.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    = 75.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN
            AND STATION LATITUDE  =  42.40 DEGREES



*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                  1.75     1.67     2.39     4.10     3.71     4.04
                            2.70     3.30     1.70     0.95     2.88     3.17

    STD. DEVIATIONS         0.61     0.62     1.28     1.20     1.61     1.04
                            1.31     1.70     0.93     0.37     1.23     0.94

  RUNOFF
  ------
    TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                            2.315    2.279    1.309    1.049    0.980    0.563

    STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                            1.039    0.522    0.900    0.348    0.370    0.175

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS                  0.8878   0.8760   1.0604   2.3886   3.2853   1.7498
                            1.3819   1.0864   1.0330   0.8424   0.6796   0.5246

    STD. DEVIATIONS         0.6171   0.2243   0.5673   1.6967   0.7851   0.6399
                            0.6631   0.2059   0.7351   0.2705   0.0867   0.1764

  PERCOLATION/LEAKAGE THROUGH LAYER  5
  ------------------------------------
    TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  LATERAL DRAINAGE COLLECTED FROM LAYER  6
  ----------------------------------------
    TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER  8
  ------------------------------------
    TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0105   0.0114   0.0125   0.0291   0.0388   0.0213
                              0.0163   0.0128   0.0126   0.0099   0.0083   0.0062

    STD. DEVIATIONS           0.0073   0.0030   0.0067   0.0207   0.0093   0.0078
                              0.0078   0.0024   0.0090   0.0032   0.0011   0.0021

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------------
                                      INCHES            CU. FEET     PERCENT
                                -------------------  -------------  ---------
 PRECIPITATION                   32.34     (   3.821)    117387.0     100.00

 RUNOFF                           0.000    (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION              17.213    (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED      15.79581 (  3.88887)    57338.801   48.84597
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)        0.037    0.00003
   LAYER  5

 AVERAGE HEAD ON TOP              0.016 (    0.004)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED       0.00001 (  0.00000)        0.028   0.00002
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.009    0.00001
   LAYER  8

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE         -0.670    (  2.0890)     -2433.71     -2.073
******************************************************************************


□
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```

```
            PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------   -------------
   PRECIPITATION                                2.56        9292.800

   RUNOFF                                       0.000          0.0000

   DRAINAGE COLLECTED FROM LAYER  3             0.39027     1416.69177

   PERCOLATION/LEAKAGE THROUGH LAYER  5         0.000000       0.00062

   AVERAGE HEAD ON TOP OF LAYER  4              0.143

   MAXIMUM HEAD ON TOP OF LAYER  4              0.284

   LOCATION OF MAXIMUM HEAD IN LAYER  3
         (DISTANCE FROM DRAIN)                  0.0 FEET

   DRAINAGE COLLECTED FROM LAYER  6             0.00000        0.00051

   PERCOLATION/LEAKAGE THROUGH LAYER  8         0.000000       0.00002

   AVERAGE HEAD ON TOP OF LAYER  7              0.000

   MAXIMUM HEAD ON TOP OF LAYER  7              0.015

   LOCATION OF MAXIMUM HEAD IN LAYER  6
         (DISTANCE FROM DRAIN)                  0.0 FEET

   SNOW WATER                                   3.28       11902.9795

   MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0580

    ***  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.

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


□
*******************************************************************************

              FINAL WATER STORAGE AT END OF YEAR    5
----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1           25.2346         0.2103

                2            1.2512         0.1043

                3            0.0056         0.0278
```

```
            4          0.0000          0.0000

            5         25.6200          0.4270

            6          0.0020          0.0100

            7          0.0000          0.0000

            8         15.3720          0.4270

        SNOW WATER     0.000

***************************************************************************************
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```

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP7NW-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP7NW-1.OUT


TIME:  10:47     DATE:   8/ 9/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P6 NW AREA

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


     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   5
          THICKNESS                  =     120.00   INCHES
          POROSITY                   =       0.4570 VOL/VOL
          FIELD CAPACITY             =       0.1310 VOL/VOL
          WILTING POINT              =       0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                                LAYER  2
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                    MATERIAL TEXTURE NUMBER   0
THICKNESS                        =       12.00    INCHES
POROSITY                         =        0.4170 VOL/VOL
FIELD CAPACITY                   =        0.0450 VOL/VOL
WILTING POINT                    =        0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT       =        0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =   0.999999978000E-02 CM/SEC


                            LAYER  3
                            --------

                  TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
THICKNESS                        =        0.20    INCHES
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.        =     1.22000003000      CM/SEC
SLOPE                            =        6.90    PERCENT
DRAINAGE LENGTH                  =      223.0     FEET


                            LAYER  4
                            --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
THICKNESS                        =        0.08    INCHES
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.        =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY              =        1.00    HOLES/ACRE
FML INSTALLATION DEFECTS         =        1.00    HOLES/ACRE
FML PLACEMENT QUALITY            =   3 - GOOD


                            LAYER  5
                            --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER  16
THICKNESS                        =       60.00    INCHES
POROSITY                         =        0.4270 VOL/VOL
FIELD CAPACITY                   =        0.4180 VOL/VOL
WILTING POINT                    =        0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT       =        0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =   0.100000001000E-06 CM/SEC


                            LAYER  6
                            --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                      =       0.20   INCHES
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.      =    1.22000003000     CM/SEC
SLOPE                          =       6.90   PERCENT
DRAINAGE LENGTH                =     223.0    FEET


                        LAYER  7
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER 35
THICKNESS                      =       0.08   INCHES
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.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS       =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY          =  3 - GOOD


                        LAYER  8
                        --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER 16
THICKNESS                      =      36.00   INCHES
POROSITY                       =       0.4270 VOL/VOL
FIELD CAPACITY                 =       0.4180 VOL/VOL
WILTING POINT                  =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
         GROUND CONDITIONS, A SURFACE SLOPE OF  7.% AND
         A SLOPE LENGTH OF  223. FEET.

SCS RUNOFF CURVE NUMBER              =      84.30
FRACTION OF AREA ALLOWING RUNOFF     =       0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =       1.000  ACRES
EVAPORATIVE ZONE DEPTH               =       6.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =       2.742  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =       2.742  INCHES
```

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
TOTAL INITIAL WATER                 =     70.838  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


              EVAPOTRANSPIRATION AND WEATHER DATA
              -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              DETROIT                MICHIGAN

         STATION LATITUDE                          =  42.40 DEGREES
         MAXIMUM LEAF AREA INDEX                   =   0.00
         START OF GROWING SEASON (JULIAN DATE)     =    121
         END OF GROWING SEASON (JULIAN DATE)       =    286
         EVAPORATIVE ZONE DEPTH                    =   6.0  INCHES
         AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DETROIT              MICHIGAN

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.86         1.69         2.54         3.15         2.77         3.43
  3.10         3.21         2.25         2.12         2.33         2.52


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DETROIT              MICHIGAN

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 23.40        25.80        35.00        47.40        58.10        67.70
 71.90        70.50        63.30        51.90        39.50        28.50


     NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DETROIT              MICHIGAN
                AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                  1.75     1.67     2.39     4.10     3.71     4.04
                           2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS         0.61     0.62     1.28     1.20     1.61     1.04
                           1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  0.428    0.393    0.386    1.823    2.687    3.000
                           2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS         0.101    0.092    0.159    0.777    0.797    0.675
                           1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                  0.8863   0.8757   1.0586   2.3840   3.2883   1.7524
                           1.3826   1.0853   1.0344   0.8428   0.6800   0.5252

   STD. DEVIATIONS         0.6171   0.2241   0.5662   1.7019   0.7897   0.6360
                           0.6640   0.2042   0.7357   0.2715   0.0870   0.1744

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                  0.0134   0.0146   0.0160   0.0373   0.0498   0.0274
                              0.0209   0.0164   0.0162   0.0128   0.0106   0.0080

    STD. DEVIATIONS           0.0093   0.0039   0.0086   0.0266   0.0120   0.0100
                              0.0101   0.0031   0.0115   0.0041   0.0014   0.0026

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH   5
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                  32.34     (   3.821)   117387.0     100.00

 RUNOFF                          0.000    (  0.0000)        0.00      0.000

 EVAPOTRANSPIRATION             17.213    (  1.6298)    62481.79     53.227

 LATERAL DRAINAGE COLLECTED     15.79561 (  3.88752)    57338.078   48.84536
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00001 (  0.00000)        0.045     0.00004
   LAYER  5

 AVERAGE HEAD ON TOP             0.020 (    0.005)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED      0.00001 (  0.00000)        0.036    0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP             0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE        -0.670    (  2.0890)    -2432.99     -2.073
*******************************************************************************


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```

```
            PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
  ------------------------------------------------------------------------
                                              (INCHES)     (CU. FT.)
                                             ----------   -------------
     PRECIPITATION                              2.56          9292.800

     RUNOFF                                     0.000            0.0000

     DRAINAGE COLLECTED FROM LAYER  3           0.37346       1355.65112

     PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000000         0.00075

     AVERAGE HEAD ON TOP OF LAYER  4            0.175

     MAXIMUM HEAD ON TOP OF LAYER  4            0.347

     LOCATION OF MAXIMUM HEAD IN LAYER  3
           (DISTANCE FROM DRAIN)                1.6 FEET

     DRAINAGE COLLECTED FROM LAYER  6           0.00000          0.00062

     PERCOLATION/LEAKAGE THROUGH LAYER  8       0.000000         0.00002

     AVERAGE HEAD ON TOP OF LAYER  7            0.000

     MAXIMUM HEAD ON TOP OF LAYER  7            0.020

     LOCATION OF MAXIMUM HEAD IN LAYER  6
           (DISTANCE FROM DRAIN)                0.0 FEET

     SNOW WATER                                 3.28         11902.9795


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4570

     MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0580

       ***  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    5
  ----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          25.2346         0.2103

                2           1.2512         0.1043

                3           0.0066         0.0328
```

```
              4             0.0000            0.0000

              5            25.6200            0.4270

              6             0.0020            0.0100

              7             0.0000            0.0000

              8            15.3720            0.4270

          SNOW WATER        0.000

*******************************************************************************
*******************************************************************************
```

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□
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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               **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:        S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:      S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6GP7SE-F.D10
OUTPUT DATA FILE:             S:\WASTE\ENGINE~1\HELP3.07\6GP7SE-1.OUT


TIME:  10:49     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P6 SE AREA

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


     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   5
           THICKNESS                    =     120.00    INCHES
           POROSITY                     =       0.4570 VOL/VOL
           FIELD CAPACITY               =       0.1310 VOL/VOL
           WILTING POINT                =       0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.2391 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                   LAYER  2
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
              MATERIAL TEXTURE NUMBER  0
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.4170 VOL/VOL
FIELD CAPACITY               =     0.0450 VOL/VOL
WILTING POINT                =     0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

             TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  0
THICKNESS                    =     0.20   INCHES
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.    =   1.22000003000     CM/SEC
SLOPE                        =     6.80   PERCENT
DRAINAGE LENGTH              =   209.0    FEET


                          LAYER  4
                          --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER 35
THICKNESS                    =     0.08   INCHES
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =     1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =     1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  5
                          --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER 16
THICKNESS                    =    60.00   INCHES
POROSITY                     =     0.4270 VOL/VOL
FIELD CAPACITY               =     0.4180 VOL/VOL
WILTING POINT                =     0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
     THICKNESS                      =       0.20   INCHES
     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.      =    1.22000003000     CM/SEC
     SLOPE                          =       6.80   PERCENT
     DRAINAGE LENGTH                =     209.0    FEET


                            LAYER  7
                            --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
     THICKNESS                      =       0.08   INCHES
     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.      =   0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY            =       1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS       =       1.00   HOLES/ACRE
     FML PLACEMENT QUALITY          =   3 - GOOD


                            LAYER  8
                            --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
     THICKNESS                      =      36.00   INCHES
     POROSITY                       =       0.4270 VOL/VOL
     FIELD CAPACITY                 =       0.4180 VOL/VOL
     WILTING POINT                  =       0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT     =       0.4270 VOL/VOL
     EFFECTIVE SAT. HYD. COND.      =   0.100000001000E-06 CM/SEC


             GENERAL DESIGN AND EVAPORATIVE ZONE DATA
             ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
            GROUND CONDITIONS, A SURFACE SLOPE OF  7.% AND
            A SLOPE LENGTH OF  209. FEET.

    SCS RUNOFF CURVE NUMBER            =     84.30
    FRACTION OF AREA ALLOWING RUNOFF   =      0.0    PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
    EVAPORATIVE ZONE DEPTH             =      6.0    INCHES
    INITIAL WATER IN EVAPORATIVE ZONE  =      2.742  INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE =      2.742  INCHES
```

```
 LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.348  INCHES
 INITIAL SNOW WATER                  =      0.000  INCHES
 INITIAL WATER IN LAYER MATERIALS    =     70.838  INCHES
 TOTAL INITIAL WATER                 =     70.838  INCHES
 TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           DETROIT                MICHIGAN

      STATION LATITUDE                          =  42.40 DEGREES
      MAXIMUM LEAF AREA INDEX                   =   0.00
      START OF GROWING SEASON (JULIAN DATE)     =    121
      END OF GROWING SEASON (JULIAN DATE)       =    286
      EVAPORATIVE ZONE DEPTH                    =   6.0  INCHES
      AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


  NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN

      NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


  NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    DETROIT             MICHIGAN
             AND STATION LATITUDE  =  42.40 DEGREES


*******************************************************************************
```

```
        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH    5
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                  1.75     1.67     2.39     4.10     3.71     4.04
                           2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS         0.61     0.62     1.28     1.20     1.61     1.04
                           1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                 0.000    0.000    0.000    0.000    0.000    0.000
                          0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                          0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                 0.428    0.393    0.386    1.823    2.687    3.000
                          2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS        0.101    0.092    0.159    0.777    0.797    0.675
                          1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                0.8867   0.8758   1.0590   2.3850   3.2877   1.7518
                         1.3824   1.0855   1.0341   0.8427   0.6799   0.5251

   STD. DEVIATIONS       0.6171   0.2242   0.5665   1.7007   0.7887   0.6369
                         0.6638   0.2046   0.7356   0.2713   0.0869   0.1748

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
                    AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER   4
  -------------------------------------
    AVERAGES                   0.0128   0.0139   0.0153   0.0355   0.0473   0.0261
                               0.0199   0.0156   0.0154   0.0121   0.0101   0.0076

    STD. DEVIATIONS            0.0089   0.0037   0.0082   0.0253   0.0114   0.0095
                               0.0096   0.0029   0.0109   0.0039   0.0013   0.0025

  DAILY AVERAGE HEAD ON TOP OF LAYER   7
  -------------------------------------
    AVERAGES                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    32.34    (   3.821)    117387.0     100.00

 RUNOFF                            0.000   (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION               17.213   (  1.6298)     62481.79     53.227

 LATERAL DRAINAGE COLLECTED       15.79566 (  3.88782)    57338.246    48.84550
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00001 (  0.00000)        0.043      0.00004
   LAYER  5

 AVERAGE HEAD ON TOP               0.019 (    0.005)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED        0.00001 (  0.00000)        0.034     0.00003
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)        0.009      0.00001
   LAYER  8

 AVERAGE HEAD ON TOP               0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE          -0.670   (  2.0890)     -2433.14     -2.073
*******************************************************************************


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```

```
            PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                                (INCHES)     (CU. FT.)
                                               ----------   -------------
  PRECIPITATION                                   2.56        9292.800

  RUNOFF                                          0.000          0.0000

  DRAINAGE COLLECTED FROM LAYER  3                0.37714     1369.02441

  PERCOLATION/LEAKAGE THROUGH LAYER  5            0.000000       0.00073

  AVERAGE HEAD ON TOP OF LAYER  4                 0.168

  MAXIMUM HEAD ON TOP OF LAYER  4                 0.334

  LOCATION OF MAXIMUM HEAD IN LAYER  3
        (DISTANCE FROM DRAIN)                     0.9 FEET

  DRAINAGE COLLECTED FROM LAYER  6                0.00000        0.00059

  PERCOLATION/LEAKAGE THROUGH LAYER  8            0.000000       0.00002

  AVERAGE HEAD ON TOP OF LAYER  7                 0.000

  MAXIMUM HEAD ON TOP OF LAYER  7                 0.018

  LOCATION OF MAXIMUM HEAD IN LAYER  6
        (DISTANCE FROM DRAIN)                     0.0 FEET

  SNOW WATER                                      3.28       11902.9795

  MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

  MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580

   ***  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.

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


0
*****************************************************************************

               FINAL WATER STORAGE AT END OF YEAR    5
----------------------------------------------------------------------
               LAYER        (INCHES)       (VOL/VOL)
               -----        --------       ---------
                 1          25.2346         0.2103

                 2           1.2512         0.1043

                 3           0.0063         0.0317
```

```
              4             0.0000          0.0000

              5            25.6200          0.4270

              6             0.0020          0.0100

              7             0.0000          0.0000

              8            15.3720          0.4270

         SNOW WATER         0.000

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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:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6FLCS-F.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6GP7SW-F.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6GP7SW-1.OUT


TIME:  10:51     DATE:   8/ 9/2011


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     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Filling) VI-G P6 SW AREA

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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   5
          THICKNESS                   =    120.00   INCHES
          POROSITY                    =      0.4570 VOL/VOL
          FIELD CAPACITY              =      0.1310 VOL/VOL
          WILTING POINT               =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.2391 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                                LAYER  2
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     12.00    INCHES
POROSITY                      =      0.4170 VOL/VOL
FIELD CAPACITY                =      0.0450 VOL/VOL
WILTING POINT                 =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0960 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.20    INCHES
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.     =   1.22000003000      CM/SEC
SLOPE                         =      4.80    PERCENT
DRAINAGE LENGTH               =    258.0     FEET


                          LAYER  4
                          --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                     =      0.08    INCHES
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.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =      1.00    HOLES/ACRE
FML INSTALLATION DEFECTS      =      1.00    HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                          LAYER  5
                          --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                     =     60.00    INCHES
POROSITY                      =      0.4270 VOL/VOL
FIELD CAPACITY                =      0.4180 VOL/VOL
WILTING POINT                 =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


                          LAYER  6
                          --------
```

```
                  TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =       0.20    INCHES
     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.    =    1.22000003000     CM/SEC
     SLOPE                        =       4.80    PERCENT
     DRAINAGE LENGTH              =     258.0     FEET


                              LAYER  7
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
     THICKNESS                    =       0.08    INCHES
     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.    =  0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
     FML INSTALLATION DEFECTS     =       1.00    HOLES/ACRE
     FML PLACEMENT QUALITY        =  3 - GOOD


                              LAYER  8
                              --------

                    TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
     THICKNESS                    =      36.00    INCHES
     POROSITY                     =       0.4270 VOL/VOL
     FIELD CAPACITY               =       0.4180 VOL/VOL
     WILTING POINT                =       0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH BARE
            GROUND CONDITIONS, A SURFACE SLOPE OF  5.% AND
            A SLOPE LENGTH OF  258. FEET.

   SCS RUNOFF CURVE NUMBER                 =      84.00
   FRACTION OF AREA ALLOWING RUNOFF        =       0.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE      =       1.000  ACRES
   EVAPORATIVE ZONE DEPTH                  =       6.0    INCHES
   INITIAL WATER IN EVAPORATIVE ZONE       =       2.742  INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE      =       2.742  INCHES
```

```
      LOWER LIMIT OF EVAPORATIVE STORAGE  =       0.348  INCHES
      INITIAL SNOW WATER                  =       0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS    =      70.838  INCHES
      TOTAL INITIAL WATER                 =      70.838  INCHES
      TOTAL SUBSURFACE INFLOW             =       0.00   INCHES/YEAR


                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DETROIT              MICHIGAN

           STATION LATITUDE                          =  42.40 DEGREES
           MAXIMUM LEAF AREA INDEX                   =   0.00
           START OF GROWING SEASON (JULIAN DATE)     =    121
           END OF GROWING SEASON (JULIAN DATE)       =    286
           EVAPORATIVE ZONE DEPTH                    =   6.0  INCHES
           AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT              MICHIGAN

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
      1.86        1.69        2.54        3.15        2.77        3.43
      3.10        3.21        2.25        2.12        2.33        2.52


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT              MICHIGAN

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
     23.40       25.80       35.00       47.40       58.10       67.70
     71.90       70.50       63.30       51.90       39.50       28.50


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DETROIT              MICHIGAN
                 AND STATION LATITUDE  =  42.40 DEGREES



***********************************************************************
```

```
                              6GP7SW-1
     AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                 1.75     1.67     2.39     4.10     3.71     4.04
                          2.70     3.30     1.70     0.95     2.88     3.17

   STD. DEVIATIONS        0.61     0.62     1.28     1.20     1.61     1.04
                          1.31     1.70     0.93     0.37     1.23     0.94

 RUNOFF
 ------
   TOTALS                 0.000    0.000    0.000    0.000    0.000    0.000
                          0.000    0.000    0.000    0.000    0.000    0.000

   STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                          0.000    0.000    0.000    0.000    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                 0.428    0.393    0.386    1.823    2.687    3.000
                          2.315    2.279    1.309    1.049    0.980    0.563

   STD. DEVIATIONS        0.101    0.092    0.159    0.777    0.797    0.675
                          1.039    0.522    0.900    0.348    0.370    0.175

 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                 0.8820   0.8747   1.0526   2.3746   3.2949   1.7591
                          1.3840   1.0829   1.0381   0.8437   0.6814   0.5269

   STD. DEVIATIONS        0.6166   0.2239   0.5620   1.7158   0.8002   0.6233
                          0.6657   0.1990   0.7369   0.2744   0.0878   0.1683

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
```

```
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER   4
  -------------------------------------
    AVERAGES                 0.0222   0.0242   0.0264   0.2491   0.0828   0.0457
                             0.0348   0.0272   0.0270   0.0212   0.0177   0.0132

    STD. DEVIATIONS          0.0155   0.0064   0.0141   0.3843   0.0201   0.0162
                             0.0167   0.0050   0.0191   0.0069   0.0023   0.0042

  DAILY AVERAGE HEAD ON TOP OF LAYER   7
  -------------------------------------
    AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    5
-------------------------------------------------------------------------------
                                    INCHES            CU. FEET        PERCENT
                               -------------------  -------------   ---------
 PRECIPITATION                  32.34     (   3.821)     117387.0     100.00

 RUNOFF                          0.000    (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION             17.213    (  1.6298)      62481.79     53.227

 LATERAL DRAINAGE COLLECTED     15.79500 (   3.88348)     57335.859   48.84347
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00002 (   0.00001)         0.083     0.00007
   LAYER  5

 AVERAGE HEAD ON TOP             0.049 (     0.036)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED      0.00002 (   0.00001)         0.074    0.00006
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH     0.00000 (   0.00000)         0.009     0.00001
   LAYER  8

 AVERAGE HEAD ON TOP             0.000 (     0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE        -0.670    (  2.0889)      -2430.80     -2.071
*******************************************************************************


▯
******************************************************************************
```

```
             PEAK DAILY VALUES FOR YEARS    1 THROUGH    5
------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
   PRECIPITATION                                2.56          9292.800

   RUNOFF                                       0.000            0.0000

   DRAINAGE COLLECTED FROM LAYER  3             0.29632       1075.63953

   PERCOLATION/LEAKAGE THROUGH LAYER  5         0.000004         0.01284

   AVERAGE HEAD ON TOP OF LAYER  4              3.959

   MAXIMUM HEAD ON TOP OF LAYER  4              7.015

   LOCATION OF MAXIMUM HEAD IN LAYER  3
          (DISTANCE FROM DRAIN)               28.9 FEET

   DRAINAGE COLLECTED FROM LAYER  6             0.00000          0.01275

   PERCOLATION/LEAKAGE THROUGH LAYER  8         0.000000         0.00002

   AVERAGE HEAD ON TOP OF LAYER  7              0.000

   MAXIMUM HEAD ON TOP OF LAYER  7              0.000

   LOCATION OF MAXIMUM HEAD IN LAYER  6
          (DISTANCE FROM DRAIN)                 0.0 FEET

   SNOW WATER                                   3.28         11902.9795

   MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4570

   MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0580

    ***  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.

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


▯
*************************************************************************

                FINAL WATER STORAGE AT END OF YEAR    5
-----------------------------------------------------------------------
                LAYER        (INCHES)      (VOL/VOL)
                -----        ---------     ----------
                  1           25.2346        0.2103

                  2            1.2512        0.1043

                  3            0.0096        0.0478
```

```
              4          0.0000          0.0000

              5         25.6200          0.4270

              6          0.0020          0.0100

              7          0.0000          0.0000

              8         15.3720          0.4270

          SNOW WATER     0.000

******************************************************************************
******************************************************************************
```

# POST CLOSURE CASES

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


PRECIPITATION DATA FILE:     S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D4
TEMPERATURE DATA FILE:       S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D7
SOLAR RADIATION DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D13
EVAPOTRANSPIRATION DATA:     S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D11
SOIL AND DESIGN DATA FILE:   S:\WASTE\ENGINE~1\HELP3.07\6FGPC.D10
OUTPUT DATA FILE:            S:\WASTE\ENGINE~1\HELP3.07\6FGPC.OUT


TIME:   7:45     DATE:   9/14/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Post-Closure) 4% Area

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


     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   0
          THICKNESS                    =     36.00   INCHES
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3747 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                                   LAYER  2
                                   --------

                        TYPE 2 - LATERAL DRAINAGE LAYER
```

```
                    MATERIAL TEXTURE NUMBER   0
THICKNESS                      =       0.20   INCHES
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.      =    1.00000000000      CM/SEC
SLOPE                          =       4.00   PERCENT
DRAINAGE LENGTH                =     375.0    FEET


                         LAYER  3
                         --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
THICKNESS                      =       0.04   INCHES
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.      =   0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS       =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY          =   3 - GOOD


                         LAYER  4
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
THICKNESS                      =       0.36   INCHES
POROSITY                       =       0.7500 VOL/VOL
FIELD CAPACITY                 =       0.7470 VOL/VOL
WILTING POINT                  =       0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =   0.240999998000E-08 CM/SEC


                         LAYER  5
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   5
THICKNESS                      =    2005.00   INCHES
POROSITY                       =       0.4570 VOL/VOL
FIELD CAPACITY                 =       0.1310 VOL/VOL
WILTING POINT                  =       0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =   0.100000005000E-02 CM/SEC


                         LAYER  6
                         --------
```

```
                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     12.00    INCHES
          POROSITY                     =      0.4170 VOL/VOL
          FIELD CAPACITY               =      0.0450 VOL/VOL
          WILTING POINT                =      0.0180 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0450 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   0.999999978000E-02 CM/SEC


                              LAYER  7
                              --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                      MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =      0.20    INCHES
          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.    =    1.22000003000      CM/SEC
          SLOPE                        =      2.50    PERCENT
          DRAINAGE LENGTH              =    250.0     FEET


                              LAYER  8
                              --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                      MATERIAL TEXTURE NUMBER  35
          THICKNESS                    =      0.08    INCHES
          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.    =   0.199999996000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00    HOLES/ACRE
          FML INSTALLATION DEFECTS     =      1.00    HOLES/ACRE
          FML PLACEMENT QUALITY        =   3 - GOOD


                              LAYER  9
                              --------

                     TYPE 3 - BARRIER SOIL LINER
                      MATERIAL TEXTURE NUMBER  16
          THICKNESS                    =     60.00    INCHES
          POROSITY                     =      0.4270 VOL/VOL
          FIELD CAPACITY               =      0.4180 VOL/VOL
          WILTING POINT                =      0.3670 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC
```

```
                             LAYER 10
                             --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                     =       0.20    INCHES
   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.     =    1.22000003000      CM/SEC
   SLOPE                         =       2.50    PERCENT
   DRAINAGE LENGTH               =     250.0     FEET


                             LAYER 11
                             --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
   THICKNESS                     =       0.08    INCHES
   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.     =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY           =       1.00    HOLES/ACRE
   FML INSTALLATION DEFECTS      =       1.00    HOLES/ACRE
   FML PLACEMENT QUALITY         =  3 - GOOD


                             LAYER 12
                             --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
   THICKNESS                     =      36.00    INCHES
   POROSITY                      =       0.4270 VOL/VOL
   FIELD CAPACITY                =       0.4180 VOL/VOL
   WILTING POINT                 =       0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT    =       0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #12 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  375. FEET.

SCS RUNOFF CURVE NUMBER              =     87.80
FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
EVAPORATIVE ZONE DEPTH               =     20.0     INCHES
```

```
INITIAL WATER IN EVAPORATIVE ZONE    =      8.017  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      9.420  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      4.200  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    317.952  INCHES
TOTAL INITIAL WATER                  =    317.952  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DETROIT               MICHIGAN

     STATION LATITUDE                         =  42.40 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   4.00
     START OF GROWING SEASON (JULIAN DATE)    =    121
     END OF GROWING SEASON (JULIAN DATE)      =    286
     EVAPORATIVE ZONE DEPTH                   =  20.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =  10.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  73.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  71.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  75.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT             MICHIGAN
            AND STATION LATITUDE  =  42.40 DEGREES
```

```
******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   1.81     1.77     2.38     3.33     2.97     3.36
                            2.93     2.98     2.31     1.66     2.36     2.63

   STD. DEVIATIONS          0.65     0.79     1.07     1.30     1.13     1.41
                            1.26     1.64     1.37     1.06     1.00     1.05

 RUNOFF
 ------
   TOTALS                   0.697    1.368    2.306    1.465    0.697    0.869
                            0.721    1.105    0.496    0.281    0.416    0.436

   STD. DEVIATIONS          0.558    1.009    1.737    1.374    0.569    0.821
                            0.569    1.228    0.507    0.447    0.428    0.495

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   0.498    0.459    0.562    2.092    3.021    4.350
                            2.253    1.817    1.460    0.774    0.570    0.462

   STD. DEVIATIONS          0.084    0.091    0.186    0.619    0.755    0.860
                            0.838    0.653    0.677    0.230    0.147    0.093

 LATERAL DRAINAGE COLLECTED FROM LAYER  2
 ----------------------------------------
   TOTALS                   0.0903   0.0330   0.0200   0.1363   0.3641   0.2668
                            0.1491   0.0919   0.0420   0.0022   0.0032   0.0828

   STD. DEVIATIONS          0.2280   0.0703   0.0458   0.2023   0.3090   0.1209
                            0.0557   0.0378   0.0318   0.0067   0.0168   0.2836

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  7
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  9
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
```

```
 LATERAL DRAINAGE COLLECTED FROM LAYER 10
 ----------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER 12
 ------------------------------------
   TOTALS                   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
   AVERAGES                 0.0048   0.0019   0.0011   0.0075   0.0195   0.0147
                            0.0080   0.0049   0.0023   0.0001   0.0002   0.0044

   STD. DEVIATIONS          0.0122   0.0041   0.0024   0.0112   0.0165   0.0067
                            0.0030   0.0020   0.0018   0.0004   0.0009   0.0152

 DAILY AVERAGE HEAD ON TOP OF LAYER  8
 -------------------------------------
   AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 DAILY AVERAGE HEAD ON TOP OF LAYER 11
 -------------------------------------
   AVERAGES                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET     PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    30.46     (   3.646)     110581.9    100.00

 RUNOFF                           10.858    (  2.3171)      39413.36    35.642

 EVAPOTRANSPIRATION               18.317    (  1.8207)      66491.70    60.129

 LATERAL DRAINAGE COLLECTED        1.28173 (  0.81211)       4652.680    4.20745
```

```
  FROM LAYER  2

PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.006     0.00001
  LAYER  4

AVERAGE HEAD ON TOP              0.006 (    0.004)
  OF LAYER  3

LATERAL DRAINAGE COLLECTED       0.00000 (  0.00000)         0.001    0.00000
  FROM LAYER  7

PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.005     0.00000
  LAYER  9

AVERAGE HEAD ON TOP              0.000 (    0.000)
  OF LAYER  8

LATERAL DRAINAGE COLLECTED       0.00000 (  0.00000)         0.000    0.00000
  FROM LAYER 10

PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.005     0.00000
  LAYER 12

AVERAGE HEAD ON TOP              0.000 (    0.000)
  OF LAYER 11

CHANGE IN WATER STORAGE          0.007    (  1.9647)        24.15     0.022
*******************************************************************************


□
*******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
  ------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------    -------------
     PRECIPITATION                                 2.92         10599.601

     RUNOFF                                        2.517         9138.0957

     DRAINAGE COLLECTED FROM LAYER  2              0.08311        301.69934

     PERCOLATION/LEAKAGE THROUGH LAYER  4          0.000000         0.00012

     AVERAGE HEAD ON TOP OF LAYER  3               0.138

     MAXIMUM HEAD ON TOP OF LAYER  3               0.274

     LOCATION OF MAXIMUM HEAD IN LAYER  2
           (DISTANCE FROM DRAIN)                   1.5 FEET

     DRAINAGE COLLECTED FROM LAYER  7              0.00000          0.00009

     PERCOLATION/LEAKAGE THROUGH LAYER  9          0.000000         0.00002

     AVERAGE HEAD ON TOP OF LAYER  8               0.000

     MAXIMUM HEAD ON TOP OF LAYER  8               0.015

     LOCATION OF MAXIMUM HEAD IN LAYER  7
```

```
          (DISTANCE FROM DRAIN)                    0.0 FEET

    DRAINAGE COLLECTED FROM LAYER 10               0.00000          0.00000

    PERCOLATION/LEAKAGE THROUGH LAYER 12           0.000000         0.00002

    AVERAGE HEAD ON TOP OF LAYER 11                0.000

    MAXIMUM HEAD ON TOP OF LAYER 11                0.003

    LOCATION OF MAXIMUM HEAD IN LAYER 10
          (DISTANCE FROM DRAIN)                    0.0 FEET

    SNOW WATER                                     8.24         29917.9609


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4540

    MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.2100

     ***  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.

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


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

                FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                LAYER          (INCHES)        (VOL/VOL)
                -----          --------        ---------
                  1            13.3742          0.3715

                  2             0.0020          0.0101

                  3             0.0000          0.0000

                  4             0.2700          0.7500

                  5           262.6550          0.1310

                  6             0.5400          0.0450

                  7             0.0020          0.0100

                  8             0.0000          0.0000

                  9            25.6200          0.4270

                 10             0.0020          0.0100

                 11             0.0000          0.0000
```

```
                     12           15.3720         0.4270

                  SNOW WATER       0.314

******************************************************************************
******************************************************************************
```

```
□
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D4
TEMPERATURE DATA FILE:        S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D7
SOLAR RADIATION DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D13
EVAPOTRANSPIRATION DATA:      S:\WASTE\ENGINE~1\HELP3.07\6ELCSPC.D11
SOIL AND DESIGN DATA FILE:    S:\WASTE\ENGINE~1\HELP3.07\6FG25PC.D10
OUTPUT DATA FILE:             S:\WASTE\ENGINE~1\HELP3.07\6FG25PC.OUT


TIME:   7:37     DATE:   9/14/2011


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

     TITLE:  WDI Site No.2 MC VI-F/G Expansion (Post-Closure) 25% Area

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


     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   0
          THICKNESS                   =     36.00   INCHES
          POROSITY                    =      0.4710 VOL/VOL
          FIELD CAPACITY              =      0.3420 VOL/VOL
          WILTING POINT               =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.3742 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


                                LAYER  2
                                --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

```
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =       0.20   INCHES
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.     =    1.00000000000     CM/SEC
SLOPE                         =      25.00   PERCENT
DRAINAGE LENGTH               =     250.0    FEET


                         LAYER  3
                         --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                     =       0.04   INCHES
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.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =       1.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD


                         LAYER  4
                         --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =       0.36   INCHES
POROSITY                      =       0.7500 VOL/VOL
FIELD CAPACITY                =       0.7470 VOL/VOL
WILTING POINT                 =       0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.240999998000E-08 CM/SEC


                         LAYER  5
                         --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   5
THICKNESS                     =    1064.00   INCHES
POROSITY                      =       0.4570 VOL/VOL
FIELD CAPACITY                =       0.1310 VOL/VOL
WILTING POINT                 =       0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                         LAYER  6
                         --------
```

```
              TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                      =     12.00   INCHES
POROSITY                       =      0.4170 VOL/VOL
FIELD CAPACITY                 =      0.0450 VOL/VOL
WILTING POINT                  =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC


                          LAYER  7
                          --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                      =      0.20   INCHES
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.      =   1.22000003000     CM/SEC
SLOPE                          =      8.20   PERCENT
DRAINAGE LENGTH                =    166.0    FEET


                          LAYER  8
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                      =      0.08   INCHES
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.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS       =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY          =  3 - GOOD


                          LAYER  9
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
THICKNESS                      =     60.00   INCHES
POROSITY                       =      0.4270 VOL/VOL
FIELD CAPACITY                 =      0.4180 VOL/VOL
WILTING POINT                  =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC
```

```
                         LAYER 10
                         --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
    THICKNESS                     =       0.20   INCHES
    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.     =    1.22000003000      CM/SEC
    SLOPE                         =       8.20   PERCENT
    DRAINAGE LENGTH               =     166.0    FEET


                         LAYER 11
                         --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
    THICKNESS                     =       0.08   INCHES
    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.     =  0.199999996000E-12 CM/SEC
    FML PINHOLE DENSITY           =       1.00   HOLES/ACRE
    FML INSTALLATION DEFECTS      =       1.00   HOLES/ACRE
    FML PLACEMENT QUALITY         =  3 - GOOD


                         LAYER 12
                         --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
    THICKNESS                     =      36.00   INCHES
    POROSITY                      =       0.4270 VOL/VOL
    FIELD CAPACITY                =       0.4180 VOL/VOL
    WILTING POINT                 =       0.3670 VOL/VOL
    INITIAL SOIL WATER CONTENT    =       0.4270 VOL/VOL
    EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE #12 WITH A
            FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
            AND A SLOPE LENGTH OF  250. FEET.

  SCS RUNOFF CURVE NUMBER                 =     88.60
  FRACTION OF AREA ALLOWING RUNOFF        =    100.0    PERCENT
  AREA PROJECTED ON HORIZONTAL PLANE      =      1.000  ACRES
  EVAPORATIVE ZONE DEPTH                  =     20.0    INCHES
```

```
INITIAL WATER IN EVAPORATIVE ZONE    =      7.998  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      9.420  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      4.200  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    194.662  INCHES
TOTAL INITIAL WATER                  =    194.662  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DETROIT                MICHIGAN

      STATION LATITUDE                          =  42.40 DEGREES
      MAXIMUM LEAF AREA INDEX                   =   4.00
      START OF GROWING SEASON (JULIAN DATE)     =    121
      END OF GROWING SEASON (JULIAN DATE)       =    286
      EVAPORATIVE ZONE DEPTH                    =  20.0  INCHES
      AVERAGE ANNUAL WIND SPEED                 =  10.20 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  73.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  71.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  75.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.86        1.69        2.54        3.15        2.77        3.43
  3.10        3.21        2.25        2.12        2.33        2.52


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 23.40       25.80       35.00       47.40       58.10       67.70
 71.90       70.50       63.30       51.90       39.50       28.50


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DETROIT              MICHIGAN
            AND STATION LATITUDE  =  42.40 DEGREES
```

```
*******************************************************************************

       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                    1.81     1.77     2.38     3.33     2.97     3.36
                             2.93     2.98     2.31     1.66     2.36     2.63

   STD. DEVIATIONS           0.65     0.79     1.07     1.30     1.13     1.41
                             1.26     1.64     1.37     1.06     1.00     1.05

 RUNOFF
 ------
   TOTALS                    0.701    1.373    2.315    1.499    0.720    0.884
                             0.733    1.134    0.510    0.297    0.442    0.456

   STD. DEVIATIONS           0.559    1.014    1.738    1.367    0.577    0.855
                             0.581    1.249    0.518    0.470    0.439    0.502

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    0.499    0.460    0.569    2.059    3.031    4.339
                             2.242    1.800    1.436    0.756    0.557    0.458

   STD. DEVIATIONS           0.084    0.091    0.185    0.603    0.747    0.855
                             0.823    0.644    0.660    0.221    0.151    0.095

 LATERAL DRAINAGE COLLECTED FROM LAYER  2
 ----------------------------------------
   TOTALS                    0.0779   0.0290   0.0194   0.1277   0.3287   0.2570
                             0.1448   0.0895   0.0386   0.0017   0.0019   0.0755

   STD. DEVIATIONS           0.2076   0.0666   0.0443   0.1983   0.2787   0.1174
                             0.0497   0.0370   0.0309   0.0049   0.0093   0.2614

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 LATERAL DRAINAGE COLLECTED FROM LAYER  7
 ----------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  9
 ------------------------------------
   TOTALS                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
```

```
 LATERAL DRAINAGE COLLECTED FROM LAYER 10
 ----------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER 12
 ------------------------------------
   TOTALS                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
   AVERAGES                0.0005   0.0002   0.0001   0.0008   0.0020   0.0016
                           0.0009   0.0005   0.0002   0.0000   0.0000   0.0005

   STD. DEVIATIONS         0.0013   0.0004   0.0003   0.0012   0.0017   0.0007
                           0.0003   0.0002   0.0002   0.0000   0.0001   0.0016

 DAILY AVERAGE HEAD ON TOP OF LAYER  8
 -------------------------------------
   AVERAGES                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 DAILY AVERAGE HEAD ON TOP OF LAYER 11
 -------------------------------------
   AVERAGES                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES              CU. FEET       PERCENT
                                -------------------   -------------    ---------
 PRECIPITATION                   30.46     (   3.646)      110581.9     100.00

 RUNOFF                          11.063    (  2.3587)      40159.16      36.316

 EVAPOTRANSPIRATION              18.206    (  1.7822)      66088.68      59.764

 LATERAL DRAINAGE COLLECTED       1.19162 (  0.76288)       4325.566      3.91164
```

```
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)          0.004      0.00000
   LAYER  4

 AVERAGE HEAD ON TOP              0.001 (    0.000)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED       0.00000 (  0.00000)          0.000    0.00000
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)          0.004      0.00000
   LAYER  9

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  8

 LATERAL DRAINAGE COLLECTED       0.00000 (  0.00000)          0.002    0.00000
   FROM LAYER 10

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)          0.002      0.00000
   LAYER 12

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER 11

 CHANGE IN WATER STORAGE          0.002    (  1.9351)          8.50       0.008
*******************************************************************************


0
*******************************************************************************

               PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
   ------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------    -------------
      PRECIPITATION                                2.92        10599.601

      RUNOFF                                       2.517        9135.9434

      DRAINAGE COLLECTED FROM LAYER  2             0.07720       280.22861

      PERCOLATION/LEAKAGE THROUGH LAYER  4         0.000000        0.00003

      AVERAGE HEAD ON TOP OF LAYER  3              0.014

      MAXIMUM HEAD ON TOP OF LAYER  3              0.083

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                  0.0 FEET

      DRAINAGE COLLECTED FROM LAYER  7             0.00000         0.00001

      PERCOLATION/LEAKAGE THROUGH LAYER  9         0.000000        0.00002

      AVERAGE HEAD ON TOP OF LAYER  8              0.000

      MAXIMUM HEAD ON TOP OF LAYER  8              0.002

      LOCATION OF MAXIMUM HEAD IN LAYER  7
```

```
         (DISTANCE FROM DRAIN)                   0.0 FEET

   DRAINAGE COLLECTED FROM LAYER 10              0.00000           0.00001

   PERCOLATION/LEAKAGE THROUGH LAYER 12          0.000000          0.00001

   AVERAGE HEAD ON TOP OF LAYER 11               0.000

   MAXIMUM HEAD ON TOP OF LAYER 11               0.002

   LOCATION OF MAXIMUM HEAD IN LAYER 10
         (DISTANCE FROM DRAIN)                   0.0 FEET

   SNOW WATER                                    8.24          29917.9609


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4546

   MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.2100


    ***  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.

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



□
******************************************************************************

                 FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                  LAYER        (INCHES)        (VOL/VOL)
                  -----        --------        ---------
                    1          13.2266          0.3674

                    2           0.0020          0.0100

                    3           0.0000          0.0000

                    4           0.2700          0.7500

                    5         139.3840          0.1310

                    6           0.5400          0.0450

                    7           0.0020          0.0100

                    8           0.0000          0.0000

                    9          25.6200          0.4270

                   10           0.0020          0.0100

                   11           0.0000          0.0000
```

```
                     12           15.3720         0.4270

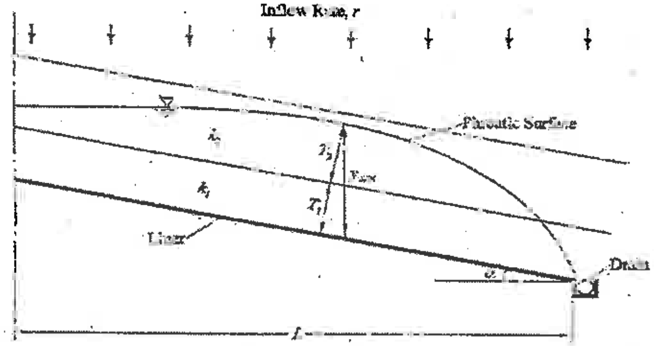
                  SNOW WATER       0.314

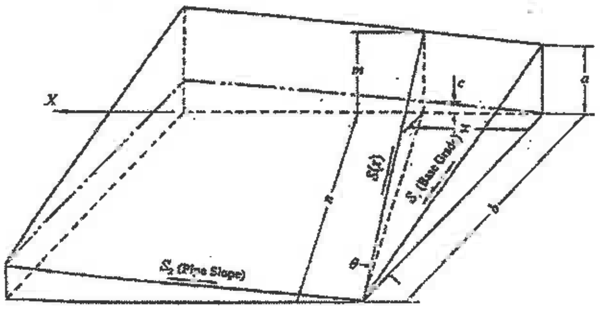
*******************************************************************************
*******************************************************************************
```

# APPENDIX B

## Mound Model Leachate Head Calculations

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





**MC VI-F Phase 2 South Area**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.4% | |
| $S_2$ = | 0.034 | |

| | | |
|---|---|---|
| S (tanα) | 0.0394 | |
| α = | 0.0394 | radians |
| α = | 2.259 | degrees |
| sinα | 0.0394 | |
| cosα | 0.9992 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.24 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.02 | cm |
| $y_{max}$ | 310.24 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.4% | |
| $S_2$ = | 0.034 | |

| | | |
|---|---|---|
| S (tanα) | 0.0394 | |
| α = | 0.0394 | radians |
| α = | 2.259 | degrees |
| sinα | 0.0394 | |
| cosα | 0.9992 | |

| | | |
|---|---|---|
| r | 5.79 | mm/day |
| r | 0.579 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.19 | cm/day |

| | | |
|---|---|---|
| b | 4347.20 | cm |
| L | 8574.02 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.294523 |
| B | -0.281835 |
| j | 0.909472 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 25.16 | cm |
| $y_{max}$ | 251.58 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.4% | |
| $S_2$ = | 0.034 | |

| | | |
|---|---|---|
| S (tanα) | 0.0394 | |
| α = | 0.0394 | radians |
| α = | 2.259 | degrees |
| sinα | 0.0394 | |
| cosα | 0.9992 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 116 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.078 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 121.28 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 12.13 | cm |
| $y_{max}$ | 121.28 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.4% | |
| $S_2$ = | 0.034 | |

| | | |
|---|---|---|
| S (tanα) | 0.0394 | |
| α = | 0.0394 | radians |
| α = | 2.259 | degrees |
| sinα | 0.0394 | |
| cosα | 0.9992 | |

| | | |
|---|---|---|
| r | 5.79 | mm/day |
| r | 0.579 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1078 | cm/sec |
| $k_{eq}$ | 9312.634 | cm/day |

| | | |
|---|---|---|
| b | 4347.203 | cm |
| L | 8574.02 | cm |

Giroud's 92 Method

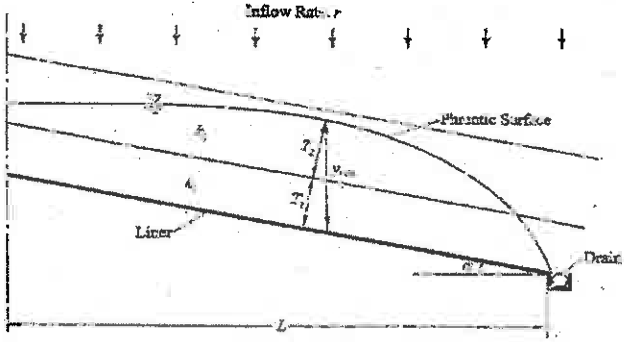
| | |
|---|---|
| A | 0.179297 |
| B | -0.557154 |
| j | 0.93126 |

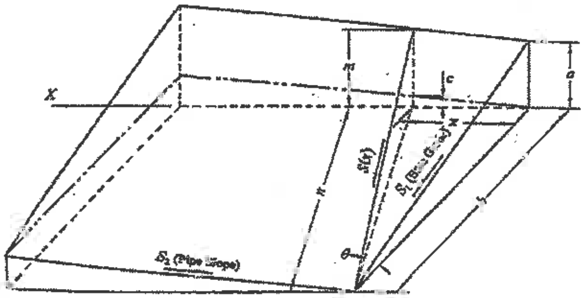
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 12.13 | cm |
| $y_{max}$ | 121.28 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* **2008**





### MC VI-F Phase 2 South Area 2

| | | |
|---|---|---|
| Base Grade | 10.9% | |
| $S_1$ = | 0.109 | |

input
trial & error
output

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.1090 | |
| α = | 0.1086 | radians |
| α = | 6.221 | degrees |
| sinα | 0.1084 | |
| cosα | 0.9941 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 311.84 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.18 | cm |
| $y_{max}$ | 311.84 | mm |

**compare**

### Trial 1

| | | |
|---|---|---|
| Base Grade | 10.9% | |
| $S_1$ = | 0.109 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.1090 | |
| α = | 0.1086 | radians |
| α = | 6.221 | degrees |
| sinα | 0.1084 | |
| cosα | 0.9941 | |

| | | |
|---|---|---|
| r | 8.75 | mm/day |
| r | 0.875 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 2502.41 | cm |
| L | 2502.41 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.1070096 |
| B | -0.94202 |
| j | 0.9532193 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 4.50 | cm |
| $y_{max}$ | 44.99 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 10.9% | |
| $S_1$ = | 0.109 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.1090 | |
| α = | 0.1086 | radians |
| α = | 6.221 | degrees |
| sinα | 0.1084 | |
| cosα | 0.9941 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 0 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 12.200 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 5.03 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 0.50 | cm |
| $y_{max}$ | 5.03 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 10.9% | |
| $S_1$ = | 0.109 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.1090 | |
| α = | 0.1086 | radians |
| α = | 6.221 | degrees |
| sinα | 0.1084 | |
| cosα | 0.9941 | |

| | | |
|---|---|---|
| r | 8.75 | mm/day |
| r | 0.875 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 1.2200 | cm/sec |
| $k_{eq}$ | 105408 | cm/day |

| | | |
|---|---|---|
| b | 2502.41 | cm |
| L | 2502.41 | cm |

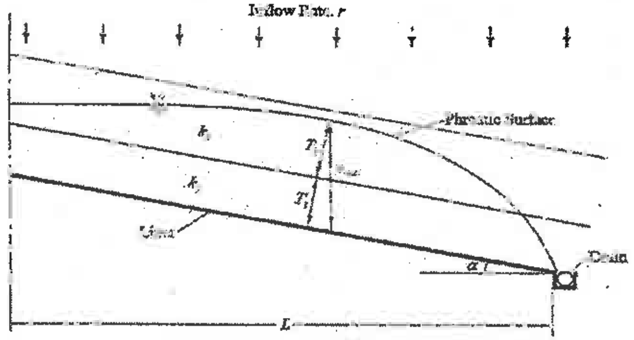
Giroud's 92 Method

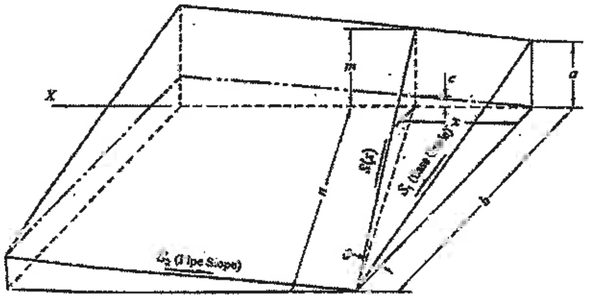
| | |
|---|---|
| A | 0.0142972 |
| B | -3.403096 |
| j | 0.9960076 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 0.19 | cm |
| $y_{max}$ | 1.91 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





**MC VI-F Phase 2 NE Area**

|  |  |  |
|---|---|---|
| Base Grade | 7.4% |  |
| $S_1$ = | 0.074 |  |

| |
|---|
| input |
| trial & error |
| output |

|  |  |  |
|---|---|---|
| Pipe Slope | 0.0% |  |
| $S_2$ = | 0.000 |  |

|  |  |  |
|---|---|---|
| S (tanα) | 0.0740 |  |
| α = | 0.0739 | radians |
| α = | 4.232 | degrees |
| sinα | 0.0738 |  |
| cosα | 0.9973 |  |

|  |  |  |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

|  |  |  |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

|  |  |  |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

|  |  |  |
|---|---|---|
| $y_{max}$ | 310.85 | mm |

**Assumed**

|  |  |  |
|---|---|---|
| $y_{max}$ | 31.08 | cm |
| $y_{max}$ | 310.85 | mm |

**compare**

**Trial 1**

|  |  |  |
|---|---|---|
| Base Grade | 7.4% |  |
| $S_1$ = | 0.074 |  |

|  |  |  |
|---|---|---|
| Pipe Slope | 0.0% |  |
| $S_2$ = | 0.000 |  |

|  |  |  |
|---|---|---|
| S (tanα) | 0.0740 |  |
| α = | 0.0739 | radians |
| α = | 4.232 | degrees |
| sinα | 0.0738 |  |
| cosα | 0.9973 |  |

|  |  |  |
|---|---|---|
| $r$ | 9.41 | mm/day |
| $r$ | 0.941 | cm/day |

|  |  |  |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

|  |  |  |
|---|---|---|
| $b$ | 7552.94 | cm |
| $L$ | 7552.94 | cm |

Giroud's 92 Method

|  |  |
|---|---|
| $A$ | 0.1817208 |
| $B$ | -0.548481 |
| $j$ | 0.9300606 |

**Calculated**

|  |  |  |
|---|---|---|
| $y_{max}$ | 20.49 | cm |
| $y_{max}$ | 204.89 | mm |

**Trial 2**

|  |  |  |
|---|---|---|
| Base Grade | 7.4% |  |
| $S_1$ = | 0.074 |  |

|  |  |  |
|---|---|---|
| Pipe Slope | 0.0% |  |
| $S_2$ = | 0.000 |  |

|  |  |  |
|---|---|---|
| S (tanα) | 0.0740 |  |
| α = | 0.0739 | radians |
| α = | 4.232 | degrees |
| sinα | 0.0738 |  |
| cosα | 0.9973 |  |

|  |  |  |
|---|---|---|
| $k1$ | 12.2 | mm/sec |
| $k2$ | 0.1 | mm/sec |

|  |  |  |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 16 | mm |

|  |  |  |
|---|---|---|
| $k_{eq}$ | 5.158 | mm/sec |

**Assumed**

|  |  |  |
|---|---|---|
| $y_{max}$ | 21.15 | mm |

**Assumed**

|  |  |  |
|---|---|---|
| $y_{max}$ | 2.11 | cm |
| $y_{max}$ | 21.15 | mm |

**compare**

|  |  |  |
|---|---|---|
| Base Grade | 7.4% |  |
| $S_1$ = | 0.074 |  |

|  |  |  |
|---|---|---|
| Pipe Slope | 0.0% |  |
| $S_2$ = | 0.000 |  |

|  |  |  |
|---|---|---|
| S (tanα) | 0.0740 |  |
| α = | 0.0739 | radians |
| α = | 4.232 | degrees |
| sinα | 0.0738 |  |
| cosα | 0.9973 |  |

|  |  |  |
|---|---|---|
| $r$ | 9.41 | mm/day |
| $r$ | 0.941 | cm/day |

|  |  |  |
|---|---|---|
| $k_{eq}$ | 0.5158 | cm/sec |
| $k_{eq}$ | 44560.814 | cm/day |

|  |  |  |
|---|---|---|
| $b$ | 7552.944 | cm |
| $L$ | 7552.94 | cm |

Giroud's 92 Method

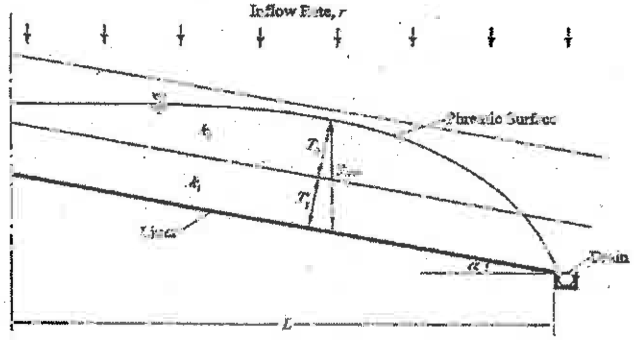
|  |  |
|---|---|
| $A$ | 0.0415847 |
| $B$ | -1.907346 |
| $j$ | 0.9821831 |

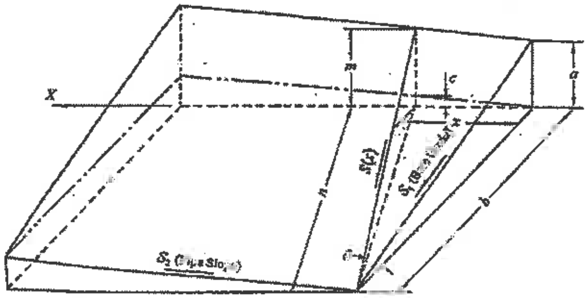
**Calculated**

|  |  |  |
|---|---|---|
| $y_{max}$ | 2.11 | cm |
| $y_{max}$ | 21.15 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* **2008**





**MC VI-F Phase 2 North Area**

| | | |
|---|---|---|
| Base Grade | 7.9% | |
| $S_1$ = | 0.079 | |

| |
|---|
| input |
| trial & error |
| output |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0790 | |
| α = | 0.0788 | radians |
| α = | 4.517 | degrees |
| sinα | 0.0788 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.97 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.10 | cm |
| $y_{max}$ | 310.97 | mm |

**compare**

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 7.9% | |
| $S_1$ = | 0.079 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0790 | |
| α = | 0.0788 | radians |
| α = | 4.517 | degrees |
| sinα | 0.0788 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| r | 9.14 | mm/day |
| r | 0.914 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 9381.74 | cm |
| L | 9381.74 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.3544403 |
| B | -0.614643 |
| j | 0.9350999 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 23.40 | cm |
| $y_{max}$ | 234.01 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 7.9% | |
| $S_1$ = | 0.079 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0790 | |
| α = | 0.0788 | radians |
| α = | 4.517 | degrees |
| sinα | 0.0788 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 50 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 2.190 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 55.46 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 5.55 | cm |
| $y_{max}$ | 55.46 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 7.9% | |
| $S_1$ = | 0.079 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0790 | |
| α = | 0.0788 | radians |
| α = | 4.517 | degrees |
| sinα | 0.0788 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| r | 9.14 | mm/day |
| r | 0.914 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.2190 | cm/sec |
| $k_{eq}$ | 18918.375 | cm/day |

| | | |
|---|---|---|
| b | 9381.74 | cm |
| L | 9381.74 | cm |

Giroud's 92 Method

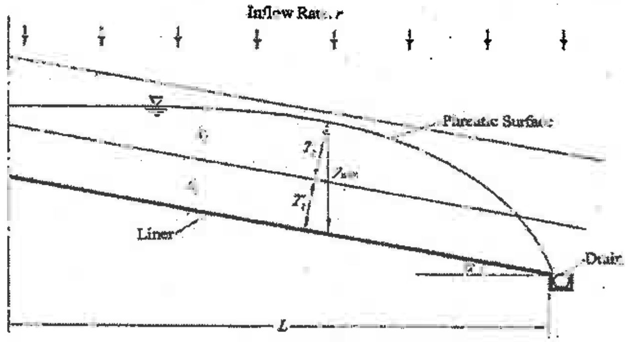
| | |
|---|---|
| A | 0.0542806 |
| B | -1.420673 |
| j | 0.9710138 |

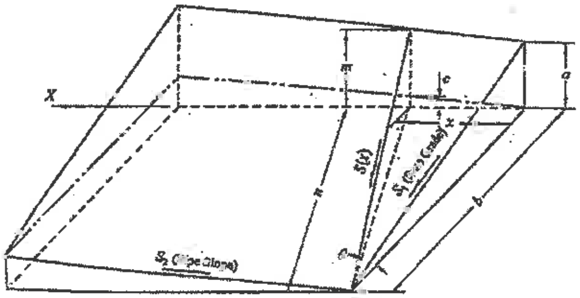
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 5.55 | cm |
| $y_{max}$ | 55.46 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-F Phase 2 North Area 2

| | | |
|---|---|---|
| Base Grade | 5.6% | |
| $S_1$ = | 0.056 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0560 | |
| α = | 0.0559 | radians |
| α = | 3.205 | degrees |
| sinα | 0.0559 | |
| cosα | 0.9984 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.49 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.05 | cm |
| $y_{max}$ | 310.49 | mm |

input
trial & error
output

**compare**

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 5.6% | |
| $S_1$ = | 0.056 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0560 | |
| α = | 0.0559 | radians |
| α = | 3.205 | degrees |
| sinα | 0.0559 | |
| cosα | 0.9984 | |

| | | |
|---|---|---|
| r | 9.62 | mm/day |
| r | 0.962 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.19 | cm/day |

| | | |
|---|---|---|
| b | 5108.45 | cm |
| L | 5108.45 | cm |

Giroud's 92 **Method**

| | |
|---|---|
| A | 0.261036 |
| B | -0.340239 |
| j | 0.914808 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 17.88 | cm |
| $y_{max}$ | 178.76 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 5.6% | |
| $S_1$ = | 0.056 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0560 | |
| α = | 0.0559 | radians |
| α = | 3.205 | degrees |
| sinα | 0.0559 | |
| cosα | 0.9984 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 8 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 7.618 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 13.02 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 1.30 | cm |
| $y_{max}$ | 13.02 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 5.6% | |
| $S_1$ = | 0.056 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0560 | |
| α = | 0.0559 | radians |
| α = | 3.205 | degrees |
| sinα | 0.0559 | |
| cosα | 0.9984 | |

| | | |
|---|---|---|
| r | 9.62 | mm/day |
| r | 0.962 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.7618 | cm/sec |
| $k_{eq}$ | 65819.87 | cm/day |

| | | |
|---|---|---|
| b | 5108.45 | cm |
| L | 5108.45 | cm |

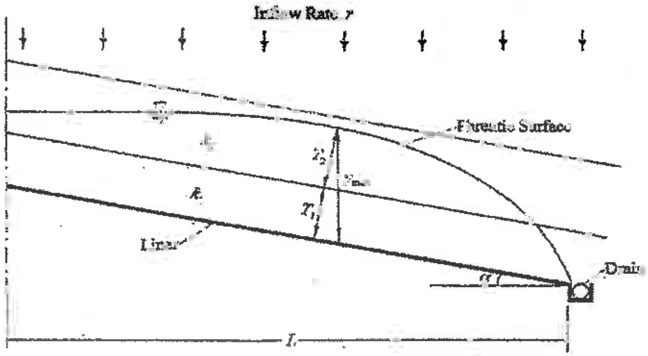
Giroud's 92 Method

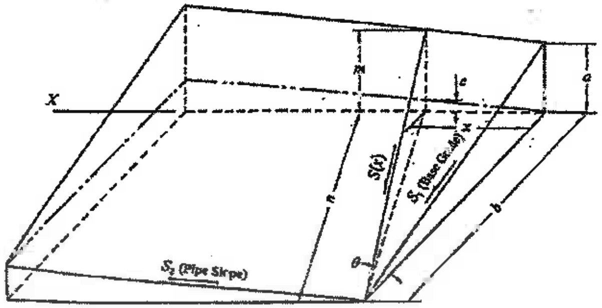
| | |
|---|---|
| A | 0.046811 |
| B | -1.767064 |
| j | 0.979518 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 1.30 | cm |
| $y_{max}$ | 13.02 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* 2008





**MC VI-F Phase 1 South Area**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| $S_2$ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0796 | |
| α = | 0.0794 | radians |
| α = | 4.549 | degrees |
| sinα | 0.0793 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.98 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.10 | cm |
| $y_{max}$ | 310.98 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| $S_2$ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0796 | |
| α = | 0.0794 | radians |
| α = | 4.549 | degrees |
| sinα | 0.0793 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| r | 6.89 | mm/day |
| r | 0.689 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.19 | cm/day |

| | | |
|---|---|---|
| b | 3614.46 | cm |
| L | 14377.42 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.136617 |
| B | -0.747354 |
| j | 0.943166 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 27.30 | cm |
| $y_{max}$ | 273.01 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| $S_2$ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0796 | |
| α = | 0.0794 | radians |
| α = | 4.549 | degrees |
| sinα | 0.0793 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 161 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.818 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 166.41 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 16.64 | cm |
| $y_{max}$ | 166.41 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| $S_2$ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0796 | |
| α = | 0.0794 | radians |
| α = | 4.549 | degrees |
| sinα | 0.0793 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| r | 6.89 | mm/day |
| r | 0.689 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0818 | cm/sec |
| $k_{eq}$ | 7071.355 | cm/day |

| | | |
|---|---|---|
| b | 3614.459 | cm |
| L | 14377.42 | cm |

Giroud's 92 Method

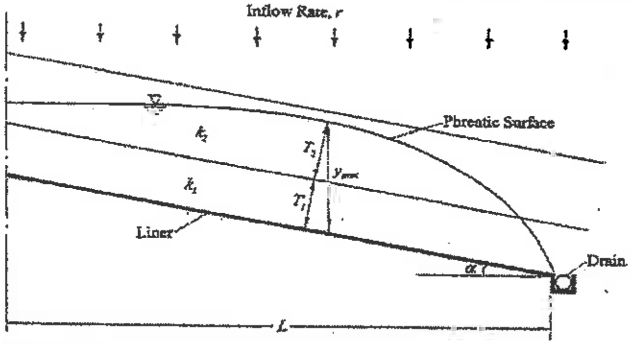
| | |
|---|---|
| A | 0.098784 |
| B | -1.010851 |
| j | 0.956322 |

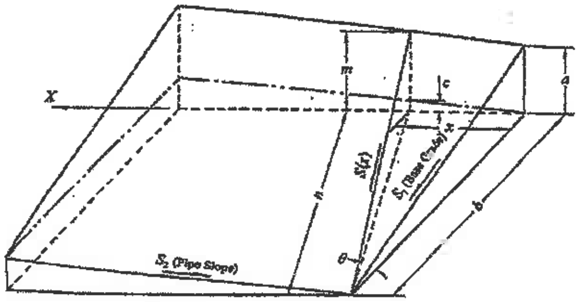
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 16.64 | cm |
| $y_{max}$ | 166.41 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-F Phase 1 South Area 2

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| S₂ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0868 | |
| α = | 0.0866 | radians |
| α = | 4.959 | degrees |
| sinα | 0.0864 | |
| cosα | 0.9963 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| T₁ | 5 | mm |
| (T₂)assumed | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 311.16 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.12 | cm |
| $y_{max}$ | 311.16 | mm |

input

trial & error

output

compare

### Trial 1

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| S₂ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0868 | |
| α = | 0.0866 | radians |
| α = | 4.959 | degrees |
| sinα | 0.0864 | |
| cosα | 0.9963 | |

| | | |
|---|---|---|
| $r$ | 9.35 | mm/day |
| $r$ | 0.935 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4203.19 | cm/day |

| | | |
|---|---|---|
| $b$ | 4334.72 | cm |
| $L$ | 9403.08 | cm |

Giroud's 92 Method

| | |
|---|---|
| $A$ | 0.148336 |
| $B$ | -0.65883 |
| $j$ | 0.93982 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 22.07 | cm |
| $y_{max}$ | 220.7 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| S₂ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0868 | |
| α = | 0.0866 | radians |
| α = | 4.959 | degrees |
| sinα | 0.0864 | |
| cosα | 0.9963 | |

| | | |
|---|---|---|
| $k1$ | 12.2 | mm/sec |
| $k2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| T₁ | 5 | mm |
| (T₂)assumed | 27 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 3.604 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.94 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 3.19 | cm |
| $y_{max}$ | 31.94 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 7.7% | |
| S₂ = | 0.077 | |

| | | |
|---|---|---|
| S (tanα) | 0.0868 | |
| α = | 0.0866 | radians |
| α = | 4.959 | degrees |
| sinα | 0.0864 | |
| cosα | 0.9963 | |

| | | |
|---|---|---|
| $r$ | 9.35 | mm/day |
| $r$ | 0.935 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.3604 | cm/sec |
| $k_{eq}$ | 31138 | cm/day |

| | | |
|---|---|---|
| $b$ | 4334.724 | cm |
| $L$ | 9403.08 | cm |

Giroud's 92 Method

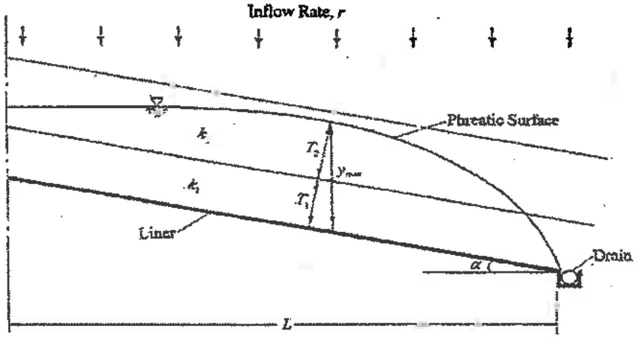
| | |
|---|---|
| $A$ | 0.042466 |
| $B$ | -1.28221 |
| $j$ | 0.98173 |

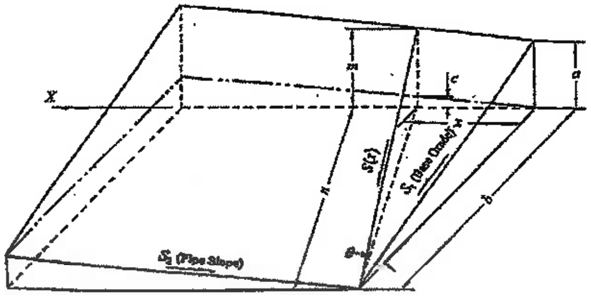
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 3.19 | cm |
| $y_{max}$ | 31.94 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* **2008**





### MC VI-F Phase 1 North Area

| | | |
|---|---|---|
| Base Grade | 9.6% | |
| $S_1$ = | 0.096 | |

| input |
|---|
| trial & error |
| [illegible] |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0960 | |
| α = | 0.0957 | radians |
| α = | 5.484 | degrees |
| sinα | 0.0956 | |
| cosα | 0.9954 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 311.43 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.14 | cm |
| $y_{max}$ | 311.43 | mm |

**compare**

### Trial 1

| | | |
|---|---|---|
| Base Grade | 9.6% | |
| $S_1$ = | 0.096 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0960 | |
| α = | 0.0957 | radians |
| α = | 5.484 | degrees |
| sinα | 0.0956 | |
| cosα | 0.9954 | |

| | | |
|---|---|---|
| r | 9.43 | mm/day |
| r | 0.943 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 9665.21 | cm |
| L | 9665.21 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.1314261 |
| B | -0.776722 |
| j | 0.9448107 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 20.91 | cm |
| $y_{max}$ | 209.12 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 9.6% | |
| $S_1$ = | 0.096 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0960 | |
| α = | 0.0957 | radians |
| α = | 5.484 | degrees |
| sinα | 0.0956 | |
| cosα | 0.9954 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 16 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 5.264 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 20.68 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 2.07 | cm |
| $y_{max}$ | 20.68 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 9.6% | |
| $S_1$ = | 0.096 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0960 | |
| α = | 0.0957 | radians |
| α = | 5.484 | degrees |
| sinα | 0.0956 | |
| cosα | 0.9954 | |

| | | |
|---|---|---|
| r | 9.43 | mm/day |
| r | 0.943 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.5264 | cm/sec |
| $k_{eq}$ | 4548.386 | cm/day |

| | | |
|---|---|---|
| b | 9665.21 | cm |
| L | 9665.21 | cm |

Giroud's 92 Method

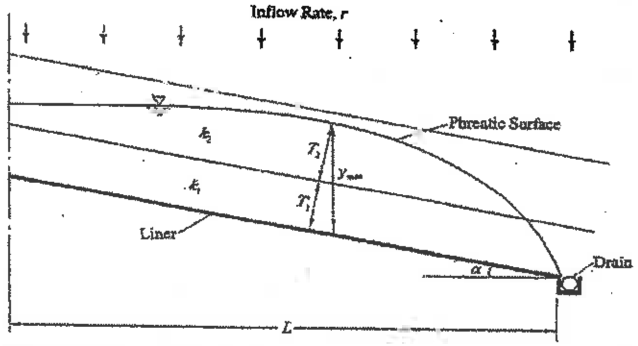
| | |
|---|---|
| A | 0.029692 |
| B | -2.332832 |
| j | 0.9983575 |

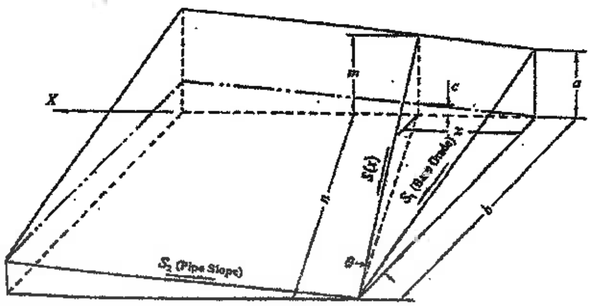
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 2.07 | cm |
| $y_{max}$ | 20.66 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

***Developed by Xuede (Dan) Qian*** **2008**





### MC VI-F Phase 1 North Area 2

| | | |
|---|---|---|
| Base Grade | 7.7% | |
| $S_1$ = | 0.077 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0770 | |
| α = | 0.0768 | radians |
| α = | 4.403 | degrees |
| sinα | 0.0768 | |
| cosα | 0.9970 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.92 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.09 | cm |
| $y_{max}$ | 310.92 | mm |

input
trial & error
output

compare

### Trial 1

| | | |
|---|---|---|
| Base Grade | 7.7% | |
| $S_1$ = | 0.077 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0770 | |
| α = | 0.0768 | radians |
| α = | 4.403 | degrees |
| sinα | 0.0768 | |
| cosα | 0.9970 | |

| | | |
|---|---|---|
| r | 9.93 | mm/day |
| r | 0.993 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| b | 5824.73 | cm |
| L | 5824.73 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | [illegible] |
| B | 0.56888 |
| j | 0.9313767 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 16.06 | cm |
| $y_{max}$ | 160.55 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 7.7% | |
| $S_1$ = | 0.077 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0770 | |
| α = | 0.0768 | radians |
| α = | 4.403 | degrees |
| sinα | 0.0768 | |
| cosα | 0.9970 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 3 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 10.206 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 8.44 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 0.84 | cm |
| $y_{max}$ | 8.44 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 7.7% | |
| $S_1$ = | 0.077 | |

| | | |
|---|---|---|
| Pipe Slope | 0.0% | |
| $S_2$ = | 0.000 | |

| | | |
|---|---|---|
| S (tanα) | 0.0770 | |
| α = | 0.0768 | radians |
| α = | 4.403 | degrees |
| sinα | 0.0768 | |
| cosα | 0.9970 | |

| | | |
|---|---|---|
| r | 9.93 | mm/day |
| r | [illegible] | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 1.0206 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| b | 5824.73 | cm |
| L | 5824.73 | cm |

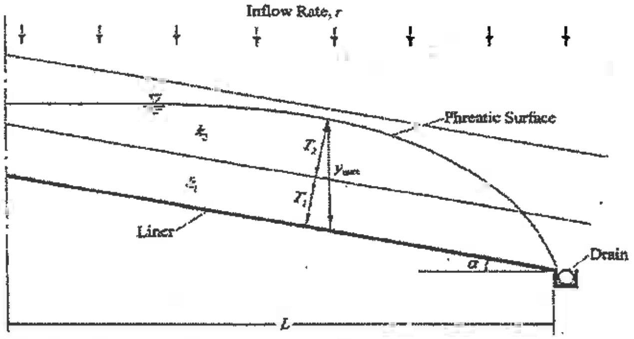
Giroud's 92 Method

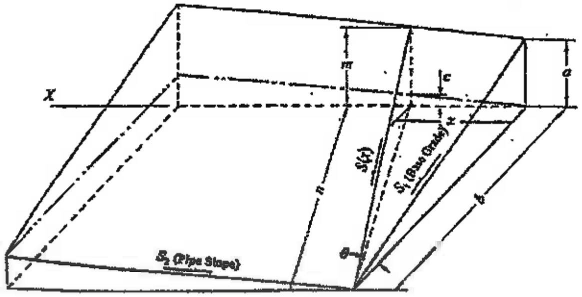
| | |
|---|---|
| A | 0.0267111 |
| B | -2.4753 |
| j | 0.9899035 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 0.84 | cm |
| $y_{max}$ | [illegible] | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** **Developed by Xuede (Dan) Qian** **2008**





**MC VI-G Phase 1 East Area**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |
| S (tanα) | 0.0250 | |
| α = | 0.0250 | radians |
| α = | 1.43 | degrees |
| sinα | 0.0250 | |
| cosα | 0.9997 | |
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.10 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.01 | cm |
| $y_{max}$ | 310.10 | mm |

input
trial & error
output

compare

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |
| S (tanα) | 0.0250 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | 0.0250 | |
| cosα | [illegible] | |
| r | 5.28 | mm/day |
| r | 0.528 | cm/day |
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4200.19 | cm/day |
| b | 4888.99 | cm |
| L | 6111.24 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.491068 |
| B | 0.035086 |
| j | 0.890682 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 23.33 | cm |
| $y_{max}$ | 233.39 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |
| S (tanα) | 0.0250 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | 0.0250 | |
| cosα | [illegible] | |
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 92 | mm |
| $k_{eq}$ | 1.311 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 97.42 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 9.74 | cm |
| $y_{max}$ | 97.42 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |
| S (tanα) | 0.0250 | |
| α = | 0.0250 | radians |
| α = | 1.432 | degrees |
| sinα | 0.0250 | |
| cosα | 0.9997 | |
| r | 5.28 | mm/day |
| r | 0.528 | cm/day |
| $k_{eq}$ | 0.1311 | cm/sec |
| $k_{eq}$ | 11322.93 | cm/day |
| b | 4888.992 | cm |
| L | 6111.24 | cm |

Giroud's 92 Method

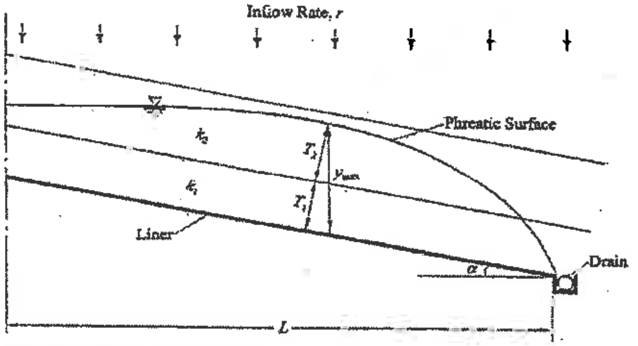
| | |
|---|---|
| A | 0.264894 |
| B | -0.332846 |
| j | 0.913874 |

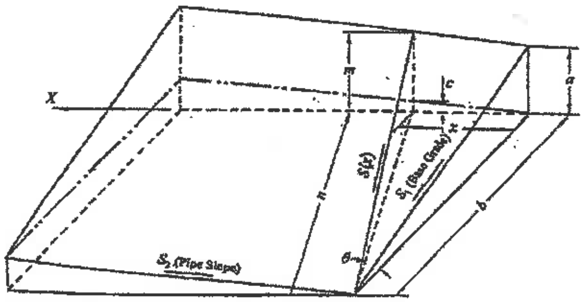
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 9.74 | cm |
| $y_{max}$ | 97.42 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 1 West Area

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.3% | |
| S₂ = | 0.033 | |

| | | |
|---|---|---|
| S (tanα) | 0.0386 | |
| α = | 0.0386 | radians |
| α = | 2.210 | degrees |
| sinα | 0.0386 | |
| cosα | 0.9993 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.23 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.02 | cm |
| $y_{max}$ | 310.23 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

### Trial 1

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.3% | |
| S₂ = | 0.033 | |

| | | |
|---|---|---|
| S (tanα) | 0.0386 | |
| α = | 0.0386 | radians |
| α = | 2.210 | degrees |
| sinα | 0.0386 | |
| cosα | 0.9993 | |

| | | |
|---|---|---|
| $r$ | 8.02 | mm/day |
| $r$ | 0.802 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| $b$ | 3097.96 | cm |
| $L$ | 5977.13 | cm |

Giroud's 92 Method

| | |
|---|---|
| $A$ | 0.371109 |
| $B$ | -0.18593 |
| $j$ | 0.9003 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 23.86 | cm |
| $y_{max}$ | 238.59 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.3% | |
| S₂ = | 0.033 | |

| | | |
|---|---|---|
| S (tanα) | 0.0386 | |
| α = | 0.0386 | radians |
| α = | 2.210 | degrees |
| sinα | 0.0386 | |
| cosα | 0.9993 | |

| | | |
|---|---|---|
| $k1$ | 12.2 | mm/sec |
| $k2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 91 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.324 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 96.40 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 9.64 | cm |
| $y_{max}$ | 96.40 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 3.3% | |
| S₂ = | 0.033 | |

| | | |
|---|---|---|
| S (tanα) | 0.0386 | |
| α = | 0.0386 | radians |
| α = | 2.210 | degrees |
| sinα | 0.0386 | |
| cosα | 0.9993 | |

| | | |
|---|---|---|
| $r$ | 8.02 | mm/day |
| $r$ | 0.802 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1324 | cm/sec |
| $k_{eq}$ | 11435.26 | cm/day |

| | | |
|---|---|---|
| $b$ | 3097.956 | cm |
| $L$ | 5977.13 | cm |

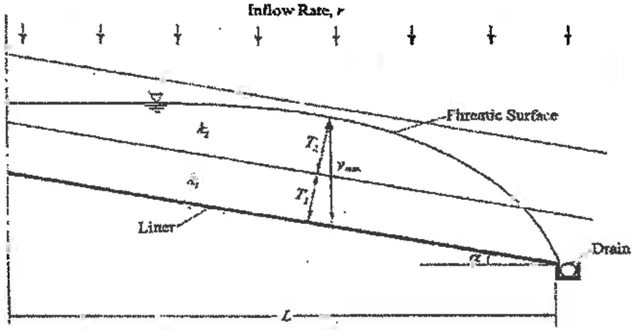
Giroud's 92 Method

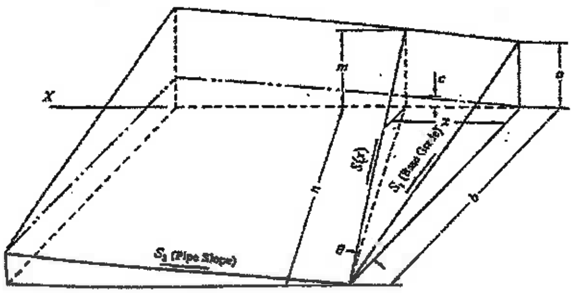
| | |
|---|---|
| $A$ | 0.198711 |
| $B$ | -1.492484 |
| $j$ | 0.926066 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 9.64 | cm |
| $y_{max}$ | 96.40 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





**MC VI-G Phase 2 West Area**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.6% | |
| $S_2$ = | 0.076 | |

| | | |
|---|---|---|
| S (tanα) | 0.0786 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | 0.0783 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.96 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.10 | cm |
| $y_{max}$ | 310.96 | mm |

input
trial & error
[illegible]

compare

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.6% | |
| $S_2$ = | 0.076 | |

| | | |
|---|---|---|
| S (tanα) | 0.0786 | |
| α = | 0.0784 | radians |
| α = | 4.493 | degrees |
| sinα | 0.0783 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| r | 8.29 | mm/day |
| r | 0.829 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| b | 2897.22 | cm |
| L | 11384.28 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.1567239 |
| B | 4.65229 |
| j | 0.0374978 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 26.02 | cm |
| $y_{max}$ | 260.25 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.6% | |
| $S_2$ = | 0.076 | |

| | | |
|---|---|---|
| S (tanα) | 0.0786 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | [illegible] | |
| cosα | [illegible] | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 120 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.046 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 125.73 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 12.57 | cm |
| $y_{max}$ | 125.73 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 7.6% | |
| $S_2$ = | 0.076 | |

| | | |
|---|---|---|
| S (tanα) | 0.0786 | |
| α = | [illegible] | radians |
| α = | 4.493 | degrees |
| sinα | 0.0783 | |
| cosα | 0.9969 | |

| | | |
|---|---|---|
| r | 8.29 | mm/day |
| r | 0.829 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1046 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| b | 2897.223 | cm |
| L | 11384.28 | cm |

Giroud's 92 Method

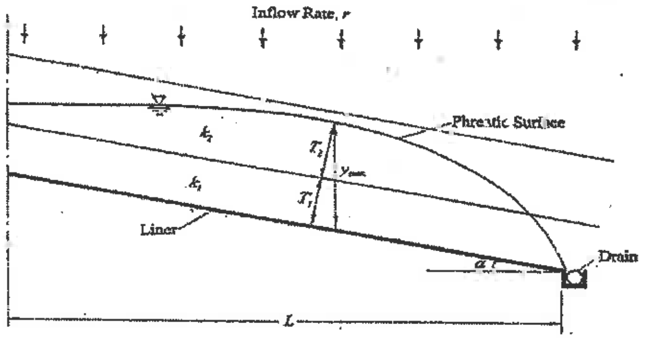
| | |
|---|---|
| A | [illegible] |
| B | -1.030364 |
| j | 0.8571748 |

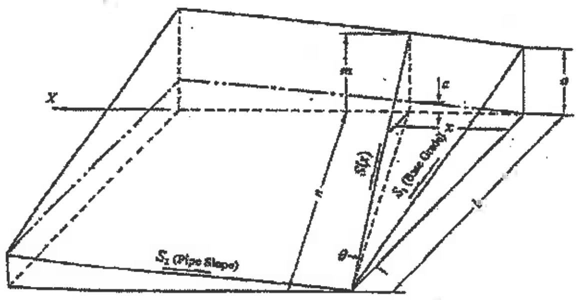
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 12.57 | cm |
| $y_{max}$ | 125.73 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 2 East Area

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 6.6% | |
| S₂ = | 0.066 | |

| | | |
|---|---|---|
| S (tanα) | 0.0690 | |
| α = | 0.0689 | radians |
| α = | 3.945 | degrees |
| sinα | 0.0688 | |
| cosα | 0.9976 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.74 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.07 | cm |
| $y_{max}$ | 310.74 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

### Trial 1

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 6.6% | |
| S₂ = | 0.066 | |

| | | |
|---|---|---|
| S (tanα) | 0.0690 | |
| α = | 0.0689 | radians |
| α = | 3.945 | degrees |
| sinα | 0.0688 | |
| cosα | 0.9976 | |

| | | |
|---|---|---|
| $r$ | 7.32 | mm/day |
| $r$ | 0.732 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.19[illegible] | cm/day |

| | | |
|---|---|---|
| $b$ | 3371.36 | cm |
| $L$ | 11625.07 | cm |

Giroud's 92 Method

| | |
|---|---|
| $A$ | 0.1695267 |
| $B$ | 0.393879 |
| $j$ | 0.953725 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 26.50 | cm |
| $y_{max}$ | 265.01 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 6.6% | |
| S₂ = | 0.066 | |

| | | |
|---|---|---|
| S (tanα) | 0.0690 | |
| α = | 0.0689 | radians |
| α = | 3.945 | degrees |
| sinα | 0.0688 | |
| cosα | 0.9976 | |

| | | |
|---|---|---|
| $k1$ | 12.2 | mm/sec |
| $k2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 139 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.927 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 144.20 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 14.42 | cm |
| $y_{max}$ | 144.20 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| S₁ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 6.6% | |
| S₂ = | 0.066 | |

| | | |
|---|---|---|
| S (tanα) | 0.0690 | |
| α = | 0.0689 | radians |
| α = | 3.945 | degrees |
| sinα | 0.0688 | |
| cosα | 0.9976 | |

| | | |
|---|---|---|
| $r$ | 7.32 | mm/day |
| $r$ | 0.732 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0927 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| $b$ | 3371.3568 | cm |
| $L$ | 11625.07 | cm |

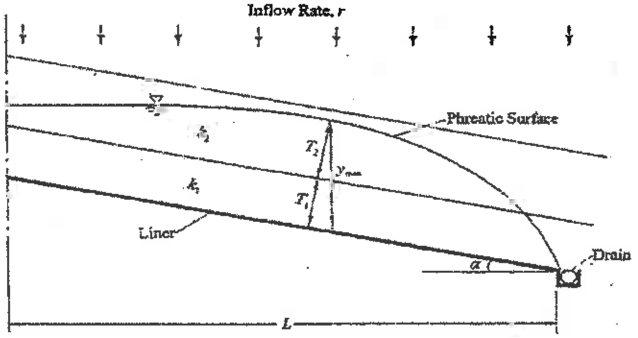
Giroud's 92 Method

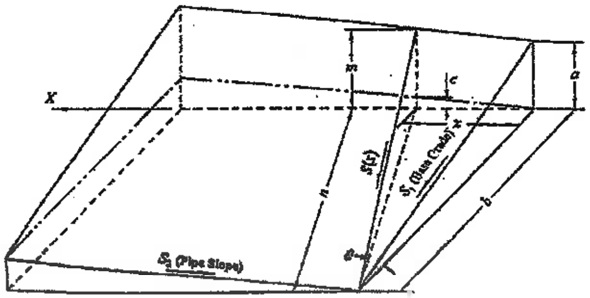
| | |
|---|---|
| $A$ | 0.1435052 |
| $B$ | 0.802905 |
| $j$ | 0.9598887 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 14.42 | cm |
| $y_{max}$ | 144.20 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





## MC VI-G Phase 3 NE Area

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0269 | |
| α = | 0.0269 | radians |
| α = | 1.541 | degrees |
| sinα | 0.0269 | |
| cosα | 0.9996 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.11 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.01 | cm |
| $y_{max}$ | 310.11 | mm |

input
trial & error
output

compare

## Trial 1

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0269 | |
| α = | 0.0269 | radians |
| α = | 1.541 | degrees |
| sinα | 0.0269 | |
| cosα | 0.9996 | |

| | | |
|---|---|---|
| r | 5.97 | mm/day |
| r | 0.597 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 4247.93 | cm |
| L | 5715.00 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.4842819 |
| B | -0.099168 |
| j | 0.8913286 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 23.00 | cm |
| $y_{max}$ | 230.02 | mm |

## Trial 2

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0269 | |
| α = | 0.0269 | radians |
| α = | 1.541 | degrees |
| sinα | 0.0269 | |
| cosα | 0.9996 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 84 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.418 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 89.28 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 8.93 | cm |
| $y_{max}$ | 89.28 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0269 | |
| α = | 0.0269 | radians |
| α = | 1.541 | degrees |
| sinα | 0.0269 | |
| cosα | 0.9996 | |

| | | |
|---|---|---|
| r | 5.97 | mm/day |
| r | 0.597 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1418 | cm/sec |
| $k_{eq}$ | 12250.31 | cm/day |

| | | |
|---|---|---|
| b | 4247.926 | cm |
| L | 5715.00 | cm |

Giroud's 92 Method

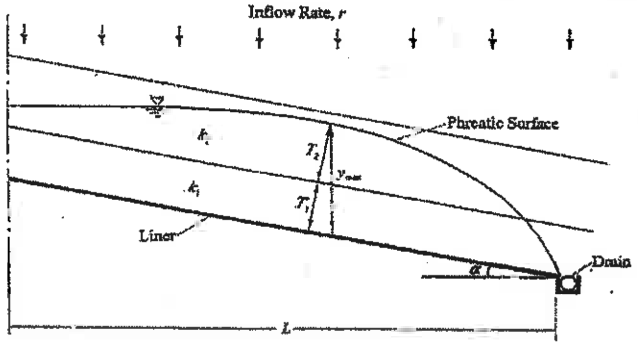
| | |
|---|---|
| A | 0.1243386 |
| B | 0.366867 |
| j | 0.916769 |

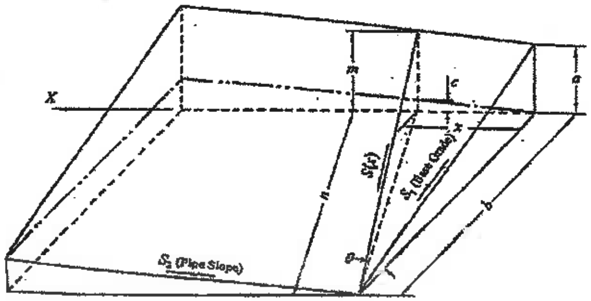
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 8.93 | cm |
| $y_{max}$ | 89.28 | mm |

# Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





## MC VI-G Phase 3 NW Area

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0539 | |
| α = | 0.0538 | radians |
| α = | 3.082 | degrees |
| sinα | 0.0538 | |
| cosα | 0.9986 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.45 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.04 | cm |
| $y_{max}$ | 310.45 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

## Trial 1

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0539 | |
| α = | 0.0538 | radians |
| α = | 3.082 | degrees |
| sinα | 0.0538 | |
| cosα | 0.9986 | |

| | | |
|---|---|---|
| r | 6.32 | mm/day |
| r | 0.632 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4208.1984 | cm/day |

| | | |
|---|---|---|
| b | 3978.98 | cm |
| L | 10713.72 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.2108140 |
| B | -0.457111 |
| j | 0.9240268 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 26.34 | cm |
| $y_{max}$ | 263.42 | mm |

## Trial 2

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0539 | |
| α = | 0.0538 | radians |
| α = | 3.082 | degrees |
| sinα | 0.0538 | |
| cosα | 0.9986 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 140 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.918 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 145.54 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 14.55 | cm |
| $y_{max}$ | 145.54 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0539 | |
| α = | 0.0538 | radians |
| α = | 3.082 | degrees |
| sinα | 0.0538 | |
| cosα | 0.9986 | |

| | | |
|---|---|---|
| r | 6.32 | mm/day |
| r | 0.632 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0918 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| b | 3978.976 | cm |
| L | 10713.72 | cm |

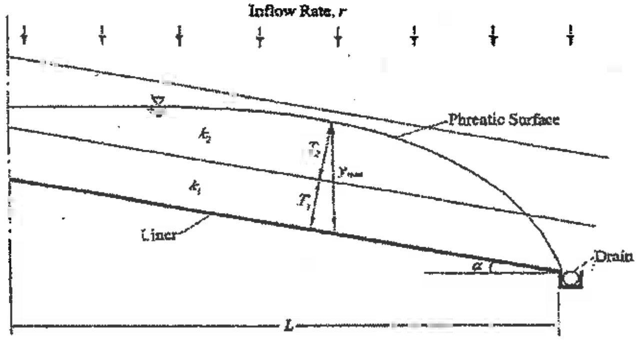
Giroud's 92 Method

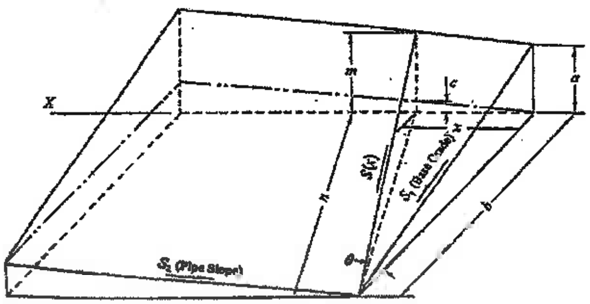
| | |
|---|---|
| A | 0.141856 |
| B | -0.719364 |
| j | 0.941553 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 14.55 | cm |
| $y_{max}$ | 145.54 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





**MC VI-G Phase 3 SE Area**

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| input | | |
| trial & error | | |
| output | | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0439 | |
| α = | 0.0438 | radians |
| α = | 2.512 | degrees |
| sinα | 0.0438 | |
| cosα | 0.9990 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.30 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.03 | cm |
| $y_{max}$ | 310.30 | mm |

compare

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0439 | |
| α = | 0.0438 | radians |
| α = | 2.512 | degrees |
| sinα | 0.0438 | |
| cosα | 0.9990 | |

| | | |
|---|---|---|
| *r* | 7.89 | mm/day |
| *r* | 0.789 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1804 | cm/day |

| | | |
|---|---|---|
| *b* | 6026.04 | cm |
| *L* | 6608.06 | cm |

Giroud's 92 Method

| | |
|---|---|
| *A* | 0.312965 |
| *B* | 0.254524 |
| *j* | 0.9069658 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 23.53 | cm |
| $y_{max}$ | 235.32 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0439 | |
| α = | 0.0438 | radians |
| α = | 2.512 | degrees |
| sinα | 0.0438 | |
| cosα | 0.9990 | |

| | | |
|---|---|---|
| *k1* | 12.2 | mm/sec |
| *k2* | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 76 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.546 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 81.18 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 8.12 | cm |
| $y_{max}$ | 81.18 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 1.8% | |
| $S_2$ = | 0.018 | |

| | | |
|---|---|---|
| S (tanα) | 0.0439 | |
| α = | 0.0438 | radians |
| α = | 2.512 | degrees |
| sinα | 0.0438 | |
| cosα | 0.9990 | |

| | | |
|---|---|---|
| *r* | 7.89 | mm/day |
| *r* | 0.789 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1546 | cm/sec |
| $k_{eq}$ | 13357.41 | cm/day |

| | | |
|---|---|---|
| *b* | 6026.036 | cm |
| *L* | 6608.06 | cm |

Giroud's 92 Method

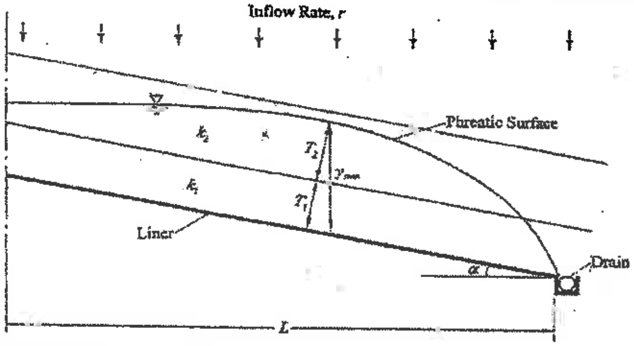
| | |
|---|---|
| *A* | 0.15207 |
| *B* | 0.669053 |
| *j* | 0.938537 |

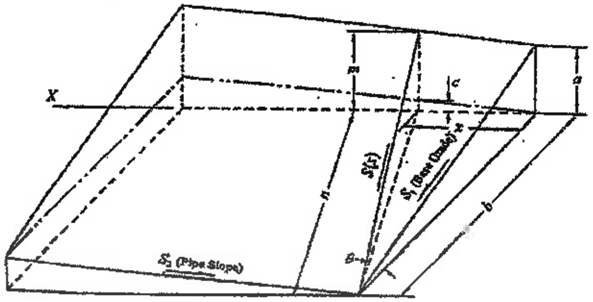
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 8.12 | cm |
| $y_{max}$ | 81.18 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 3 SW Area

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0640 | |
| α = | 0.0639 | radians |
| α = | 3.662 | degrees |
| sinα | 0.0639 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 310.63 | mm |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 31.06 | cm |
| $y_{max}$ | 310.63 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

### Trial 1

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0640 | |
| α = | 0.0639 | radians |
| α = | 3.662 | degrees |
| sinα | 0.0639 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| r | 8.09 | mm/day |
| r | 0.809 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 5615.10 | cm |
| L | 8988.55 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.1981202 |
| B | -0.494309 |
| j | 0.9268009 |

Calculated

| | | |
|---|---|---|
| $y_{max}$ | 23.98 | cm |
| $y_{max}$ | 239.81 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0640 | |
| α = | 0.0639 | radians |
| α = | 3.664 | degrees |
| sinα | 0.0639 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 69 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.670 | mm/sec |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 74.64 | mm |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 7.46 | cm |
| $y_{max}$ | 74.64 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 5.0% | |
| $S_2$ = | 0.050 | |

| | | |
|---|---|---|
| S (tanα) | 0.0640 | |
| α = | 0.0639 | radians |
| α = | 3.664 | degrees |
| sinα | 0.0639 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| r | 8.09 | mm/day |
| r | 0.809 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1670 | cm/sec |
| $k_{eq}$ | 14428.8 | cm/day |

| | | |
|---|---|---|
| b | 5615.104 | cm |
| L | 8988.55 | cm |

Giroud's 92 Method

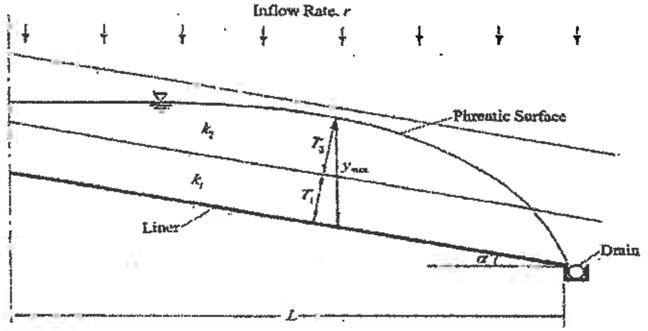
| | |
|---|---|
| A | 0.0601744 |
| B | -1.076334 |
| j | 0.9599919 |

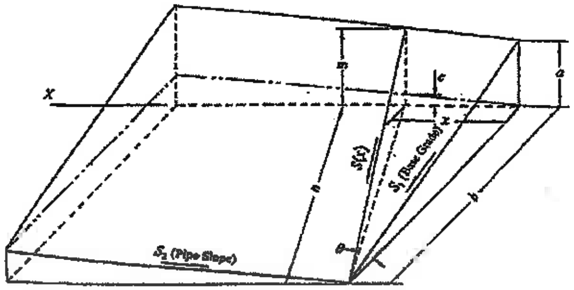
Calculated

| | | |
|---|---|---|
| $y_{max}$ | 7.46 | cm |
| $y_{max}$ | 74.64 | mm |

# Maximum Leachate Head Calculation in Two-Layer Drainage Media

***Developed by Xuede (Dan) Qian*** **2008**





## MC VI-G Phase 4 NE Area

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| $S_1$ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0570 | |
| α = | 0.0569 | radians |
| α = | 3.263 | degrees |
| sinα | 0.0569 | |
| cosα | 0.9984 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.50 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.05 | cm |
| $y_{max}$ | 310.50 | mm |

| |
|---|
| input |
| trial & error |
| output |

**compare**

## Trial 1

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| $S_1$ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0570 | |
| α = | 0.0569 | radians |
| α = | 3.263 | degrees |
| sinα | 0.0569 | |
| cosα | 0.9984 | |

| | | |
|---|---|---|
| r | 9.27 | mm/day |
| r | 0.927 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4208.1904 | cm/day |

| | | |
|---|---|---|
| b | 6095.86 | cm |
| L | 6318.50 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | [illegible]124943 |
| B | 0.363671 |
| j | 0.9165856 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 21.07 | cm |
| $y_{max}$ | 210.67 | mm |

## Trial 2

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| $S_1$ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0570 | |
| α = | 0.0568 | radians |
| α = | 3.263 | degrees |
| sinα | 0.0569 | |
| cosα | 0.9934 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 26 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 3.734 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 30.62 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 3.06 | cm |
| $y_{max}$ | 30.62 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| $S_1$ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0570 | |
| α = | 0.0568 | radians |
| α = | 3.255 | degrees |
| sinα | 0.0568 | |
| cosα | 0.9984 | |

| | | |
|---|---|---|
| r | 9.27 | mm/day |
| r | 0.927 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.3734 | cm/sec |
| $k_{eq}$ | 32261.54 | cm/day |

| | | |
|---|---|---|
| b | 6095.864 | cm |
| L | 6318.50 | cm |

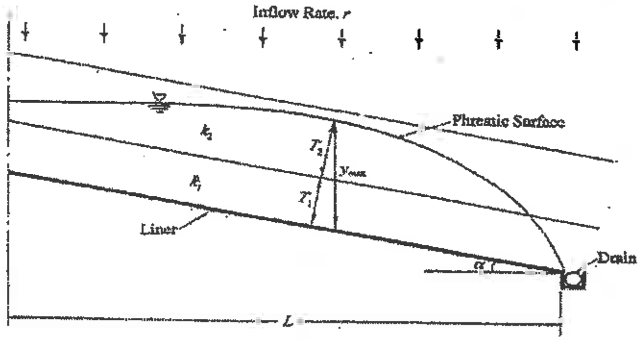
Giroud's 92 Method

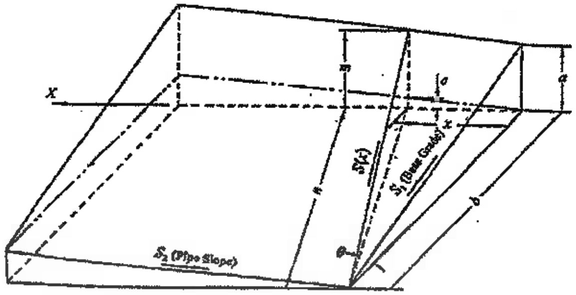
| | |
|---|---|
| A | 0.969846 |
| B | 1.333902 |
| j | 0.9684463 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 3.06 | cm |
| $y_{max}$ | 30.62 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





**MC VI-G Phase 4 NW Area**

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| S₁ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| S₂ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0631 | |
| α = | 0.0631 | radians |
| α = | 3.613 | degrees |
| sinα | 0.0630 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.62 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.06 | cm |
| $y_{max}$ | 310.62 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| S₁ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| S₂ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0631 | |
| α = | 0.0631 | radians |
| α = | 3.613 | degrees |
| sinα | 0.0630 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| r | 9.25 | mm/day |
| r | 0.925 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| b | 6107.13 | cm |
| L | 7010.40 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.2192571 |
| B | 0.434342 |
| j | 0.9222771 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 21.43 | cm |
| $y_{max}$ | 214.27 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| S₁ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| S₂ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0631 | |
| α = | 0.0631 | radians |
| α = | 3.613 | degrees |
| sinα | 0.0630 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 27 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 3.605 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.87 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 3.19 | cm |
| $y_{max}$ | 31.87 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 5.5% | |
| S₁ = | 0.055 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| S₂ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0631 | |
| α = | 0.0631 | radians |
| α = | 3.613 | degrees |
| sinα | 0.0630 | |
| cosα | 0.9980 | |

| | | |
|---|---|---|
| r | 9.25 | mm/day |
| r | 0.925 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.3605 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |

| | | |
|---|---|---|
| b | 6107.125 | cm |
| L | 7010.40 | cm |

Giroud's 92 Method

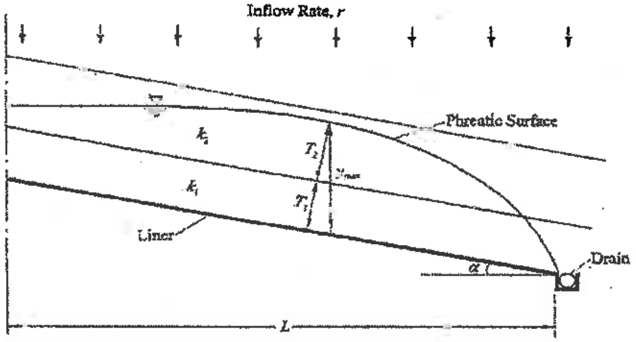
| | |
|---|---|
| A | 0.062757 |
| B | -1.445623 |
| j | 0.971728 |

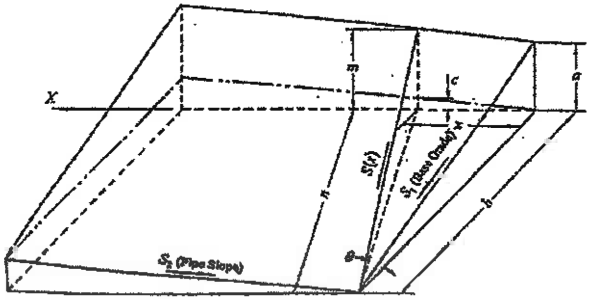
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 3.19 | cm |
| $y_{max}$ | 31.87 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 4 SE Area

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| |
|---|
| input |
| trial & error |
| output |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0427 | |
| α = | 0.0427 | radians |
| α = | 2.446 | degrees |
| sinα | 0.0427 | |
| cosα | 0.9991 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.28 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.03 | cm |
| $y_{max}$ | 310.28 | mm |

compare

### Trial 1

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0427 | |
| α = | 0.0427 | radians |
| α = | 2.446 | degrees |
| sinα | 0.0427 | |
| cosα | 0.9991 | |

| | | |
|---|---|---|
| r | 8.89 | mm/day |
| r | 0.889 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 5060.02 | cm |
| L | 5404.10 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.348518 |
| B | -0.209556 |
| j | 0.9026869 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 21.85 | cm |
| $y_{max}$ | 218.5 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0427 | |
| α = | 0.0427 | radians |
| α = | 2.446 | degrees |
| sinα | 0.0427 | |
| cosα | 0.9991 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 46 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 2.350 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 51.21 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 5.12 | cm |
| $y_{max}$ | 51.21 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 1.5% | |
| $S_2$ = | 0.015 | |

| | | |
|---|---|---|
| S (tanα) | 0.0427 | |
| α = | 0.0427 | radians |
| α = | 2.446 | degrees |
| sinα | 0.0427 | |
| cosα | 0.9991 | |

| | | |
|---|---|---|
| r | 8.89 | mm/day |
| r | 0.889 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.2350 | cm/sec |
| $k_{eq}$ | 20299.76 | cm/day |

| | | |
|---|---|---|
| b | 5060.02 | cm |
| L | 5404.10 | cm |

Giroud's 92 Method

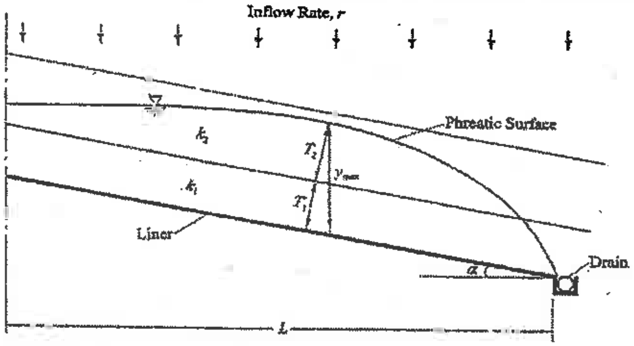
| | |
|---|---|
| A | 0.130967 |
| B | -0.702829 |
| j | 0.045152 |

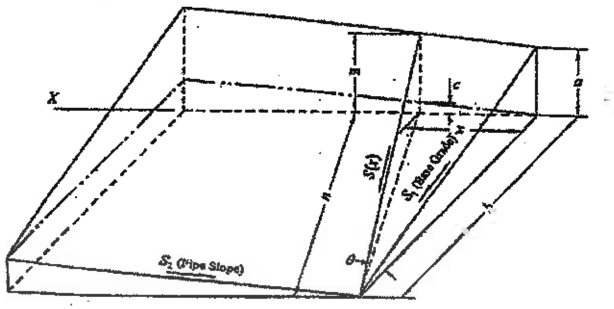
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 5.12 | cm |
| $y_{max}$ | 51.21 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 4 SW Area

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| $S_2$ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0506 | |
| α = | 0.0506 | radians |
| α = | 2.897 | degrees |
| sinα | 0.0505 | |
| cosα | 0.9987 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.40 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.04 | cm |
| $y_{max}$ | 310.40 | mm |

**compare**

| |
|---|
| input |
| trial & error |
| output |

### Trial 1

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| $S_2$ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0506 | |
| α = | 0.0505 | radians |
| α = | 2.897 | degrees |
| sinα | 0.0505 | |
| cosα | 0.9987 | |

| | | |
|---|---|---|
| r | 8.93 | mm/day |
| r | 0.893 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 5003.88 | cm |
| L | 6330.70 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.2827985 |
| B | -0.300877 |
| j | 0.9111798 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 22.48 | cm |
| $y_{max}$ | 224.84 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| $S_2$ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0506 | |
| α = | 0.0506 | radians |
| α = | 2.897 | degrees |
| sinα | 0.0505 | |
| cosα | 0.9987 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 50 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 2.211 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 54.78 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 5.48 | cm |
| $y_{max}$ | 54.78 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 3.1% | |
| $S_2$ = | 0.031 | |

| | | |
|---|---|---|
| S (tanα) | 0.0506 | |
| α = | 0.0506 | radians |
| α = | 2.897 | degrees |
| sinα | 0.0505 | |
| cosα | 0.9987 | |

| | | |
|---|---|---|
| r | 8.93 | mm/day |
| r | 0.893 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.2211 | cm/sec |
| $k_{eq}$ | 19091.[illegible] | cm/day |

| | | |
|---|---|---|
| b | 5003.877 | cm |
| L | 6330.70 | cm |

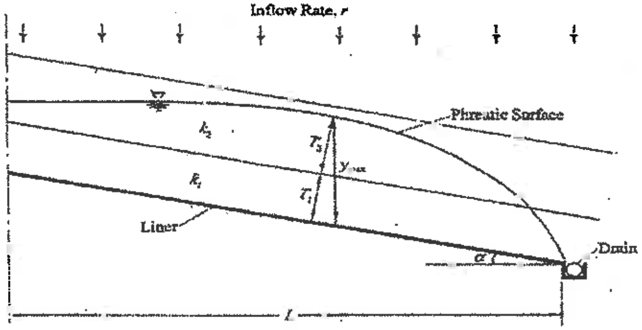
Giroud's 92 Method

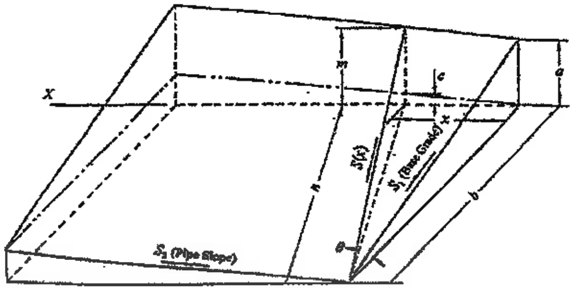
| | |
|---|---|
| A | 0.109891 |
| B | -0.919752 |
| j | 1.352166 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 5.48 | cm |
| $y_{max}$ | 54.78 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





**MC VI-G Phase 5 NE Area**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| |
|---|
| input |
| trial & error |
| output |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| $S_2$ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0825 | |
| α = | 0.0823 | radians |
| α = | 4.[illegible] | degrees |
| sinα | 0.0822 | |
| cosα | 0.9966 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 311.05 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.11 | cm |
| $y_{max}$ | 311.05 | mm |

**compare**

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| $S_2$ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0825 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | 0.0822 | |
| cosα | [illegible] | |

| | | |
|---|---|---|
| r | 9.21 | mm/day |
| r | 0.921 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4206[illegible]304 | cm/day |

| | | |
|---|---|---|
| b | 1228.63 | cm |
| L | 5065.78 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.1566012 |
| B | -0.648355 |
| j | 0.9372514 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 12.26 | cm |
| $y_{max}$ | 122.58 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| $S_2$ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0825 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | 0.0822 | |
| cosα | [illegible] | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 0 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 12.150 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 5.36 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 0.54 | cm |
| $y_{max}$ | 5.36 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| $S_2$ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0825 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | 0.0822 | |
| cosα | 0.9966 | |

| | | |
|---|---|---|
| r | 9.21 | mm/day |
| r | 0.921 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 1.2150 | cm/sec |
| $k_{eq}$ | 104974.4 | cm/day |

| | | |
|---|---|---|
| b | 1228.631 | cm |
| L | 5065.78 | cm |

Giroud's 92 Method

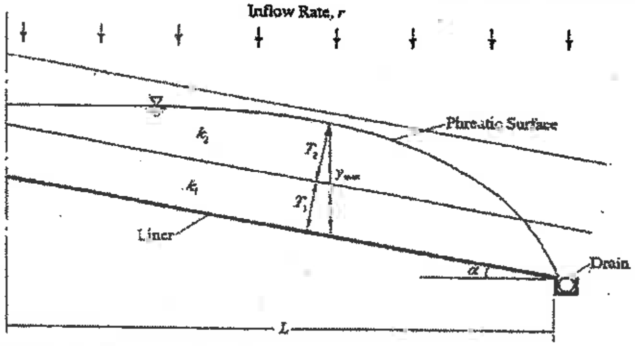
| | |
|---|---|
| A | [illegible] |
| B | -2.81655 |
| j | 0.982823 |

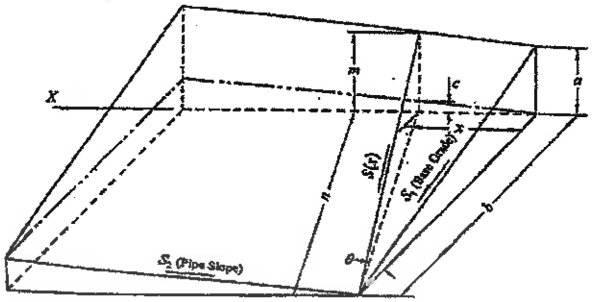
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 0.54 | cm |
| $y_{max}$ | 5.36 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

***Developed by Xuede (Dan) Qian*** **2008**





### MC VI-G Phase 5 NW Area

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |

| | | |
|---|---|---|
| S (tanα) | 0.0320 | |
| α = | 0.0320 | radians |
| α = | 1.834 | degrees |
| sinα | 0.0320 | |
| cosα | 0.9995 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.16 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.02 | cm |
| $y_{max}$ | 310.16 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

### Trial 1

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |

| | | |
|---|---|---|
| S (tanα) | 0.0320 | |
| α = | 0.0320 | radians |
| α = | 1.834 | degrees |
| sinα | 0.0320 | |
| cosα | 0.9995 | |

| | | |
|---|---|---|
| $r$ | 5.4 | mm/day |
| $r$ | 0.54 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1504 | cm/day |

| | | |
|---|---|---|
| $b$ | 4765.89 | cm |
| $L$ | 7629.14 | cm |

Giroud's 92 Method

| | |
|---|---|
| $A$ | 0.3650114 |
| $B$ | 0.190537 |
| $j$ | 0.8008182 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 24.77 | cm |
| $y_{max}$ | 247.67 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |

| | | |
|---|---|---|
| S (tanα) | 0.0320 | |
| α = | 0.0320 | radians |
| α = | 1.834 | degrees |
| sinα | 0.0320 | |
| cosα | 0.9995 | |

| | | |
|---|---|---|
| $k1$ | 12.2 | mm/sec |
| $k2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 114 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.093 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 119.39 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 11.94 | cm |
| $y_{max}$ | 119.39 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 2.0% | |
| $S_1$ = | 0.020 | |

| | | |
|---|---|---|
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |

| | | |
|---|---|---|
| S (tanα) | 0.0320 | |
| α = | 0.0320 | radians |
| α = | 1.834 | degrees |
| sinα | 0.0320 | |
| cosα | 0.9995 | |

| | | |
|---|---|---|
| $r$ | 5.4 | mm/day |
| $r$ | 0.54 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1093 | cm/sec |
| $k_{eq}$ | 9441.196 | cm/day |

| | | |
|---|---|---|
| $b$ | 4765.888 | cm |
| $L$ | 7629.14 | cm |

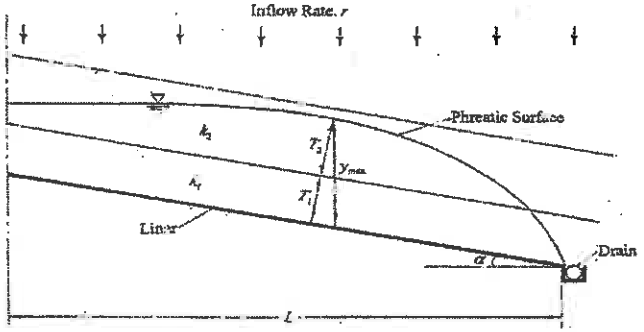
Giroud's 92 Method

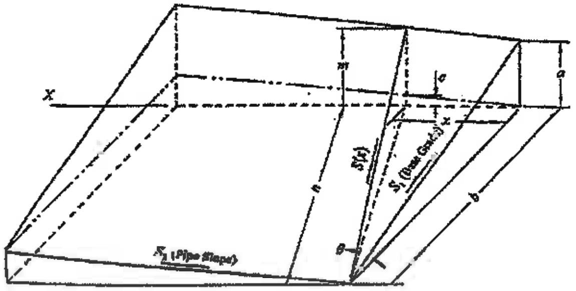
| | |
|---|---|
| $A$ | 0.220914 |
| $B$ | 0.430098 |
| $j$ | 0.321942 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 11.94 | cm |
| $y_{max}$ | 119.39 | mm |

**Maximum Leachate Head Calculation in Two-Layer Drainage Media** *Developed by Xuede (Dan) Qian* **2008**





**MC VI-G Phase 5 SE Area**

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| S₂ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0894 | |
| α = | 0.0892 | radians |
| α = | 5.111 | degrees |
| sinα | 0.089 | |
| cosα | 0.9960 | |

| | | |
|---|---|---|
| *k*₁ | 12.2 | mm/sec |
| *k*₂ | 0.1 | mm/sec |

| | | |
|---|---|---|
| T₁ | 5 | mm |
| (T₂)assumed | 305 | mm |

| | | |
|---|---|---|
| *k*eq | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| *y*max | 311.24 | mm |

**Assumed**

| | | |
|---|---|---|
| *y*max | 31.12 | cm |
| *y*max | 311.24 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

**Trial 1**

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| S₂ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0894 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | [illegible] | |
| cosα | [illegible] | |

| | | |
|---|---|---|
| *r* | 10.13 | mm/day |
| *r* | 1.013 | cm/day |

| | | |
|---|---|---|
| *k*eq | 0.0487 | cm/sec |
| *k*eq | [illegible] | cm/day |

| | | |
|---|---|---|
| *b* | 2604.90 | cm |
| *L* | 5824.73 | cm |

Giroud's 92 Method

| | |
|---|---|
| *A* | 6.1501591 |
| *B* | [illegible] |
| *j* | 0.039091 |

**Calculated**

| | | |
|---|---|---|
| *y*max | 14.36 | cm |
| *y*max | 143.57 | mm |

**Trial 2**

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| S₂ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0894 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | [illegible] | |
| cosα | [illegible] | |

| | | |
|---|---|---|
| *k1* | 12.2 | mm/sec |
| *k2* | 0.1 | mm/sec |

| | | |
|---|---|---|
| T₁ | 5 | mm |
| (T₂)assumed | 2 | mm |

| | | |
|---|---|---|
| *k*eq | 11.500 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| *y*max | 6.61 | mm |

**Assumed**

| | | |
|---|---|---|
| *y*max | 0.66 | cm |
| *y*max | 6.61 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| S₁ = | 0.040 | |

| | | |
|---|---|---|
| Pipe Slope | 8.0% | |
| S₂ = | 0.080 | |

| | | |
|---|---|---|
| S (tanα) | 0.0894 | |
| α = | 0.0892 | radians |
| α = | 5.111 | degrees |
| sinα | 0.0891 | |
| cosα | 0.9960 | |

| | | |
|---|---|---|
| *r* | 10.13 | mm/day |
| *r* | 1.013 | cm/day |

| | | |
|---|---|---|
| *k*eq | 1.1500 | cm/sec |
| *k*eq | 99356.99 | cm/day |

| | | |
|---|---|---|
| *b* | 2604.898 | cm |
| *L* | 5824.73 | cm |

Giroud's 92 Method

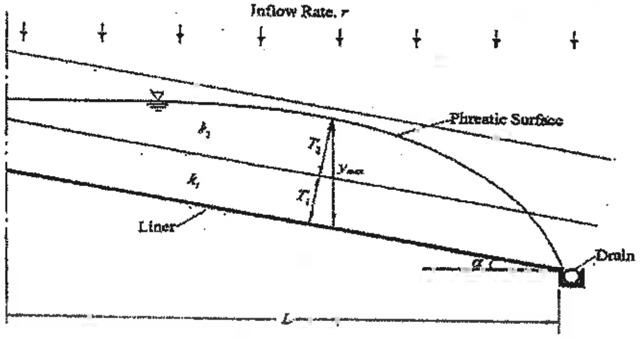
| | |
|---|---|
| *A* | 0.020816 |
| *B* | 2.327767 |
| *j* | 0.992903 |

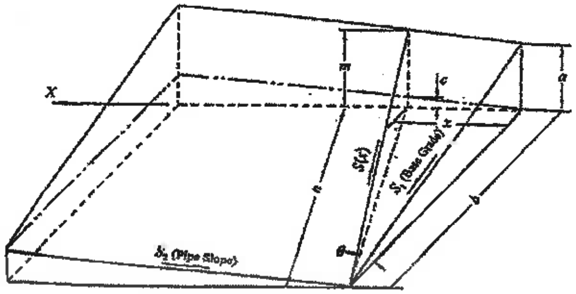
**Calculated**

| | | |
|---|---|---|
| *y*max | 0.66 | cm |
| *y*max | 6.61 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 5 SW Area

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |
| S (tanα) | 0.0472 | |
| α = | 0.0471 | radians |
| α = | 2.701 | degrees |
| sinα | 0.0471 | |
| cosα | 0.9989 | |
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |
| $k_{eq}$ | 0.487 | mm/sec |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 310.34 | mm |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 31.03 | cm |
| $y_{max}$ | 310.34 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

### Trial 1

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |
| S (tanα) | 0.0472 | |
| α = | 0.0471 | radians |
| α = | 2.701 | degrees |
| sinα | 0.0471 | |
| cosα | 0.9989 | |
| r | 8.2 | mm/day |
| r | 0.82 | cm/day |
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |
| b | 5753.54 | cm |
| L | 6784.85 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.2927543 |
| B | 0.284619 |
| j | 0.9097239 |

Calculated

| | | |
|---|---|---|
| $y_{max}$ | 23.61 | cm |
| $y_{max}$ | 236.06 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |
| S (tanα) | 0.0472 | |
| α = | 0.0471 | radians |
| α = | 2.701 | degrees |
| sinα | 0.0471 | |
| cosα | 0.9989 | |
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 75 | mm |
| $k_{eq}$ | 1.564 | mm/sec |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 80.18 | mm |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 8.02 | cm |
| $y_{max}$ | 80.18 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 4.0% | |
| $S_1$ = | 0.040 | |
| Pipe Slope | 2.5% | |
| $S_2$ = | 0.025 | |
| S (tanα) | 0.0472 | |
| α = | 0.0471 | radians |
| α = | 2.701 | degrees |
| sinα | 0.0471 | |
| cosα | 0.9989 | |
| r | 8.2 | mm/day |
| r | 0.82 | cm/day |
| $k_{eq}$ | 0.1564 | cm/sec |
| $k_{eq}$ | [illegible] | cm/day |
| b | 5753.54 | cm |
| L | 6784.85 | cm |

Giroud's 92 Method

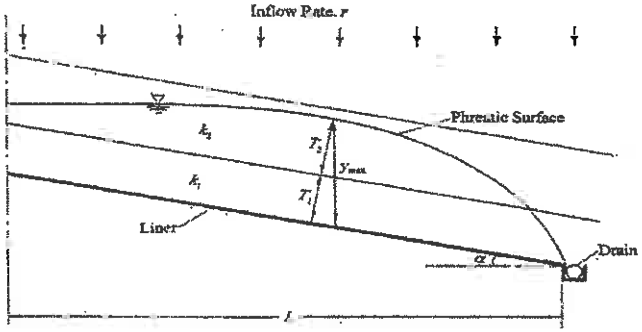
| | |
|---|---|
| A | 0.141245 |
| B | 0.722548 |
| j | 0.941738 |

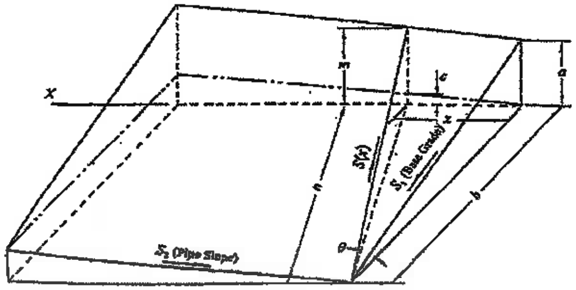
Calculated

| | | |
|---|---|---|
| $y_{max}$ | 8.02 | cm |
| $y_{max}$ | 80.18 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 6 NE Area

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| $S_1$ = | 0.058 | |

| |
|---|
| input |
| trial & error |
| output |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0842 | |
| α = | 0.0840 | radians |
| α = | 4.811 | degrees |
| sinα | 0.0839 | |
| cosα | 0.9965 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 311.10 | mm |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 31.11 | cm |
| $y_{max}$ | 311.10 | mm |

compare

### Trial 1

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| $S_1$ = | 0.058 | |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0842 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | [illegible] | |
| cosα | 0.9965 | |

| | | |
|---|---|---|
| r | 9.91 | mm/day |
| r | 0.991 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4208.1904 | cm/day |

| | | |
|---|---|---|
| b | 3782.11 | cm |
| L | 5488.78 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.1467844 |
| B | -0.634857 |
| j | 0.9363669 |

Calculated

| | | |
|---|---|---|
| $y_{max}$ | 13.98 | cm |
| $y_{max}$ | 139.77 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| $S_1$ = | 0.058 | |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0842 | |
| α = | 0.0840 | radians |
| α = | 4.811 | degrees |
| sinα | 0.0839 | |
| cosα | 0.9965 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 1 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 11.643 | mm/sec |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 6.39 | mm |

Assumed

| | | |
|---|---|---|
| $y_{max}$ | 0.64 | cm |
| $y_{max}$ | 6.39 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| $S_1$ = | 0.058 | |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0842 | |
| α = | 0.0840 | radians |
| α = | [illegible] | degrees |
| sinα | 0.0839 | |
| cosα | 0.9965 | |

| | | |
|---|---|---|
| r | 9.91 | mm/day |
| r | 0.991 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 1.1643 | cm/sec |
| $k_{eq}$ | 100595.9 | cm/day |

| | | |
|---|---|---|
| b | 3782.109 | cm |
| L | 5488.78 | cm |

Giroud's 92 Method

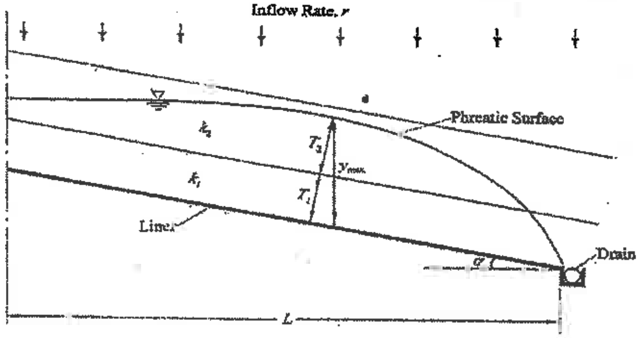
| | |
|---|---|
| A | [illegible] |
| B | -2.748812 |
| j | 0.99232 |

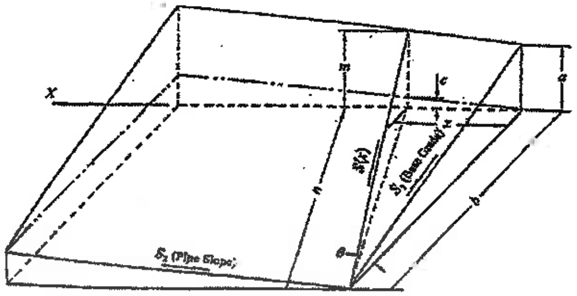
Calculated

| | | |
|---|---|---|
| $y_{max}$ | 0.64 | cm |
| $y_{max}$ | 6.39 | mm |

# Maximum Leachate Head Calculation in Two-Layer Drainage Media

***Developed by Xuede (Dan) Qian*** **2008**





## MC VI-G Phase 6 NW Area

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| S₁ = | 0.058 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| S₂ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0,0688 | |
| α = | [illegible] | radians |
| α = | 3.936 | degrees |
| sinα | 0.0696 | |
| cosα | [illegible] | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| T₁ | 5 | mm |
| (T₂)assumed | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.73 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.07 | cm |
| $y_{max}$ | 310.73 | mm |

**compare**

| |
|---|
| input |
| trial & error |
| output |

## Trial 1

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| S₁ = | 0.058 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| S₂ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0.0688 | |
| α = | 0.0687 | radians |
| α = | 3.936 | degrees |
| sinα | 0.0686 | |
| cosα | 0.9976 | |

| | | |
|---|---|---|
| $r$ | 9.48 | mm/day |
| $r$ | 0.948 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 42[illegible] | cm/day |

| | | |
|---|---|---|
| $b$ | 5722.62 | cm |
| $L$ | 6787.90 | cm |

Giroud's 92 Method

| | |
|---|---|
| $A$ | 0.1999842 |
| $B$ | -0.488507 |
| $j$ | 0.9263623 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 19.74 | cm |
| $y_{max}$ | 197.36 | mm |

## Trial 2

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| S₁ = | 0.058 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| S₂ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0.0688 | |
| α = | 0.0687 | radians |
| α = | 3.936 | degrees |
| sinα | 0.0686 | |
| cosα | 0.9976 | |

| | | |
|---|---|---|
| $k1$ | 12.2 | mm/sec |
| $k2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| T₁ | 5 | mm |
| (T₂)assumed | 13 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 5.915 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 17.94 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 1.79 | cm |
| $y_{max}$ | 17.94 | mm |

**compare**

| | | |
|---|---|---|
| Base Grade | 5.8% | |
| S₁ = | 0.058 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| S₂ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0.0688 | |
| α = | 0.0687 | radians |
| α = | 3.936 | degrees |
| sinα | 0.0686 | |
| cosα | 0.9976 | |

| | | |
|---|---|---|
| $r$ | 9.48 | mm/day |
| $r$ | 0.948 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.5915 | cm/sec |
| $k_{eq}$ | 51106.5 | cm/day |

| | | |
|---|---|---|
| $b$ | 5722.62 | cm |
| $L$ | 6787.90 | cm |

Giroud's 92 Method

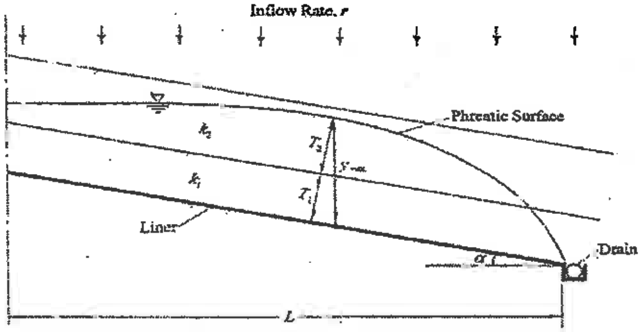
| | |
|---|---|
| $A$ | 0.042667 |
| $B$ | -1.895246 |
| $j$ | 0.981965 |

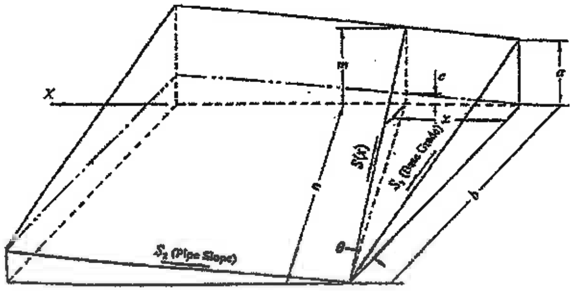
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 1.79 | cm |
| $y_{max}$ | 17.93 | mm |

## Maximum Leachate Head Calculation in Two-Layer Drainage Media

*Developed by Xuede (Dan) Qian* 2008





### MC VI-G Phase 6 SE Area

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0680 | |
| α = | 0.0679 | radians |
| α = | 3.889 | degrees |
| sinα | 0.0678 | |
| cosα | 0.9977 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.72 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.07 | cm |
| $y_{max}$ | 310.72 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

### Trial 1

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0680 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | 0.0678 | |
| cosα | 0.9977 | |

| | | |
|---|---|---|
| r | 9.57 | mm/day |
| r | 0.957 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1901 | cm/day |

| | | |
|---|---|---|
| b | 2236.77 | cm |
| L | 5068.36 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.2042024 |
| B | -0.478016 |
| j | 0.9254496 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 15.02 | cm |
| $y_{max}$ | 150.18 | mm |

### Trial 2

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0680 | |
| α = | [illegible] | radians |
| α = | [illegible] | degrees |
| sinα | [illegible] | |
| cosα | 0.9977 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 3 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 10.850 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 7.52 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 0.75 | cm |
| $y_{max}$ | 7.52 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 6.1% | |
| $S_2$ = | 0.061 | |

| | | |
|---|---|---|
| S (tanα) | 0.0680 | |
| α = | 0.0679 | radians |
| α = | 3.889 | degrees |
| sinα | [illegible] | |
| cosα | 0.9977 | |

| | | |
|---|---|---|
| r | 9.57 | mm/day |
| r | 0.957 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 1.0850 | cm/sec |
| $k_{eq}$ | 93746.45 | cm/day |

| | | |
|---|---|---|
| b | 2236.769 | cm |
| L | 5068.36 | cm |

Giroud's 92 Method

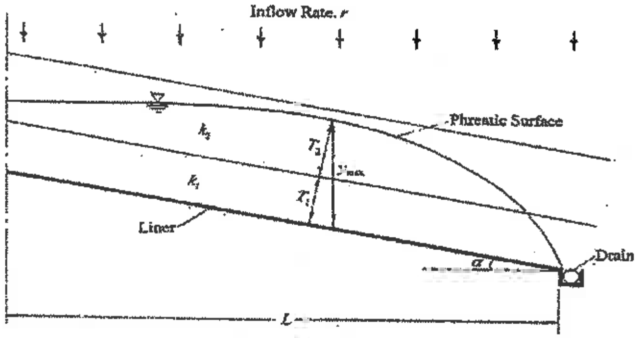
| | |
|---|---|
| A | 3.029367 |
| B | -2.347894 |
| j | 0.986532 |

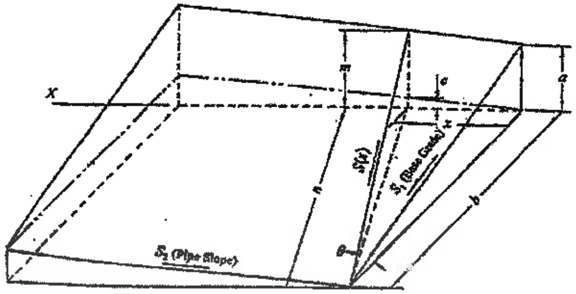
**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 0.75 | cm |
| $y_{max}$ | 7.52 | mm |

# Maximum Leachate Head Calculation in Two-Layer Drainage Media

**Developed by Xuede (Dan) Qian** 2008





## MC VI-G Phase 6 SW Area

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| $S_2$ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0.0476 | |
| α = | 0.0476 | radians |
| α = | 2.727 | degrees |
| sinα | 0.0476 | |
| cosα | 0.9989 | |

| | | |
|---|---|---|
| $k_1$ | 12.2 | mm/sec |
| $k_2$ | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 305 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 0.487 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 310.35 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 31.04 | cm |
| $y_{max}$ | 310.35 | mm |

compare

| |
|---|
| input |
| trial & error |
| output |

## Trial 1

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| $S_2$ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0.0476 | |
| α = | 0.0476 | radians |
| α = | 2.727 | degrees |
| sinα | 0.0476 | |
| cosα | 0.9989 | |

| | | |
|---|---|---|
| r | 7.52 | mm/day |
| r | 0.752 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.0487 | cm/sec |
| $k_{eq}$ | 4209.1904 | cm/day |

| | | |
|---|---|---|
| b | 4958.42 | cm |
| L | 7872.98 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.2739521 |
| B | -0.316102 |
| j | 0.9125297 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 25.13 | cm |
| $y_{max}$ | 251.33 | mm |

## Trial 2

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| $S_2$ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0.0476 | |
| α = | 0.0476 | radians |
| α = | 2.727 | degrees |
| sinα | 0.0476 | |
| cosα | 0.9989 | |

| | | |
|---|---|---|
| k1 | 12.2 | mm/sec |
| k2 | 0.1 | mm/sec |

| | | |
|---|---|---|
| $T_1$ | 5 | mm |
| $(T_2)_{assumed}$ | 113 | mm |

| | | |
|---|---|---|
| $k_{eq}$ | 1.108 | mm/sec |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 117.64 | mm |

**Assumed**

| | | |
|---|---|---|
| $y_{max}$ | 11.76 | cm |
| $y_{max}$ | 117.64 | mm |

compare

| | | |
|---|---|---|
| Base Grade | 3.0% | |
| $S_1$ = | 0.030 | |

| | | |
|---|---|---|
| Pipe Slope | 3.7% | |
| $S_2$ = | 0.037 | |

| | | |
|---|---|---|
| S (tanα) | 0.0476 | |
| α = | 0.0476 | radians |
| α = | 2.727 | degrees |
| sinα | 0.0476 | |
| cosα | 0.9989 | |

| | | |
|---|---|---|
| r | 7.52 | mm/day |
| r | 0.752 | cm/day |

| | | |
|---|---|---|
| $k_{eq}$ | 0.1108 | cm/sec |
| $k_{eq}$ | 9573.119 | cm/day |

| | | |
|---|---|---|
| b | 4958.421 | cm |
| L | 7872.98 | cm |

Giroud's 92 Method

| | |
|---|---|
| A | 0.763946 |
| B | 0.001685 |
| j | 0.035232 |

**Calculated**

| | | |
|---|---|---|
| $y_{max}$ | 11.76 | cm |
| $y_{max}$ | 117.64 | mm |

Attachment B: 2018 Permit Engineering Drawings

Revision D, May 8, 2018

Submitted Under Separate Cover

# Attachment C: Correspondence Regarding the WDI 2018 Permit Modification

Revision 1, May 16, 2018

| Question Date | Question From MDEQ/U.S. EPA Region 5 | Answer from Wayne Disposal, Inc./CTI and Associates, Inc. | Corresponding information in the 2018 Permit Modification Request |
|---|---|---|---|
| 4/5/2018 | How will the different liners for different landfill cells be tied together or combined? | Liner tie-ins are detailed in the Permit Engineering Drawings | Attachment B, Permit Engineering Drawings |
| 4/5/2018 | What is the thickness of the HDPE plastic liner under the leachate collection system? At on-site meeting, Jim thought he heard that something less than 80 mil HDPE was going to be used. | The thickness for both primary and secondary geomembrane will be 80-mil HDPE geomembrane. | 2018 Permit Modification Letter Report Figure 2 and Attachment B, Permit Engineering Drawings |
| 4/5/2018 | Attenuation layer at 1.0 x $10^{-5}$ permeability. When combined with the two GCL layers, how long will it take waste to travel through liner? | This is a complicated question that does not have a definitive answer. As shown in this submittal, when "comparing apples to apples", the proposed liner system will be at least equivalent to (if not superior than) the current liner system in this regard. | 2018 Permit Modification Letter Report section titled "Equivalency Demonstration" |
| 4/5/2018 | Steady state solute flux table from presentation shows a "composite permeability" number. Uncertain how this was arrived at or how valid it is for answering the question in third bullet. Also, did MDEQ have some questions about this table? | Composite permeability (or "equivalent" permeability") is a weighted average of permeability of a system consisting of a number of horizontal layers having different permeabilities and thicknesses. CTI will use the equivalent permeability of the two GCL layers (excluding the flow retardation provided by the attenuation layer for conservatism) to demonstrate that the steady-state solute flux of the proposed liner system is equivalent to (if not superior than) the current liner system in this regard. | 2018 Permit Modification Letter Report section titled "Equivalency Demonstration" |
| 4/5/2018 | Is geogrid sufficient to prevent damage to landfill structure? | In general, geogrid helps to increase the stiffness of the subgrade and reduce localized subsidence. Additionally, GCL is added to the MC VI-G Phase 2 liner with this proposed permit modification. GCL is well known for its superior capability to endure settlement induced tensioning. Dr. Qian of the MDEQ stated in his book ["Geotechnical aspects of landfill design and construction". New Jersey: Prentice Hall Inc. (2001)] that a compacted clay liner can only tolerate settlement induced strain of 0.1 to 4% whereas geocomposite clay liner can tolerate 5 - 16% strain. There are no proposed changes to the geogrid already approved by the EPA and MDEQ. | N/A |
| 4/5/2018 | Need Cross-Sections in design package that not only show the new proposed design but that also show the old design and landfill design below the new cells. We think there should be at least three cross-sections as follows: -General cross-section showing liner below old landfill cell all the way up to the cap of the new proposed design. - Detailed cross-section of previously approved design for new landfill cell. -Detailed cross-section of design modification for new landfill cell. | The revised Permit Engineering Drawings include cross-sectional views of both the old design and the new design. | Attachment B, Permit Engineering Drawings |
| 4/5/2018 | Comparison of leachate collection system between design modification and previously approved design. | The leachate collection system in this proposed permit modification has not changed from the currently permitted system. This proposed permit modification includes the addition of GCL in the baseliner of Master Cell VI-G Phase 2 but does not modify other components of the leachate collection system. | Attachment B, Permit Engineering Drawings |
| 4/5/2018 | In summary, the landfill design modification should be at least comparable to the old design modification regarding protectiveness. | The 2018 Permit Modification Letter Report discusses the equivalency of the permit modification. | 2018 Permit Modification Letter Report section titled "Equivalency Demonstration" |
| 4/13/2018 | We're assuming that the Engineering design will also include the specifications, not just the drawings (schematics). We would like to see what materials/vendors they specify if possible. | This proposed permit modification includes the addition of Geosynthetic Clay Liner (GCL) in the base liner of Master Cell VI-G Phase 2. Distinct GCL products from the manufacturer, CETCO, have been specified in this request and are detailed in the 2018 Permit Modification Letter Report and on the accompanying Permit Engineering Drawings. | 2018 Permit Modification Letter Report Figure 2 and Attachment B, Permit Engineering Drawings |

| Question Date | Question From MDEQ/U.S. EPA Region 5 | Answer from Wayne Disposal, Inc./CTI and Associates, Inc. | Corresponding information in the 2018 Permit Modification Request |
|---|---|---|---|
| 4/13/2018 | Will the cover system also be revised from the original design? A. If so, was that included in the overall slope stability analysis? B. Will the specific materials of the revised material be identified? When? | No. The cover system will remain unchanged as a part of this proposed permit modification. | N/A |
| 4/13/2018 | How Did the slope stability analysis results differ from the original design? | The proposed base liner system does not introduce any interface that is more critical (lower) than what is in the permitted liner system. The stability of the permitted liner system was demonstrated in the 2011 permit submittal. In addition, all of the GCL products in the proposed liner system are internally reinforced with needle-punched fibers to ensure that the shear resistance of the internal (Bentonite) layer also exceeds the stability requirement. Improvement in stability is expected since the interface shear resistance of HDPE/GCL in the proposed liner system is superior than the interface shear resistance of HDPE/CCL in the permitted liner system. | Attachment A, Equivalency Demonstration and References |
| 4/13/2018 | a.The 2011 report identified seemingly satisfactory sliding (or translational) factors of safety under various conditions, but made no mention of rotational factors of safety, including possibly failure surfaces that could intersect well into the underlying landfill and natural soil layer. Were rotational failure envelopes part of the analysis? What were the resulting factors of safety for various conditions? | Rotational failure envelops were actually examined in the 2011 permit submittal. Both rotational (aka, "circular") and sliding (aka, "non-circular") slipping planes were part of the 2011 analyses. Ranges of FS-value were 1.5-2.4 (for pre-filling condition); 1.5-1.6 (for partial filling condition); and 1.5-2.0 (for post-filling condition). | "Volume III – WDI Operating License Application, Master Cells VI F & G, Basis of Design Report", NTH Consultants, submitted February 2011, revised September 2011 |
| 4/13/2018 | How will the design ensure that no new leachate from the expansion make it to the unlined waste cell beneath the expansion? | The approved 2011 design incorporates a "complete encapsulation" of the expansion waste by incorporating (1) continuous transition of liner systems between adjacent sub-cells and (2) tie-in of the final cover geomembrane to the expansion waste primary base liner geomembrane. Leachate from the expansion waste will be separated from the underlying (unlined) waste. | Attachment B, Permit Engineering Drawings |
| 4/13/2018 | What is the anticipated settlement of the underlying landfill after the expansion? | According to the 2011 expansion submittal, approved by the EPA and MDEQ, the total settlement of the MC VI-F & G cell floor ranges from 2.5 feet to 17 feet under maximum expansion waste loading. The current proposed design changes will not alter these calculations. | N/A |
| 4/13/2018 | How will the anticipated differential and global settlement of the preregulatory landfill challenge the expansion liner? i. Have the biaxial properties of geogrid and GCL been evaluated for those conditions? | The estimated settlement will not adversely impact the proposed liner system. GCL is well known for its superior capability to endure settlement induced tensioning. Dr. Qian of the MDEQ stated in his book ["Geotechnical aspects of landfill design and construction". New Jersey: Prentice Hall Inc. (2001)] that a compacted clay liner can only tolerate settlement induced strain of 0.1 to 4% whereas geocomposite clay liner can tolerate 5 - 16% strain. There are no proposed changes to the geogrid already approved by the EPA and MDEQ. | N/A |
| 4/13/2018 | What is the anticipated of differential and global settlement on the slope and performance of the leachate collection system? | As concluded in the approved 2011 permit submittal, the post settlement slopes are greater than 2.24 percent on the cell floor and greater than 1.0 percent along the leachate collection pipe locations – both satisfying the regulatory requirements and demonstrating satisfactory performance of the leachate collection system. Nevertheless, as indicated in the response above, GCLs are superior than CCLs in resisting any settlement induced tensioning. | N/A |

| Question Date | Question From MDEQ/U.S. EPA Region 5 | Answer from Wayne Disposal, Inc./CTI and Associates, Inc. | Corresponding information in the 2018 Permit Modification Request |
|---|---|---|---|
| 4/13/2018 | GCLs can be subject to rapid changes in hydraulic properties when exposed to specific leachate constituents like calcium. Have the GCLs been evaluated for chemical resistance to the anticipated waste leachates? What method was used and what was the result? | Yes the GCLs had been conservatively evaluated by the manufacture's R&D laboratory for chemical resistance (compatibility) of the primary GCL (Resistex 200$^{TM}$) against leachate samples supplied by WDI.<br>After 100 hours of permeation , the lab has measured a permeability of 1.0 x $10^{-9}$ cm/sec with 0.35 pore volumes of leachate passing through the specimen. This means that the bentonite polymer blend in the Resistex® 200 FLW9 GCL is hydrating and cutting off flow. The GCL manufacture, based on the preliminary test results, recommend a conservative "upper bound" estimate for permeability as 5 x $10^{-9}$ cm/sec to be used for techcnial purposes. With additional time and data collected from the site specific testing, the permeability value is expected to decrease further.<br>For the demonstrative calculations, a conservative permeability of 1 x $10^{-8}$ cm/sec was used in the flux demonstration. In other words, an extra adjustment factor of 2.0 was applied for additional conservatism. | 2018 Permit Modification Letter Report section titled "Equivalency Demonstration" |
| 4/13/2018 | GCLs can be subject to thinning under strain and wetting. How will this be prevented? | Thinning of GCLs can be prevented by maintaining adequate thickness (min. 1 ft) of cover soil between the equipment tires/tracks and the GCL at all times during the installation process. This important requirement will be included in the CQA plan and will be strictly enforced via full-time CQA observation/verification during construction of the proposed liner system. | 2018 Permit Modification Letter Report Attachment C, GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines. |
| 4/13/2018 | The design recognizes that subgrade preparation will be essential, yet 1 inch diameter stones are allowable before the proof rolling (final prep) of the surface. Once assembled, those stones may contribute to localized thinning of the GCL clay. Have designers considered a smaller allowable stone size AND considered a specification pertaining to angularity of the stones, which also affect thinning and/or puncture of the GCL material? | Based on the industry standard and past experiences, stone particle protrusion can be effectively eliminated by limiting the maximum-allowed stone size to 1" in the upper most lift of the attenuation layer and requiring proof-rolling of the prepared subgrade before GCL deployment. All subgrade preparation requirements will be listed in the CQA Plan and technical specifications. The Certifying Engineer's approval of the subgrade will be obtained prior to GCL installation. | 2018 Permit Modification Letter Report section titled "Proposed Liner System" |
| 4/13/2018 | How will the GCLs be protected after installation? The bearing capacity slide of March 28 indicates 1 ft of soil atop the GCL at all times, is this sufficient for construction vehicles? | Industry standard and past experiences have demonstrated that an adequate thickness of cover soil (minimum 12") will prevent damage of GCLs due to construction equipment loading. Specifications of allowable construction vehicles will be listed in the CQA plan or on the drawings issued for construction. | 2018 Permit Modification Letter Report section titled "Proposed Liner System" |
| 4/13/2018 | What is the estimated Impact of the overburden on leachate generation from the cell underlying the expansion? | Leachate generation will be reduced due to cutting off infiltration through the existing cell's clay cap by the installation of the new double composite liner. Although not required by rule, WDI will continue to remove leachate from the underlying cell. | N/A |
| 4/13/2018 | Is there a plan to circulate leachate on the expansion? | No. There is no plan to recirculate leachate on the expansion. | N/A |

# Proposed Permit Modification - Upgrades to MC VI-G Phase 2 Liner Design
# Wayne Disposal, Inc., Belleville, Wayne County, Michigan

## Response to MDEQ's May 03, 2018 Comments

1. CTI needs to consider increasing both the width and depth of the anchor trench shown in West Perimeter Dike 4 on revised Drawing No. 22A. It seems to be impossible to bend and bury total 9 to 10 layers of geosynthetic materials (including four layers of GCL, two layers of 80-mil geomembrane, two layers of geocomposite, and one or two layers of geogrid) into a 2'x´ 2' standard anchor trench.

   Response:

   The size of the anchor trench is increased to 3 ft x 3 ft as now shown on Detail 4 of Drawing No. 22A, included in Attachment B of the Permit Modification Letter Report.

2. The geocomposite used as the primary leachate drainage layer in MC VI-G Phase 2 (Subcell G3) shown in MC VI Phase 2 (Subcell 6E) to MC VI-G Phase 2 (Subcell G3) Tie-In Detail 1 on the revised Drawing No. 22B should be extended to overlap the existing primary leachate drainage geocomposite layer in MC VI Phase 2 (Subcell 6E) and the geonet cores should be joined by ties with plastic fasteners and the top geotextiles should be sewed together. The geocomposite used as the leak detection layer should also do this.

   Response:

   The detail is revised. The requirements for geocomposite connection are added in Detail 3 on Sheet 22A, included in Attachment B of the Permit Modification Letter Report. Detail 3 on Sheet 22A was referenced to all tie-in connections.

3. The overlapped connections of the geocomposite layers used as the primary leachate drainage layer and the leak detection layer shown in in MC VI-G Phase 1 and MC VI-G Phase 2 Tie-In Detail 2 on revised Drawing No. 22B should be revised. The geocomposite used as the primary leachate drainage layer in MC VI-G Phase 2 (Subcells G2 and G3) shown in MC VI-G Phase 1 and MC VI-G Phase 2 Tie-In Detail 2 on revised Drawing No. 22B should be extended to cover the existing primary leachate drainage geocomposite layer and the geonet cores should be joined by ties with plastic fasteners and the top geotextiles should be sewed together. The geocomposite used as the leak detection layer should also do this. Just like the shingles and tiles on the roof, the shingles on the upper part of the slope should always cover the shingles on the lower part of the slope.

Response:

The detail is revised. The requirements for geocomposite connection are added in Detail 3 on Drawing No. 22A, included in Attachment B of the Permit Modification Letter Report. Detail 3 on Sheet 22A was referenced to all tie-in connections including those on Drawing No. 22B.

# Proposed Permit Modification - Upgrades to MC VI-G Phase 2 Liner Design
# Wayne Disposal, Inc., Belleville, Wayne County, Michigan

## Response to MDEQ's May 09, 2018 Comments

Attachment A: Equivalency Information and References

1. Two shear resistance requirements obtained from the slope stability analysis shown Page 10/13 should not only include the interfaces between geosynthetic-to-geosynthetic or geosynthetic-to-soil, but also include internal shear strengths for different GCLs.

   Response:

   Agree. The following paragraph will replace the current language on Page 10 of 13 of the Equivalency Information and References (Attachment A).

   "WDI will, as part of the CQA requirements, conduct direct shear tests (ASTM D6243) for relevant GCL-related interfaces (e.g., against 80-mil textured HDPE geomembranes, between different GCL products, against cohesive attenuation layer soils, etc.) as well as internal shear strength for different GCL products before approving the products to be used for construction of the MC VI-G Phase 2 liner system."

Appendix A-2: Maximum Head-on-Liner Calculation

2. It is indicated in Design Criteria/Design Basis (with Reference to Source of Data) in Page 1 of 2 that "1. Average daily peak leachate generation rates were obtained from "Leachate Generation Estimation and Head Calculation" (NTH, 2011), which are 8,960 gal/acre/day for Subcell G2 and 7,874 gal/acre/day for Subcell G3. This part of the calculation process and calculation results conducted by NTH should be attached in Appendix A-2 for checking by the reviewers.

   Response:

   The calculation sheets and related attachments for Leachate Generation Estimation and Head Calculation (NTH, 2011) are included in this response package as Appendix A-2.4.

3. It is only indicated in Design Criteria/Design Basis (with Reference to Source of Data) in Page 1 of 2 that the maximum drainage length of Subcells G2 and G3 is 200 ft and floor slopes are 5.6% and 5.8%, respectively. But, the maximum slope lengths of the 3:1 sideslope in Subcells G2 and G3, which were used in the maximum leachate head calculation, were not indicated.

Response:

A new figure on page 1 of Appendix A-2.2, indicating the location of the maximum drainage length on the side slope, is included in the revised calculation sheet.

4. The same inflow rate of 8,960 gal/acre/day was used to calculate the maximum leachate head on the liner for Subcell G2 floor and 3(H):1(V) sideslope. If the inflow rate was calculated by using HELP model, the inflow rate results should be different for the flat subbase and 3(H):1(V) sideslope. It is the same for Subcell G3 floor and 3(H):1(V) sideslope.

   Response:

   A single leachate generation rate for each cell was reported in the current permit application report (approved by the MDEQ on May 4, 2012 and EPA on September 27, 2013). The generation rates of 8,960 and 7,874 gal/acre/day were estimated for Subcells G2 and G3, respectively. According to CTI's past design experiences, these leachate generation rates for sideslopes are significantly higher than any other landfill in Michigan. It is also CTI's understanding that steeper (e.g., 3H:1V) sideslope inclination tends to result in higher drainage capacity and the maximum head-on-liner will likely occur near the toe of the slope.

   To verify this understanding, CTI repeated the head-on-liner calculation using a "doubled" leachate generation rate. As shown in the attached calculation sheet, the calculated maximum head-on-liner value remains unchanged. Please also note that the higher performance Resistex® 200 GCL used on the cell floor will be extended 5-ft vertically up the side slope. The estimated maximum leachate head on the sideslope will actually occur within this "enhanced" section.

5. In Head on Liner Calculation for Subcell G2 – Side Slope, it was obtained that the maximum head on liner (McEnroe numerical) in all slope is equal to 5.18 inches. However, the result listed in the box indicate that the maximum head on liner (McEnroe 93 with free drain) is only 0.9982 inches. It is the same for Subcell G3 – Side Slope. CTI must clarify this discrepancy.

   Response:

   Since the "free draining" condition will not be met for the sideslope cases, the results from the McEnroe 96 equation (for free draining condition) are not valid in this calculation. The value was included on the spreadsheet for comparison purposes only. All irrelevant results have been removed from the spreadsheet to avoid confusion.

6. "The maximum head on liner (McEnroe 93 with free drain + Superposition)" is listed in the box in Head on Liner Calculations. What is this meaning and what is "Superposition"?

Response:

“Superposition” in this case is an approach which estimates the head-on-liner by adding the depth of leachate at the discharge point (i.e., leachate collection pipe) to the maximum head-on-liner determined using the McEnroe Equitation under a free draining condition). All irrelevant results have been removed from the spreadsheet to avoid confusion. Results from the numerical solution, which are relevant to this calculation, remain.

7. CTI should give a description to explain how two equations used for Slope 1 and Slopes 2 – 5 were derived from McEnroe 1993’s paper. Is it not continuous to connect these five segments of the curves, i.e., it should be a continuous phreatic surface of the leachate flow?

Response:

The derivation of the equations and verification of the results using numerical solution are documented in a CTI internal report, which is attached with this response package. The phreatic surface is continuous however the shape of the curve at each segment may vary.

8. In Head on Liner Calculations, the thicknesses of sand used in the calculations were 3.0, 3.0, 3.0, 3.0, and 2.0 inches for Slopes 5, 4, 3, 2, and 1 at Subcell G2 – Floor; 2.0, 2.0, 2.0, 2.0, and 2.0 at Subcell G3 – Floor; 6.0, 6.0, 6.0, 6.0, and 6.0 at Subcells G2 and G3 – Side Slope. Do these thicknesses represent the saturated depth of the 12-inch protective sand placed on the geocomposite drainage layer? Was the combined (apparent) permeability calculated from the combination of the permeabilities of the thickness of the geocomposite and the saturated depth of the sand layer? If so, the leachate flow in the geocomposite and protective sand layer is in a unconfining flow condition. If the leachate depth is greater than the thickness of the geocomposite, the saturated depth in the protective sand layer is unknown. It will change with the phreatic surface. The true saturated depth in the sand layer can be calculated by using trial and error method. Using a fixed saturated sand depth will affect the correctness of the calculated maximum leachate head results.

Response:

An assumed saturated thickness of the sand layer is used to determine the combined hydraulic conductivity of the saturated drainage layer per the approach presented by Qian et al. 2004 (Qian, X.D., Gray, D.H., and Koerner, R.M. (2004), “Estimation of Maximum Liquid Head over Landfill Barriers,” Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 130:5, 488-497).

$$k_{combined} = k_{geonet} + \left(k_{sand} - k_{geonet}\right)\frac{t_{sand}{}^{2}}{\left(t_{sand} + t_{geonet}\right)^{2}}$$

One of the ways to estimate the thickness of the saturated sand layer is using the trial-and-error method. However, even with the trial-and-error method, thickness of the saturated sand layer is not a “true” depth of leachate in the layer since the saturated thicknesses vary within each segment. To simplify the calculation and provide a conservative result (higher head on liner), an assumed saturated thickness, which is greater than the maximum head-on-liner in the same segment was utilized in the calculation.

9. CTI should explain why the thickness of geonet was assumed to be 0 for Slope 5 at Subcells G2 and G3 – Side Slope and the thickness of sand was still 6.0 inches.

Response:

The thickness of the geonet is not zero in "Slope 5". The thickness of the geonet is zero in "Slope 1" which was not used in the calculation. Note that the flow length was also set to zero for "Slope 1" in both spreadsheets.

Material and Construction Specifications and CQA Program

10. The geosynthetic-to-geosynthetic interface, geosynthetic-to-soil interface and GCL internal friction requirements obtained from slope stability analysis must be added in the CQA program document beyond GCL CQA program and the material and construction specifications shown in the Drawings.

Response:

Agree. All interface- and internal-shear resistance testing associated with various GCL products, including standard methods, procedures and minimum requirements will be included both in the technical specifications and on the construction drawings as part of the CQA program.

11. The material specifications of 5-ft cohesive soil used as an attenuation layer placed beneath the two layers of GCL primary liner, such as particle gradation or CL, LL and PI, dry density requirement for compaction, must be also included in the CQA program document and shown in the Drawings.

Response:

Agree. Soil properties such as Atterberg limits (ASTM D4318) and grain size distribution (ASTM D422) will be tested to confirm that the proposed material meets the classification requirements (SC, CH, CL, CL/ML or ML per the Unified Soil Classification System - ASTM D2487). Modified Proctor moisture-density correlation (ASTM D1557) will also be tested to determine the maximum dry density of the tested soil. Field testing will be performed to verify the in-place density of the attenuation soil meets the minimum 90% requirement.

# Proposed Permit Modification - Upgrades to MC VI-G Phase 2 Liner Design
# Wayne Disposal, Inc., Belleville, Wayne County, Michigan

## Response to EPA's May 14, 2018 Comments

1. Will a Construction Quality Assurance (CQA) program document be submitted?

   Response:

   Other than the GCL Section, which will be superseded by the CQA documents included in Attachment D of the submitted Permit Modification Letter Report ("GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines"), the current CQA Plan (approved by the MDEQ on May 4, 2012 and EPA on September 27, 2013) will remain as the official CQA program document for the construction of Master Cell VI-F & G.

   a. CQA must address the Geomembrane/Geocomposite interface with regards to slope stability.

      Response:

      The following paragraphs on Page 10 of 13 of the "Equivalency Information and References" (Attachment A of the submitted Permit Modification Letter Report) should properly address all interface- and internal shear resistance issues associated with slope stability.

      - *As long as the interim waste slope during filling does not exceed an inclination of 3.5(H) to 1(V), a friction angle of 13.8 degrees or higher between any different geosynthetic-to-geosynthetic or geosynthetic-to-soil interfaces will result in satisfactory factor of safety (FS) values of 1.5 or greater.*

      - *As long as a combination of friction and adhesion under an overburden pressure of 1.0 psi is greater than a friction angle of 21.8 degrees, stability of liner systems on slopes not steeper than 3(H) to 1(V) can be ensured.*

      *WDI will, as part of the CQA requirements, conduct direct shear tests (ASTM D6243) for relevant GCL-related interfaces (e.g., against 80-mil textured HDPE geomembranes, between different GCL products, against cohesive attenuation layer soils, etc.) as well as internal shear strength for different geosynthetic products before approving the products to be used for construction of the MC VI-G Phase 2 liner system."*

b. CQA must address the rolling and prepping of soil upon which the GCL lies.

Response:

As indicated on Page 11 of 13 of the “Equivalency Information and References” (Attachment A of the submitted Permit Modification Letter Report), technical specifications for the GCL (included in Attachment D of the submitted Permit Modification Letter Report) limit any stone particle in the upper most lift of the subgrade soils (i.e., the attenuation layer and the structural fill) to be not larger than 1 inch (25 mm) in size. Proof-rolling of the prepared subgrade surface is also required to reduce stone particle protrusion.

c. CQA must address the weights of vehicles allowed after installation of GCL.

Response:

As indicated on Page 17 of 25 of CETCO GCL CQA Manual (Attachment D of the submitted Permit Modification Letter Report entitled “GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines”) no heavy equipment should come in direct contact with the GCL. In some cases, however, it is necessary to drive equipment directly on the GCL. Permission to do so will be granted by CETCO through the CQA engineer on a case-by-case basis only and will include restrictions on low-pressure, rubber-tired equipment only.

Additionally, as indicated on Page 10 of 13 of the “Equivalency Information and References” (Attachment A of the submitted Permit Modification Letter Report), a minimum thickness of 1 foot (300 mm) of cover soil is specified as a technical requirement and CQA site personnel will observe/verify/document that such a requirement is maintained between the equipment tires/tracks and the GCL at all times during the installation process.

2. Anticipated settlement of underlying landfill after expansion is 3-17 feet. Did designer consider increasing overlap of the GCL materials to allow for this deformation to prevent overlapped GCL panels from separating and opening flow paths during settlement?

Response:

As indicated in the CETCO GCL CQA Manual (Attachment D of the Permit Modification Letter Report entitled “GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines”), the minimum acceptable overlap between GCL panels is 6 inches (150 mm). This overlap distance is considered as industry standard for over 2 decades and has been commonly used in numerous applications – including many landfill overfill liner (aka “piggybacking”) and final closure systems.

To name a few, the following commercial and municipal MSW landfills all have incorporated GCL in their permitted piggybacking liner or final closure systems using the same overlapping distance:

- Eagle Valley Security Landfill – Orion Charter Township, Michigan
- Westside Security Landfill – Three Rivers, Michigan
- Pine Tree Acres Landfill - Lenox, Michigan
- Northern Oaks Security Landfill – Harrison, Michigan
- Woodland Meadows Security Landfill – Van Buren Township, Michigan
- Smiths Creek Landfill – Smiths Creek, Michigan
- City of Midland Landfill – Midland, Michigan
- Wexford County Landfill – Manton, Michigan

It is important to recognize that final closure systems (of landfills, surface impoundments, etc.), compared with the proposed cell liner application, provide much less "confining" overburden pressure. Higher overburden pressure, and consequently greater shear resistance, keeps the overlapped GCL seams from separating when experiencing uneven settlement.

WDI believes that the proposed overlapping distance, with much greater confining overburden pressure provided by the proposed cell liner application, will adequately prevent the separation of GCL panels. However, WDI will request "offsetting" the overlapping area between the upper and lower GCL layers to provide additional redundancy and maximize the protection. This additional installation and CQA requirements will be incorporated in the construction drawings of Subcells G2 and G3.

3. What damage might occur to the leachate collection system during settlement of the underlying landfill?

   Response:

   As concluded in the approved 2011 permit submittal, the "post settlement" slopes are greater than 2.24 percent on the cell floor and greater than 1.0 percent along the leachate collection pipe locations – both satisfying the regulatory requirements and demonstrating satisfactory performance of the leachate collection system.

4. The buffer layer for the GCL does not address the angularity of stone. Has this been addressed?

   Response:

   As indicated on Page 11 of 13 of the "Equivalency Information and References" (Attachment A of the submitted Permit Modification Letter Report), maximum stone size in the upper most lift of the subgrade soils (i.e., the attenuation layer underneath the primary liner and the structural fill layer underneath the secondary liner) will be limited to not larger than 1 inch (25 mm). Any stone particles that are greater than 1' in size, or more angular than “sub-rounded” in shape will be handpicked and the remaining cavity will be backfilled with clay.

Moreover, proof-rolling of the subgrade surface is also required before the deployment of GCL. This procedure is intended to create a “smooth” subsurface and further reduce the chance of any significant stone particle protrusion.

Combining with the superb “self-healing” characteristic inherent to bentonite, it is believed that the above CQA requirements are sufficient and adequate to address potential concerns associated with substrate stone angularity and ensure a superb liner performance.

# Attachment D: GCL Manufacturer Specifications, CQA Manual, and Installation Guidelines

**TECHNICAL REFERENCE**

# RESISTEX® 200 FLW9 CERTIFIED PROPERTIES

CETCO® Resistex® geosynthetic clay liners are engineered to provide the highest level of chemical compatibility in extremely aggressive leachate environments such as some coal combustion product storage facilities, mining operations, and industrial waste storage facilities. Site-specific compatibility testing is strongly recommended.[7]

| MATERIAL PROPERTY | TEST METHOD | TEST FREQUENCY | CERTIFIED VALUES |
|---|---|---|---|
| Scrim-reinforced Nonwoven Base Geotextile Mass/Area[1] | ASTM D5261 | 200,000 ft$^2$ (20,000 m$^2$) | 6.0 oz/yd$^2$ (200 g/m$^2$) min. |
| Nonwoven Cap Geotextile Mass/Area[1] | ASTM D5261 | 200,000 ft$^2$ (20,000 m$^2$) | 9.0 oz/yd$^2$ (300 g/m$^2$) min. |
| Bentonite Moisture Content[2] | ASTM D2216 | 1 per 50 tonnes | 12% max. |
| Bentonite Swell Index[2] | ASTM D5890 | 1 per 50 tonnes | 24 mL/2g min. |
| Bentonite Fluid Loss[2] | ASTM D5891 | 1 per 50 tonnes | 18 mL max. |
| Bentonite Mass/Area[3] | ASTM D5993 | 40,000 ft$^2$ (4,000 m$^2$) | 0.75 lb/ft$^2$ (3.7 kg/m$^2$) min. |
| Total Mass/Area[3] | ASTM D5993 | 40,000 ft$^2$ (4,000 m$^2$) | 0.85 lb/ft$^2$ (4.2 kg/m$^2$) min. |
| GCL Moisture Content | ASTM D5993 | 40,000 ft$^2$ (4,000 m$^2$) | 35% max. |
| GCL Grab Strength[4] | ASTM D6768 | 200,000 ft$^2$ (20,000 m$^2$) | 50 lbs/in (8.8 kN/m) min. |
| GCL Peel Strength | ASTM D6496 | 40,000 ft$^2$ (4,000 m$^2$) | 3.5 lbs/in (610 N/m) min. |
| GCL Hydraulic Conductivity[5] | ASTM D5887 | 250,000 ft$^2$ (25,000 m$^2$) | 3 x 10$^{-11}$ m/s max. |
| GCL Hydrated Internal Shear Strength[6] | ASTM D6243 | 1,000,000 ft$^2$ (100,000 m$^2$) | 500 psf (24 kPa) typ.@ 200 psf (9.6 kPa) |

Notes:

[1] Geotextile property tests performed on the geotextile components before they are incorporated into the finished GCL product.

[2] Bentonite property tests performed before the bentonite is incorporated into the finished GCL product.

[3] Reported at 0 percent moisture content.

[4] All tensile strength testing is performed in the machine direction using ASTM D6768.

[5] Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (550 kPa) cell pressure, 77 psi (530 kPa) headwater pressure and 75 psi (515 kPa) tailwater pressure.

[6] Peak values measured at 200 psf (9.6 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

TECHNICAL REFERENCE

# BENTOMAT® CL CERTIFIED PROPERTIES

CETCO® Bentomat® CL is a reinforced geosynthetic clay liner (GCL) consisting of a layer of sodium bentonite between a polypropylene woven geotextile and a polypropylene nonwoven geotextile, which are needle-punched together and laminated to a polyethylene geofilm.

| MATERIAL PROPERTY | TEST METHOD | TEST FREQUENCY | CERTIFIED VALUES |
|---|---|---|---|
| Bentonite Moisture Content[2] | ASTM D2216 | 1 per 50 tonnes | 12% max. |
| Bentonite Swell Index[2] | ASTM D5890 | 1 per 50 tonnes | 24 mL/2g min. |
| Bentonite Fluid Loss[2] | ASTM D5891 | 1 per 50 tonnes | 18 mL max. |
| Bentonite Mass/Area[3] | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 0.75 $lb/ft^2$ (3.7 $kg/m^2$) min. |
| Geofilm Density[1] | ASTM D1505 | 200,000 $ft^2$ (20,000 $m^2$) | 0.92 $g/cm^3$ |
| Geofilm Thickness[1] | ASTM D5199 | 200,000 $ft^2$ (20,000 $m^2$) | 5 mil (0.12 mm) min. |
| Geofilm Break Strength[1,4] | ASTM D882 | 200,000 $ft^2$ (20,000 $m^2$) | 14 lbs/in (2.5 kN/m) min. |
| Total Mass/Area[3] | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 0.84 $lb/ft^2$ (4.1 $kg/m^2$) min. |
| GCL Moisture Content | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 35% max. |
| GCL Grab Strength[5] | ASTM D6768 | 200,000 $ft^2$ (20,000 $m^2$) | 30 lbs/in (5.3 kN/m) min. |
| GCL Peel Strength | ASTM D6496 | 40,000 $ft^2$ (4,000 $m^2$) | 3.5 lbs/in (610 N/m) min. |
| GCL Hydraulic Conductivity[6] | ASTM D5887 | 250,000 $ft^2$ (25,000 $m^2$) | 5 x $10^{-12}$ m/s max. |
| GCL Index Flux[6] | ASTM D5887 | 250,000 $ft^2$ (25,000 $m^2$) | 1 x $10^{-9}$ $m^3/m^2/s$ max. |
| GCL Hydrated Internal Shear Strength[7] | ASTM D6243 | 1,000,000 $ft^2$ (100,000 $m^2$) | 500 psf (24 kPa) typ.@ 200 psf (9.6 kPa) |

Notes:

[1] Geosynthetic property tests performed on the geosynthetic components before they are incorporated into the finished GCL product.

[2] Bentonite property tests performed before the bentonite is incorporated into the finished GCL product.

[3] Reported at 0 percent moisture content.

[4] Geofilm tensile break strength performed in the machine and cross-machine directions using ASTM D882.

[5] GCL tensile strength testing is performed in the machine direction using ASTM D6768.

[6] ASTM D5887 is modified to include the laminated thin flexible membrane on the test specimen. Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (550 kPa) cell pressure, 77 psi (530 kPa) headwater pressure and 75 psi (515 kPa) tailwater pressure. ASTM D5887 (modified) testing is performed only on a periodic basis because the thin flexible membrane is essentially impermeable. The Bentomat® GCL core (without the flexible membrane) has a maximum hydraulic conductivity of 5 x $10^{-11}$ m/s with deaired distilled/deionized water. For more information, see CETCO® Technical Reference (TR) Nos. 111 and 112.

[7] Peak values measured at 200 psf (9.6 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

TR 401-BCL D5889/GRI-GCL3
07/2017

MINERALS TECHNOLOGIES CETCO®

TECHNICAL REFERENCE

# BENTOMAT® DN CERTIFIED PROPERTIES

CETCO® Bentomat® DN is a reinforced geosynthetic clay liner (GCL) consisting of a layer of sodium bentonite between two polypropylene nonwoven geotextiles, which are needle-punched together.

| MATERIAL PROPERTY | TEST METHOD | TEST FREQUENCY | CERTIFIED VALUES |
|---|---|---|---|
| Bentonite Moisture Content[1] | ASTM D2216 | 1 per 50 tonnes | 12% max. |
| Bentonite Swell Index[1] | ASTM D5890 | 1 per 50 tonnes | 24 mL/2g min. |
| Bentonite Fluid Loss[1] | ASTM D5891 | 1 per 50 tonnes | 18 mL max. |
| Bentonite Mass/Area[2] | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 0.75 lb/$ft^2$ (3.7 kg/$m^2$) min. |
| Total Mass/Area[2] | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 0.83 lb/$ft^2$ (4.1 kg/$m^2$) min. |
| GCL Moisture Content | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 35% max. |
| GCL Grab Strength[3] | ASTM D6768 | 200,000 $ft^2$ (20,000 $m^2$) | 50 lbs/in (8.8 kN/m) min. |
| GCL Peel Strength | ASTM D6496 | 40,000 $ft^2$ (4,000 $m^2$) | 3.5 lbs/in (610 N/m) min. |
| GCL Hydraulic Conductivity[4] | ASTM D5887 | 250,000 $ft^2$ (25,000 $m^2$) | 5 x $10^{-11}$ m/s max. |
| GCL Index Flux[4] | ASTM D5887 | 250,000 $ft^2$ (25,000 $m^2$) | 1 x $10^{-8}$ $m^3/m^2/s$ max. |
| GCL Hydrated Internal Shear Strength[5] | ASTM D6243 | 1,000,000 $ft^2$ (100,000 $m^2$) | 500 psf (24 kPa) typ.@ 200 psf (9.6 kPa) |

Notes:

[1] Bentonite property tests performed before the bentonite is incorporated into the finished GCL product.

[2] Reported at 0 percent moisture content.

[3] All tensile strength testing is performed in the machine direction using ASTM D6768.

[4] Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (550 kPa) cell pressure, 77 psi (530 kPa) headwater pressure and 75 psi (515 kPa) tailwater pressure.

[5] Peak values measured at 200 psf (9.6 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

**TECHNICAL REFERENCE**

# BENTOMAT® ST CERTIFIED PROPERTIES

CETCO® Bentomat® ST is a reinforced geosynthetic clay liner (GCL) consisting of a layer of sodium bentonite between a polypropylene woven geotextile and a polypropylene nonwoven geotextile, which are needle-punched together.

| MATERIAL PROPERTY | TEST METHOD | TEST FREQUENCY | CERTIFIED VALUES |
|---|---|---|---|
| Bentonite Moisture Content[1] | ASTM D2216 | 1 per 50 tonnes | 12% max. |
| Bentonite Swell Index[1] | ASTM D5890 | 1 per 50 tonnes | 24 mL/2g min. |
| Bentonite Fluid Loss[1] | ASTM D5891 | 1 per 50 tonnes | 18 mL max. |
| Bentonite Mass/Area[2] | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 0.75 $lb/ft^2$ (3.7 $kg/m^2$) min. |
| Total Mass/Area[2] | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 0.81 $lb/ft^2$ (4.0 $kg/m^2$) min. |
| GCL Moisture Content | ASTM D5993 | 40,000 $ft^2$ (4,000 $m^2$) | 35% max. |
| GCL Grab Strength[3] | ASTM D6768 | 200,000 $ft^2$ (20,000 $m^2$) | 30 lbs/in (5.3 kN/m) min. |
| GCL Peel Strength | ASTM D6496 | 40,000 $ft^2$ (4,000 $m^2$) | 3.5 lbs/in (610 N/m) min. |
| GCL Hydraulic Conductivity[4] | ASTM D5887 | 250,000 $ft^2$ (25,000 $m^2$) | $5 \times 10^{-11}$ m/s max. |
| GCL Index Flux[4] | ASTM D5887 | 250,000 $ft^2$ (25,000 $m^2$) | $1 \times 10^{-8}$ $m^3/m^2/s$ max. |
| GCL Hydrated Internal Shear Strength[5] | ASTM D6243 | 1,000,000 $ft^2$ (100,000 $m^2$) | 500 psf (24 kPa) typ.@ 200 psf (9.6 kPa) |

Notes:

[1] Bentonite property tests performed before the bentonite is incorporated into the finished GCL product.

[2] Reported at 0 percent moisture content.

[3] All tensile strength testing is performed in the machine direction using ASTM D6768.

[4] Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (550 kPa) cell pressure, 77 psi (530 kPa) headwater pressure and 75 psi (515 kPa) tailwater pressure.

[5] Peak values measured at 200 psf (9.6 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

# CETCO GCL

# CONSTRUCTION QUALITY ASSURANCE (CQA) MANUAL

Version 6.0, August 2008

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SECTION PAGE

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## LIST OF APPENDICES

# SECTION 1
# INTRODUCTION

## 1.1 Definitions

**Construction Quality Assurance.** For the purposes of this manual, construction quality assurance (CQA) is defined as a planned system of activities that provides assurance that *installation* of the geosynthetic clay liner (GCL) proceeds in accordance with the project design drawings and specifications. In general, these activities include continuous inspection of the installation, testing of materials and procedures, and overall documentation.

**Construction Quality Control.** Again, for the purposes of this manual, construction quality control (CQC) is defined as a planned system of activities that provides assurance that the properties of the GCL *materials* meet the requirements of the project specifications. These activities primarily include materials testing and documentation.

There is a great deal of overlap in the nature of CQA and CQC, and from a practical standpoint, CQA and CQC activities are often performed by the same party. For this reason, we will use the term CQA to describe *all* of the quality-oriented tasks relating to the GCL and its installation.

## 1.2 Scope and Purpose of the CQA Manual

This manual is written to address third-party CQA activities and is *not* intended as a guide for GCL installation. Installation guidelines are available separately from CETCO (see Technical References TR-402). This manual is also not intended to describe the various *manufacturing* quality assurance and quality control (MQA/MQC) activities performed by CETCO at the GCL manufacturing facilities (see Technical Reference No. TR-403).

The purpose of the CQA Manual is provide the project CQA personnel with a general format for assuring that the GCL delivered to the job meets the requirements of the specifications and that this material is installed in accordance with the design drawings and specifications. This manual should be modified as necessary by the design or CQA engineer in order to account for site-specific or project-specific concerns and conditions. Any such changes, however, should be discussed with CETCO before they are introduced into the final version of the project CQA plan.

For the convenience of the CQA personnel, an overall CQA Checklist is provided in Appendix A. This checklist or a similar version thereof is designed to be used on a daily basis to document that all CQA activities are consistently executed throughout the project. The checklists should be maintained at the job site and should be included chronologically in the final CQA documentation package (Section 7).

# SECTION 2
## PERSONNEL QUALIFICATIONS AND RESPONSIBILITIES

It is vital that all parties involved in the installation of the GCL are in close communication with each other throughout the project, and that they fully understand the requirements of the project CQA plan. For the purposes of this manual, the qualifications and responsibilities of the various parties are delineated as follows:

### Installing Contractor

Responsible for installing the GCL. The contractor should appoint an on-site Construction Supervisor to coordinate the installation effort and to interact with the other parties on the job site. The installing contractor should have prior experience in GCL installation and should staff the project with qualified technicians.

### On-Site Engineer

Usually the design engineer or designee, this person is responsible for general oversight of the installation. Provides assurance that construction is performed as designed, although not formally responsible for CQA. Primary contact when the installing contractor is in need of clarification of design issues. Primary contact for dispute/problem resolution. This person should be a registered professional engineer.

### CQA Engineer

Charged with CQA for Bentomat installation as well as for any other liner system components. Oversees all CQA inspection, testing, and documentation. This person should be a registered professional engineer or a certified geosynthetics installation technician. This person must also be independent of the other parties on site.

### Manufacturer's Representative

CETCO may provide on-site start-up assistance, especially those in which the installer has little or no prior experience or where unusual site conditions exist. The on-site engineer or installer is responsible for notifying CETCO of the intended installation schedule such that CETCO may provide timely guidance during the start-up process. CETCO’s GCL installation experience may provide valuable insights to the uninitiated engineer and/or installer.

CETCO also acts as the liaison between the manufacturing plant and the installer and coordinates the release of GCL from the plant in accordance with the installer’s schedule. CETCO’s *on-site* involvement is typically lessened when it is determined that the installer is sufficiently capable of installing GCL without CETCO’s continuous assistance. CETCO remains available throughout the project should questions or problems arise.

## CQA Laboratory

The GCL conformance tests in this manual are designed to be performed at the job site to facilitate real-time response as test results are generated. In some projects where additional testing is required, however, it may be necessary to utilize the services of an off-site laboratory. The on-site engineer should verify that the selected laboratory has ample experience in the testing of GCLs and is aware of the general content of the project CQA plan as well as its specific testing requirements. The CQA engineer should establish a key contact at the laboratory to coordinate sample delivery procedures, confirm testing parameters and methods, and arrange the timely reporting of test results.

It is recommended that a preconstruction meeting be held between the above parties in order to establish working relationships with one another and to review the design drawings and specifications prior to deployment of the GCL. Thereafter, regular meetings on a daily or weekly basis are recommended as the project continues.

# SECTION 3
# ON-SITE HANDLING

This section describes the procedures and equipment to be used in handling the GCL when it arrives at the job site. Proper execution of these procedures will ensure that the GCL is not damaged prior to installation. It should be noted that ASTM D 5888 also provides guidelines for GCL handling. The recommendations included herein are consistent with all ASTM guidelines.

CETCO's GCLs are produced in slightly different sizes depending upon the product selected. Weights and dimensions of these products and their corresponding core pipe sizes required for safe handling are provided in Table 1 below.

| **Product** | **Panel Size (m)** | **Roll Diam. (mm)** | **Typ. Roll Weight (kg)** | **Core Diam. (mm)** | **Core Pipe Diameter (mm)** | **Core Pipe Length (m)** | **Minimum Core Pipe Strength** |
|---|---|---|---|---|---|---|---|
| Bentomat | 4.57 x 45.7 | 610 | 1,200 | 100 | 89 | 6.1 | XXH |
| Claymax | 4.57 x 45.7 | 510 | 1,250 | 100 | 89 | 6.1 | XXH |

Table 1. GCL panel sizes and corresponding core pipe requirements.

It should be recognized that the weight of the GCL rolls will dictate what type of core pipe will be sufficiently strong for unloading and handling activities. Experience has shown that the type of steel from which the pipe was produced will influence its ability to sustain the weight of the roll. The strongest steel available should be used to prevent pipe bending. A core pipe that deflects more than 75 mm as measured from end to midpoint when the roll is lifted can cause damage to the GCL and is *not acceptable.* The pipes used to unload or deploy the GCL *must not bend* at any time.

## 3.1 Unloading Procedures

The GCL may be delivered to the job site in one of two ways: by flatbed truck or by closed trailer/container. Regardless of the delivery method, all unloading activities should take place away from main roadways and high-traffic areas at the site. The designated unloading area should be flat, dry, and stable, and should provide adequate peripheral access for the unloading equipment. Different techniques for unloading the GCL are used accordingly. Using the procedures and equipment described below will minimize unloading time.

### 3.1.1 Flatbed Truck Delivery

A front-end loader or backhoe is typically used to remove the rolls from the flatbed truck. Starting from the top rolls on the truck, the core pipe is inserted through the roll core. The core has an inside diameter of 100 mm but may be slightly bowed upon arrival to the job site. In this case, it may be necessary to assist the core pipe insertion process by using the back of the loader bucket to carefully push the pipe through the core.

After the core pipe has been inserted, straps or chains are looped around each end of the pipe protruding from the roll. The other ends of the chains should be connected to a spreader bar (typically an I-beam) of equal length to the core pipe. The spreader bar itself is suspended from the loader bucket. The purpose of the spreader bar is to prevent the chains from chafing the ends of the roll as it is lifted. It is recommended that the chains or straps be secured by the placing a pin through each end of the pipe. The GCL roll should then be lifted and slowly carried from the flatbed to the temporary storage area.

GCL rolls can also be provided with a pair of slings to facilitate lifting and handling.

### 3.1.2 Trailer or Container Delivery

The GCL may also be delivered in closed trailers or shipping containers. In these cases, different unloading equipment and techniques must be employed. Because of limited access to the GCL rolls, it is usually necessary to utilize an extendable-boom forklift with a "stinger" attachment. The forklift dealer or manufacturer can provide details on selecting the proper stinger for the type of forklift used at the job site.

The rolls are placed inside the trailer or container in the same way that they are positioned on a flatbed truck. The rolls are removed by inserting the stinger through the roll cores and lifting/pulling the rolls from the trailer/container.

## 3.2 Materials Handling

The equipment used to unload the GCL from the delivery vehicle may also be used to handle the material on site and to convey it to work areas. All unloading and handling activities must be undertaken with great care to avoid damage to the GCL. The GCL should never be handled in ways that could affect its performance. Some activities to avoid:

- Dropping the rolls from the edge of the delivery truck or container.
- Pushing or pulling the rolls on the ground surface.
- Lifting the roll without a core pipe.
- Bending the rolls by using a core pipe that cannot bear the weight of the roll.
- Forcing a bent core pipe through the core.
- Carrying the GCL over excessively rutted, bumpy terrain, causing the roll to bend and bounce in transit.

Adherence to these common-sense precautions will prevent handling-related damage to the Bentomat.

The CQA engineer or designee should supervise the unloading and storage operations. It is the duty of the CQA engineer to maintain records of the shipments and to verify that the roll numbers on the labels match the roll numbers on the bills of lading. Any apparent discrepancies should be noted and reported to CETCO.

At this time, all of the rolls should also be visually inspected for damage. Damaged rolls should be clearly marked and set aside where they will not be immediately used. Major damage suspected to have occurred during shipment should *immediately* be reported to the carrier and to CETCO (see Section 4.8.1).

## 3.3 On-Site Storage

The GCL may be stored at a project site indefinitely, provided that proper storage procedures are followed. First, a dedicated storage area should be identified. This area should be level, dry, well drained, and located away from high-traffic areas of the job site.

For reasons of safety and material integrity, GCL rolls must never be stored on end. Rolls should be stored horizontally, in small stacks not to exceed four rolls in height. It is preferred that the bottom rolls be placed on plywood, on an arrangement of pallets, or on some other man-made surface, to promote drainage and to prevent damage by contact with the ground surface. If the rolls are to be placed directly on the ground, the local ground surface should be carefully prepared and proof-rolled to minimize the potential for damage. It is good practice to cover the stored rolls with a tarpaulin or plastic sheeting for supplemental protection from the elements.

The polyethylene sleeves of the GCL rolls should be examined for any obvious rips or tears. Sleeve damage should be repaired immediately with adhesive tape or additional plastic sheeting. At this time it is also recommended that the labels be examined and taped to the roll if they were displaced in transit.

# SECTION 4
# INSTALLATION

This section of the CETCO GCL CQA Manual covers the techniques and procedures to be used for ensuring the quality of a GCL installation. Although some installation techniques are described, this section is *not* an installation guide. Refer instead to CETCO GCL Technical Reference TR-402 for specific GCL installation guidelines. ASTM D 6102 also contains sound GCL installation guidelines.

## 4.1 Start-Up Assistance

CETCO or its representatives can provide on-site start-up assistance, especially where the installer has no prior GCL installation experience or in which the application is relatively unique. CETCO will work with the on-site engineer and CQA engineer in order to verify that the proper unloading, installation and conformance testing procedures are utilized. CETCO's input is based on extensive experience with GCL installation and on intimate knowledge of the physical characteristics of GCLs. It should be recognized, however, that it is the site engineer's responsibility to implement CETCO's recommendations.

## 4.2 Equipment

In many projects, the equipment used for unloading the GCL can also be used to install it. Most applications require a vehicle to lift and suspend the roll as it is deployed. Front-end loaders, bulldozers, boom cranes, forklifts, and tracked excavators all have been successfully used for this task. Other, more specialized equipment exists for these operations and may also be used. The equipment for unrolling the GCL should be able to lift the roll and suspend it *freely* such that it does not chafe against the vehicle or the ground. The vehicle must also have the ability to accommodate a spreader bar above the roll of GCL.

The spreader bar should be sufficiently strong to bear the full weight of the GCL roll without bending. Readily available I-beams or T-beams made of structural steel are typically used for this purpose, although steel pipes have also been successfully used. The chains or straps should be checked for their strength before the installation begins and should continually be inspected for wear as the installation continues.

The core pipe should be of the dimensions and strength indicated in Table 1. It has been CETCO's experience that the schedule of the core pipe is not always an accurate indicator of its strength. The type of steel from which the pipe is made, the presence of a longitudinal weld, and the overall length of the pipe all have an influence on its ability to sustain the weight of the GCL. It is essential that the core pipe *does not bend* when the full roll of GCL is suspended from it. Lastly, it is recommended that the core pipe have a means to prevent the chains or straps from slipping off the ends of the pipe. This can be accomplished by using pins or clamps.

It will often be necessary to cut the GCL before the end of the roll or to cut it to fit in certain confined areas. Cutting the GCL requires a *sharp* utility knife. It is very important to maintain the sharpness of the knife blades used for cutting the GCL, in order to prevent tearing its geosynthetic components and damaging the GCL where the cut is made. Frequent blade changes for the utility knives are strongly recommended.

For construction of the bentonite enhanced overlapped seams of the Bentomat products, an acceptable fillet of bentonite can be poured directly from the bags of granular bentonite supplied with each roll of Bentomat, but a watering can (without a sprinkler head) is easier to use and produces a more controlled seam enhancement. A line chalker, such as those used for marking athletic fields, may also be used.

## 4.3 Field Conditions

At the beginning of each working day, the CQA engineer should confirm that there are no ambient site conditions which could affect the quality of the installation. Specifically, the presence at the job site of excessively high winds, rain, standing water, or snow may be construed as unsuitable weather for GCL installation. There are no temperature restrictions for installing the GCL, however.

Bentomat is not as susceptible as Claymax to damage due to "premature hydration" (i.e., hydration before a confining stress is applied). Although Bentomat will not delaminate when wetted, CETCO nevertheless recommends that it be installed in dry weather as with Claymax. This lessens the potential for damage to the material and ensures that its integrity is not compromised by the swelling of the bentonite. Should the GCL become prematurely hydrated, it urged that CETCO be contacted in order to recommend a project-specific and product-specific recommendation as to whether the GCL must be removed and replaced. CETCO's Technical Reference TR-312 provides a checklist for evaluating GCL that has been hydrated when no confining pressure is present.

## 4.4 Site Inspection

Prior to each day's installation activities, the site engineer and/or CQA engineer should inspect the work area to ensure that it has been prepared in accordance with the specification and design drawings. Specifically, the design grades should be verified, the slope length and steepness should be checked, the anchor trench dimensions should be measured, and the subgrade should be inspected and approved. Any deviations from the specifications or design drawings should be noted and rectified before the GCL is installed.

The anchor trench is especially important in applications where slopes are present. The anchor trench must meet or exceed the design dimensions but must also be free of any sharp corners or protrusions which could put excessive stress on the GCL. The CQA engineer must ensure that the anchor trench is as carefully prepared as the rest of the subgrade.

## 4.5 Panel Placement

The unrolling and placement of the GCL should be performed in such a way that the GCL is not damaged or unduly stretched, folded, or creased. The GCL rolls are typically suspended from the front of the vehicle while it travels backwards along the intended path of placement. During this activity, the roll should be able to rotate freely around the core pipe. Excessive friction due to a bent or large-diameter core pipe, or due to contact between the roll and the deployment equipment, may cause undesirable levels of tension to develop. It is necessary that the GCL be deployed in a fully relaxed (but not wrinkled) state.

A common deployment technique when the GCL is placed on slopes is to suspend the roll at the top of the slope while several laborers unroll it as they walk downslope. This is an acceptable technique, but the CQA engineer should verify that excessive tension does not develop on the material and that the underside of the panel is not damaged by friction with the subgrade. Unless the subgrade is acceptably smooth, the GCL should be unrolled over an already-placed panel and then moved laterally into its correct position. Flat-bladed vise grips are very useful for handling and moving unrolled panels.

It is important to ensure that, at the top of a slope, the GCL is properly placed in the anchor trench. After confirming that the trench has been constructed according to the specifications, the GCL should be placed in the trench such that it extends across the trench floor but not up the rear wall of the trench. Excess material if any, should be cut off, *not* folded over on top of the existing material. Proper anchorage will be achieved if and only if the GCL is placed within the trench in this manner.

The orientation of the GCL panels is important. When working in sloping areas, the panels should be positioned such that their long dimension is parallel to the direction of the slope. Panels may only be placed across the slope when the slope is less steep than 4H:1V or when the slope length is very short (less than or equal to 3 m).

## 4.6 Seaming

Proper field seaming is vital for the liner to function to its maximum abilities. There are three elements of CQA for this important task:

- Verification of the minimum acceptable overlap.
- Verification of the continuity of the accessory bentonite (Bentomat only).
- Verification that there is no dirt in the overlap zone or on the bottom geotextile of the overlying GCL panel.

These elements for field seam CQA are straightforward and require only visual inspection by the CQA engineer. The upper surface of the GCL has two heavy dashed lines on both sides of the panel. The lap lines are 150 mm from the edges of the panel, and the match lines are 250 mm from the edges of the panel. The minimum acceptable overlap is 150 mm. Thus, the installer’s objective is to place the overlying panel *between* the two lines of the underlying panel. The CQA engineer needs only to visually verify that the 150-mm lap line of the underlying panel is not visible. A properly executed seam, therefore, is verified when three dashed lines (not four) are visible at the overlap, as shown in Figure 1.

The hydraulic performance of Bentomat is maximized when the accessory bentonite is placed *continuously* within the overlap zone. Continuity is best achieved when a watering can or other similar device is used. Pouring the bentonite directly from the bag is less effective in this regard. Verification of continuity should be performed visually by the CQA engineer. The CQA engineer should observe the accessory bentonite as it is being placed within the overlap zone and should give verbal approval of the seam before the overlap is flipped back into place.

Bentomat ST, DN, and SDN with Supergroove® have self-seaming capabilities in their longitudinal overlaps (Figure 2) and do not require supplemental bentonite. For these Bentomat products, supplemental bentonite is required for the end-of-panel overlapped seams. For pond applications, supplemental bentonite must be used in longitudinal seams regardless of the CETCO GCL used.

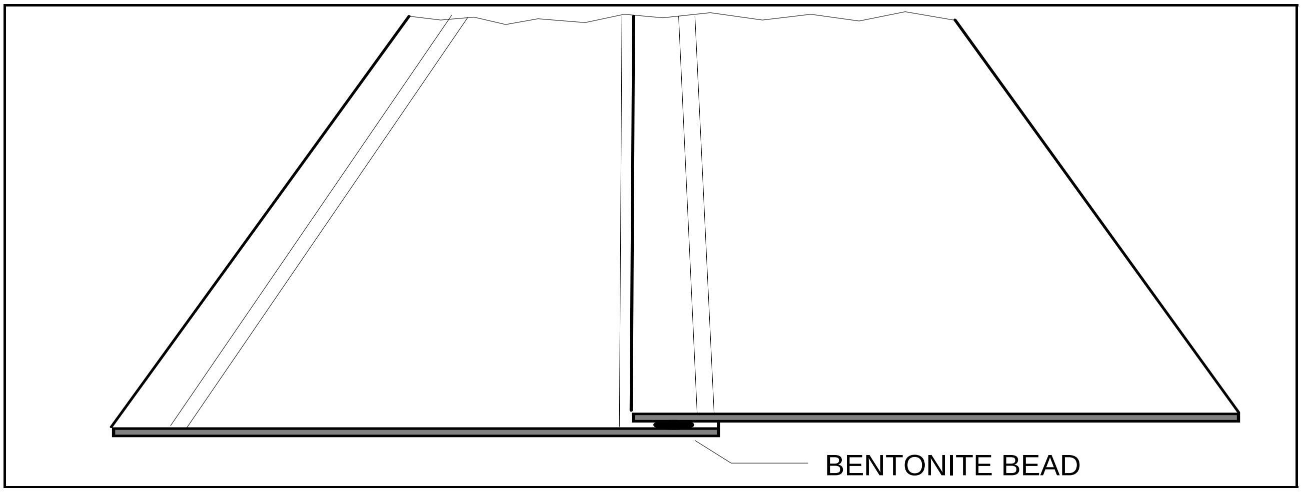


Figure 1. Schematic representation of a properly executed Bentomat field seam.

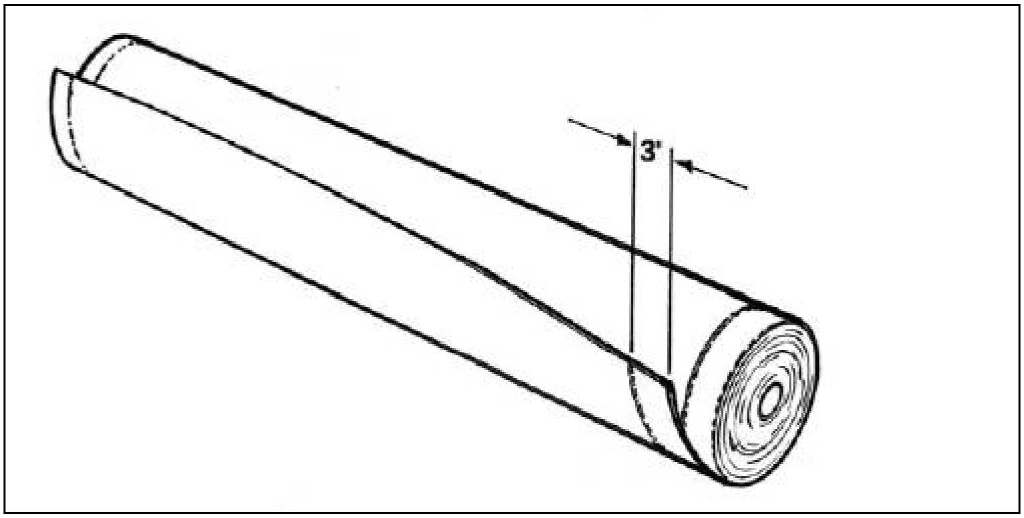


Figure 2. Supergroove Bentomat field seam.

Verification of the cleanliness of the overlap is also required, because dirt can enter the overlap and create a conduit for excessive lateral leakage. This is one reason CETCO recommends that the overlying panel is placed and then its edge flipped back to reveal the overlap zone. Exposing the overlap in this manner forces extra attention on the seam and reveals the presence of loose dirt that may have inadvertently entered the overlap zone or may have become adhered to the bottom geotextile of the overlying panel. The CQA engineer should either verify that no dirt is present or ensure that the dirt is swept out of the overlap.

Verification of the *amount* of bentonite placed at the seam may be achieved by ensuring that one full 22.5 kg bag of granular bentonite is used for the lateral and longitudinal seaming of each roll of GCL. CETCO recommends that a minimum of 375 grams of granular bentonite be applied per lineal meter of seam. If the installer places bentonite at the rate of one bag per roll, this target application rate will be achieved.

The longitudinal overlap for the GCL should be at least 150 mm (Bentomat) and 300 mm (Claymax). Overlaps at the *ends* of the rolls, however, ("transverse" overlaps) should be at least 300 mm (Bentomat) and 600 mm (Claymax) to account for any incidental loss of bentonite that could occur due to excessive handling of this portion of the roll or to stress relaxation after placement. Overlap distances can be increased if unusual site conditions (such as a soft subgrade, or GCL covered only with geomembrane) exist.

## 4.7 Detail Work

The term "detail work" refers to the placement of GCL around structures such as vertical walls, gas vents, drainage basins, and pipe penetrations. In all of these cases, it is necessary to utilize granular bentonite or a bentonite mastic to create a seal between the GCL and the structure. CQA of these areas involves a visual inspection of the methods used to make the seal. Specific items requiring inspection include:

- Dimensions of the "notch" excavated around the structure.
- Amount of bentonite applied to the detail
- Condition of the GCL at its cut edge (the cut should be clean, not frayed, with little or no bentonite edge loss from the GCL)
- Integrity of the detail as cover material is placed over and around it.

When cutting the GCL, it is important to ensure that the cut is made where the GCL hangs from the roll or where it rests on the subgrade . The GCL cut should *never* be made on the roll itself or when it rests on any other liner system component.

## 4.8 Damage and Damage Repair

Even when all reasonable protective measures are taken, the GCL may still become damaged during shipping and handling or during installation. This section provides instructions on assessing and managing the damaged materials.

### 4.8.1 Damage From Shipping and Handling

Occasionally, a GCL roll will arrive at a job site with its protective plastic sleeve torn due to movement during transit. This roll should be inspected for damage in the area where the sleeve was torn. If the geotextile under the torn sleeve is also torn, The outermost wrap of GCL on the roll should be unwound and discarded when the roll is installed. It is not necessary to consider the entire roll unusable. It is important, however, to mark the roll in order to alert the installer that the initial wrap should be cut away and discarded, because the damaged geotextile may be hidden from view when the GCL is unrolled. It is remotely possible that further layers of GCL on the roll could be similarly damaged. If this happens, additional wraps may be unrolled and discarded prior to placement.

Damage due to poor handling may occur as a result of accidentally dropping a suspended roll onto the ground or using weak core pipes that bend when the GCL is lifted. These activities can cause damage not just to the outer wrap of GCL but to the entire roll. If such damage occurs, the rolls should be clearly marked and moved away from the storage area. The CQA engineer should ensure that procedures are immediately implemented in order to prevent the recurrence of this problem. The CQA engineer should also contact CETCO to help make a determination as to whether the mis-handled GCL is acceptable for use on the project.

### 4.8.2 Damage From Installation Activities

The more commonly observed incidents of damage occur during installation, as a result of inadvertent contact by heavy equipment. Because this type of damage will potentially have the largest overall effect on the integrity of the liner system, CETCO strongly recommends that equipment operating on or near the GCL *be monitored continuously.*

Equipment operators should be made fully aware of the importance of their actions and should be encouraged to notify the CQA engineer directly if they suspect at any time that the liner may have become damaged by their equipment. Close communication among everyone involved in the installation will help to ensure that this type of damage is reported and repaired.

Repeated passes by loaded dump trucks over GCL, which has minimal cover, can cause damage. It is therefore preferred to prevent potential for such damage by placing the GCL over these high-traffic areas *after* cover material delivery is largely completed. If this is not possible, then extra cover should be placed over high-traffic areas. At least 600-900 mm of screened, cohesive soil is recommended.

Should damage occur to the already-installed GCL, the following procedures should be followed:

1. Remove equipment from the damaged area and notify the CQA engineer.
2. *Manually* clean away all cover material within a 600-mm radius of the damaged area. Use a broom to sweep away the remaining dirt in order to make the area as clean as possible.
3. If necessary, repair the subgrade to its original conditions. Replace the torn/damaged GCL as closely as possible to its original position.
4. Place a bead of granular bentonite or bentonite paste at the minimum rate of 500 g per lineal meter around the damaged area.
5. Cut a patch of new GCL to fit over the damaged area and extending 600 mm beyond it.

6. Place the patch over the damaged area and carefully backfill over the patch.

Note that it is necessary only to repair the damaged portion of the GCL. It is usually not necessary to remove and replace the entire panel, unless the damage has occurred on a slope. In this case, slope stability may be compromised and the site engineer should be contacted to help determine whether a repair is acceptable.

# SECTION 5
# PLACEMENT OF COVER MATERIALS

As mentioned previously, the proper placement of cover on the GCL is crucial to the overall success of the installation. This section of the Bentomat CQA manual includes recommended materials and procedures, which will help to ensure that the integrity of the GCL is not compromised when it is covered.

Regardless of the nature of the cover material used, it should be placed as soon as possible after the GCL has been deployed. The efforts of placing the GCL and placing the final cover should be coordinated to the extent that only as much GCL as can be covered should be deployed in one working day. This will prevent premature hydration and will greatly reduce the chances for incidental damage to the GCL during other activities.

## 5.1 Soil/Stone Cover

When a GCL is the sole liner system component, soil or stone cover *must* be placed over it to provide protection from physical damage, erosional forces, and degradation by UV light. The presence of cover also provides a confining stress, which allows the overlapped seam to perform properly and enhances the long-term physical integrity of the material. Lastly, the cover may provide a base for vehicular traffic. Because it serves so many functions, proper placement and CQA of the soil/stone cover is essential.

Frequently used cover materials include sand, gravel, crushed stone, and common earth fill. Regardless of the type of material selected for the cover, it should be free of large stones (greater than 50 mm in diameter), sticks, and any other materials, which could cause puncture or tearing. The source of all cover material should be identified in order to ascertain its suitability well in advance of the installation.

In addition to particle size, the *angularity* of a crushed stone or gravel will impact the construction survivability of the GCL. It is preferred that relatively rounded materials be utilized. If these materials are not available, then extra caution must be taken during cover placement. Dumping the cover from a loader bucket positioned high above the GCL is unacceptable. The cover should be gently placed from as low a height as possible. Vehicular traffic should also be restricted if particularly angular or abrasive material is used. If there is some doubt as to the suitability of a potential cover material, a representative sample should be submitted to CETCO for analysis.

With respect to the equipment used to place the protective cover, it is strongly recommended that no heavy equipment come in direct contact with the GCL. Obviously, tracked equipment will damage the liner. In some cases, however it is necessary to drive equipment directly on the GCL. This can be accomplished with low-pressure, *rubber-tired* equipment. Permission to do so will be granted by CETCO through the CQA engineer on a case-by-case basis *only* and will include restrictions on the equipment itself and on the type of movements the vehicle may make on the GCL.

The chemical nature of the cover soil must also be considered. The use of fine-grained, calcareous soil or stone is strongly discouraged due to the potential for an adverse reaction with the sodium bentonite contained in the GCL.

The cover material placed as backfill in the anchor trench should be of the same quality as the rest of the backfill. It is especially important that the anchor trench backfill be compacted either by hand tamping or by the use of a small walk-behind compactor. Compaction should be performed over each 150-mm lift of backfill placed in the anchor trench.

## 5.2 Geosynthetic Cover

A geomembrane or other geosynthetic liner system component is often placed over the GCL. Caution must be used during this activity to prevent GCL damage. Again, it is strongly recommended that no heavy equipment directly contact the GCL, but exceptions can be made on a project-specific basis.

A special precaution should be taken when textured geomembrane is installed directly over the GCL in a composite liner system. Because considerable friction may develop between the geomembrane and the GCL, it is difficult to pull the geomembrane into position for welding to adjacent sheets. A smooth "slip sheet" can be used to provide a low-friction sliding surface for the geomembrane until it is in position for welding.

# SECTION 6
# CONFORMANCE TESTING

Conformance testing is necessary in order to verify that the materials installed meet the requirements set forth in the specification. Although CETCO performs regular testing on its GCLs as part of its manufacturing QA/QC program, the engineer may require additional testing at the job site. This section lists several tests, which may be utilized to verify the quality of the delivered materials and the quality of the installation of those materials.

## 6.1 Bentonite Mass Per Unit Area

A relatively simple test to verify that the specified amount of bentonite has been encapsulated in the GCL is to measure the bentonite mass per unit area of representative samples cut from delivered rolls. The results of this test may be used in conjunction with the results of the bentonite swell test described in Section 6.2 to arrive at an indirect verification of the hydraulic performance of the GCL.

ASTM D 5993 provides procedures for performing the mass per unit area test. After the correction for geotextile mass is made, there should be at least 3,600 g of bentonite contained within the GCL per square meter. This is CETCO's minimum average roll value (MARV) for bentonite content of all of its GCLs. These values are always subject to change, so please refer to GCL Technical Reference No. TR-404 for the most recent list of certified physical GCL properties.

If for any reason the resulting mass per unit area values do not meet the required MARVs, the corresponding rolls should be set-aside for additional inspection and testing. CETCO should be notified to assist in resolving the problem if it persists.

## 6.2 Bentonite Swell Index and Fluid Loss

The swell index and fluid loss of the bentonite are two of the most important indicators of its ability to function as a barrier material. ASTM D 5890 provides a detailed free swell testing procedure used by CETCO. CETCO's MARV requirement for the bentonite is 24 mL/2g. ASTM D5891 provides a detailed fluid loss testing procedure. CETCO's maximum requirement for fluid loss of the bentonite is 18 ml. As with the mass per unit area test described in Section 6.1, if these values are not achieved in conformance testing, the corresponding rolls should be set aside for additional inspection and testing. CETCO should be notified to assist in resolving the problem if it persists.

## 6.3 Other Conformance Tests

Other conformance tests may be conducted at the request of the on-site engineer or the CQA engineer on a project specific basis. ASTM D6495 suggests grab tensile strength and index flux/permeability (as per ASTM D 5887), although it should be cautioned that rapid "real-time" results of index flux/permeability are not possible due to the time required to achieve steady-state permeability values. Thus, it is difficult to use permeability testing as a pass/fail criterion for GCL acceptance at the job site.

Also, the laminated GCLs are not easily tested for index flux/permeability due to potential sidewall leakage around the membrane. CETCO has a special setup procedure for its laminated GCLs in TR-302.

Lastly, it should be recognized that field-scale test pads and infiltrometer tests are typically *not* performed in GCL projects. This contrasts with compacted clay liner (CCL) projects, in which, for two reasons, field-scale data is almost always required. First, field data for CCL projects is necessary because there are many variables involved in their construction (compactor weight, speed, number of passes; soil type; moisture content; lift thickness; etc.). It is therefore necessary to build a test pad to ensure that the construction materials and methods intended for the project will provide the required level of performance. Second, laboratory test results and field test results may vary significantly with CCLs due to the difficulties in retrieving representative, undisturbed samples. This factor also warrants that field data be obtained for CCL projects.

With GCL installations, however, there are very few construction-related variables. Additionally, the GCL that is tested for permeability in the laboratory is the *same* material deployed in the field. For this reason, a GCL such as Bentomat or Claymax does not require a field permeability test.

# SECTION 7
# DOCUMENTATION

Thorough documentation of all CQA activities and tests is necessary in order to provide a written record that the GCL has been properly installed. The CQA documentation package for a GCL installation should include the following items:

- Bills of lading and corresponding packing list confirming receipt of all GCL installed at the site.
- A panel layout drawing in which the GCL roll numbers are keyed to their location in the field. Locations where damage was encountered and repaired should also be marked.
- The roll numbers from which samples were taken for conformance tests, along with the results of those tests.
- A daily report or diary of the activities undertaken at the site during construction.
- Certification that the requirements for the subgrade and for the cover material were achieved.
- A compilation of all CQA checklists completed during the installation.
- The manufacturing quality control (MQC) certification and accompanying test data.
- A description of deviations, if any, made to the original CQA plan during the installation.
- Photographs of the GCL during installation.

CETCO provides the MQC certification. All other items on the above list are the responsibility of the CQA engineer.

# APPENDIX A
## List of Applicable ASTM Standards

**ASTM D 5887, "Standard Test Method for Measurement of the Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter," *Annual Book of ASTM Standards, Vol. 4.09,* American Society for Testing and Materials, W. Conshohocken, PA.**

This method describes the specimen preparation, stress and gradient conditions, and testing procedures to be used for determining the flux (flow per unit area) through GCLs. Adherence to the specimen preparation procedures presented will help to minimize sidewall leakage, a common problem when testing thin barriers. This is an index test designed to determine product acceptability and uses a maximum confining stress of 35 kPa (5 psi) and a hydraulic gradient of 14 kPa (2 psi).

**ASTM D 5888, "Standard Guide for Storage and Handling of Geosynthetic Clay Liners," *Annual Book of ASTM Standards, Vol. 4.09,* American Society for Testing and Materials, W. Conshohocken, PA.**

This is a guide for the safe handling of GCL rolls at a job site, identifying the equipment and techniques typically employed to unload the material from delivery trucks and to place it in a dedicated storage area. Procedures are also presented for proper storage of the GCL in order to minimize the potential for product damage while in storage.

**ASTM D 5889, "Standard Practice for Quality Control of Geosynthetic Clay Liners," *Annual Book of ASTM Standards, Vol. 4.09,* American Society for Testing and Materials, W. Conshohocken, PA.**

Test methods and testing frequencies are presented for manufacturing quality control (MQC) of GCLs. This standard practice includes conformance tests to be performed on the GCL components (bentonite and geotextiles and/or geomembranes) as well as tests to be performed on the finished GCL product. Special procedures for GCL permeability/flux testing require the manufacturer to provide an historical database to demonstrate the consistency of the hydraulic performance of the finished product and to justify the reduced need for frequent MQA permeability testing.

**ASTM D 5890, "Standard Test Method for Swell Index Measurement of Clay Mineral Component of Geosynthetic Clay Liners," *Annual Book of ASTM Standards, Vol. 4.09,* American Society for Testing and Materials, W. Conshohocken, PA.**

This test method was adapted from the basic elements of a swell test presented in the USP/NF (United States Pharmacopeia/National Formulary). Two grams of dried and powdered bentonite are slowly dropped into a graduate cylinder containing 100 mL of distilled water. The swell value in mL is recorded after 24 hours, by reading the value on the graduate cylinder at the clay/water interface.

## APPENDIX A (continued)
## List of Applicable ASTM Standards

**ASTM D 5891, "Standard Test Method for Measurement of Fluid Loss of Clay Mineral Component of Geosynthetic Clay Liners."**

This test method was adapted from the API (American Petroleum Institute) Procedure 13A/13B for bentonite. A bentonite slurry is created, aged, and then filtered in a pressurized cell. The amount of water passing through the filter cake in a specified time interval is recorded as the filtrate loss or fluid loss. The test indicates the clay's general ability to function as a barrier to liquids.

**ASTM D 5993, "Standard Test Method for Measuring the Mass per Unit Area of Geosynthetic Clay Liners."**

This test method describes how to measure the bentonite mass per unit area of a GCL sample. A GCL specimen of a certain minimum area is weighed, oven-dried, and weighed again. The dry weight of the specimen, minus the nominal weight of the geosynthetic component(s), is then divided by the area of the specimen. The moisture content of the specimen is determined by subtracting the dry weight from the wet weight.

**ASTM D 6072, "Standard Guide for Obtaining Samples of Geosynthetic Clay Liners."**

Presents procedures for obtaining representative samples of GCL material for laboratory testing purposes. These samples may be obtained either at the factory or in the field. Procedures for packaging and protecting the sample are also included to prevent the possibility of damage in transit to the laboratory.

**ASTM D 6102, "Standard Guide for Installation of Geosynthetic Clay Liners."**

Provides detailed recommendations for the proper installation of GCLs. Discusses the necessary site conditions, equipment, and techniques for installing GCLs without damaging them. Includes recommendations on panel placement, overlaps, and special considerations for slopes. Also discusses the preferred types of soil cover and equipment used to apply this cover.

**ASTM D 6243, "Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method."**

This test method covers a procedure for determining the internal shear resistance of a GCL or the interface shear resistance between the GCL and an adjacent material under a constant rate of displacement or constant stress.

**ASTM D 6496, "Standard Test Method for Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners."**

This test method was adapted from ASTM D 4632 for grab strength testing of geotextiles. The method covers the laboratory determination of the average bonding strength between the top and bottom layers of a sample of a GCL. These results provide an indication of a GCL's internal reinforcement and internal shear strength.

## APPENDIX A (continued)
## List of Applicable ASTM Standards

**ASTM D 6768, "Standard Test Method for Tensile Strength of Geosynthetic Clay Liners."**

This test method was adapted from ASTM D 4632 for grab strength testing of geotextiles. The test method establishes the procedures for the measurement of tensile strength of a GCL. This test method is strictly an index test method to be used to verify the tensile strength of GCLs. Results from this test method should not be considered as an indication of actual or long-term performance of the geosynthetic in field applications.

**ASTM D 6495, "Standard Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners".**

Provides guidelines for acceptance testing requirements for GCLs, including test methods and verifications.

# APPENDIX B

## CETCO GCL Construction Quality Assurance Checklist

Project Name/Number:_______________________________________________

CQA Inspector:___________________________________________________

Date:___________________Weather:_______________________________

### STORAGE AREA

- _______ Rolls covered/tarped
- _______ Rolls labeled
- _______ No standing water present
- _______ Packaging intact/repaired
- _______ Accessory bentonite protected

### MATERIALS RECEIVED TODAY

- _______ Packaging intact
- _______ Rolls inspected for damage-- none found
- _______ Damage suspected (indicate roll numbers and nature of damage ___________________________

___________________________

___________________________

### SITE INSPECTION

- _______ Subgrade surface acceptable
- _______ Installation area dry
- _______ Anchor trenches acceptable
- _______ Design grades achieved
- _______ Cover soil acceptable (as applicable)

### INSTALLATION

- _______ Number of rolls deployed today (attach list of roll numbers)
- _______ Anchor trench fill compacted
- _______ Min. seam overlap achieved
- _______ All seams visually inspected
- _______ Seam bentonite added (as applicable)
- _______ All detail work inspected
- _______ Downslope panel orientation
- _______ All mat covered at end of day
- _______ Storage area maintained

### INSTALLATION EQUIPMENT

- _______ Core pipe straight
- _______ Spreader bar straight
- _______ Chains/Straps inspected
- _______ Knife blades replaced
- _______ Seaming clay supply available

### CONFORMANCE TESTING

***Bentonite Mass/Area:***

| Bentomat Roll No. | Bentonite (g/sm) | Pass/ Fail? |
|---|---|---|
| | | |
| | | |
| | | |

***Bentonite Swell:***

| Bentomat Roll No. | Final Swell Value (mL/2g) | Pass/ Fail? |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

### NOTES/OBSERVATIONS

_______________________________________________

_______________________________________________

_______________________________________________

NOTE:

This checklist is intended to serve as a *guideline* for the CQA engineer to use in the development of a project-specific or company-specific CQA plan. The checklist is not all-inclusive. The items presented in this list are those that CETCO feels are the most important for the proper installation of Bentomat.

LINING TECHNOLOGIES | REMEDIATION TECHNOLOGIES | DRILLING SYSTEMS | BUILDING ENVELOPE | CONTRACTING SERVICES

# BENTOMAT® INSTALLATION GUIDELINES

## GEOSYNTHETIC CLAY LINERS

CETCO®

# BENTOMAT®

## GEOSYNTHETIC CLAY LINERS

## CONTENTS

***NOTICE: THIS DOCUMENT IS INTENDED FOR USE AS A GENERAL GUIDELINE FOR THE INSTALLATION OF CETCO GCLS. THE INFORMATION AND DATA CONTAINED HEREIN ARE BELIEVED TO BE ACCURATE AND RELIABLE. CETCO MAKES NO WARRANTY OF ANY KIND AND ACCEPTS NO RESPONSIBILITY FOR THE RESULTS OBTAINED THROUGH APPLICATION OF THIS INFORMATION. INSTALLATION GUIDELINES ARE SUBJECT TO PERIODIC CHANGES. PLEASE CONSULT OUR WEBSITE @ WWW.CETCO.COM/LT FOR THE MOST RECENT VERSION.***

# SECTION 1

# INTRODUCTION

## 1.1

This document provides procedures for the installation of CETCO GCLs in a manner that maximizes safety, efficiency, and the physical integrity of the GCL.

## 1.2

These guidelines are based upon many years of experience at a variety of sites and should be generally applicable to any type of lining project using CETCO GCLs. Variance from these guidelines is at the engineer's discretion.

## 1.3

The performance of the GCL is wholly dependent on the quality of its installation. It is the installer's responsibility to adhere to these guidelines, and to the project specifications and drawings as closely as possible. It is the engineer's and owner's responsibility to provide construction quality assurance (CQA) for the installation. This will ensure that the installation has been executed properly. This document covers only installation procedures.

## 1.4

For additional guidance, refer to ASTM D5888 (Standard Guide For Storage and Handling of Geosynthetic Clay Liners) and ASTM D 6102 (Standard Guide For Installation of Geosynthetic Clay Liners).

# SECTION 2

# EQUIPMENT REQUIREMENTS

## 2.1

CETCO GCLs are delivered in rolls typically 2,600-2,950 lbs (1180-1340 kg). Roll dimensions and weights will vary with the dimensions of the product ordered. It is necessary to support this weight using an appropriate core pipe, as indicated in Table 1. For any installation, the core pipe must not deflect more than 3 inches (75 mm), as measured from end to midpoint when a full GCL roll is lifted.

## 2.2

Lifting chains or straps appropriately rated should be used in combination with a spreader bar made from an I-beam, as shown in Figure 1.

## 2.3

The spreader bar ensures that lifting chains or straps do not chafe against the ends of the GCL roll, allowing it to rotate freely during installation. Spreader bar and core pipe kits are available through CETCO.

## 2.4

A front end loader, backhoe, dozer, or other equipment can be utilized with the spreader bar and core pipe or slings. Alternatively, a forklift with a "stinger" attachment may be used for on-site handling. A forklift without a stinger attachment should not be used to lift or handle the GCL rolls. Stinger attachments (Figures 2-4) are specially fabricated to fit various forklift makes and models.

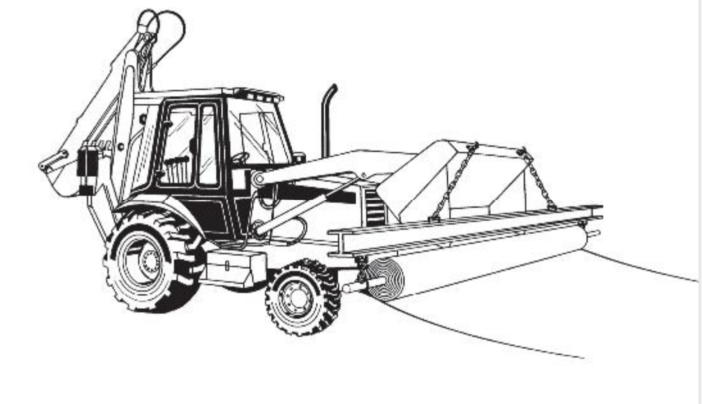
**Table 1: Core Requirements**

| Product | Nominal GCL Roll Size Lenth X Diameter | Typical GCL Roll Weight | Interior Core Size | Core Pipe Length x Diameter | Minimum Core Pipe Strength |
|---|---|---|---|---|---|
| BENTOMAT DN, SDN | 16' x 24" (4.9 m x 610 mm) | 2,650 lbs. (1204 kg) | 3 3/4“ (100 mm) | 20' x 3.5" O.D. (6.1 m x 89 mm) | XXH |
| BENTOMAT ST | 16' x 24" (4.9 m x 610 mm) | 2,650 lbs. (1204 kg) | 3 3/4“ (100 mm) | 20' x 3.5" O.D. (6.1 m x 89 mm) | XXH |
| BENTOMAT STM | 16' x 32" (4.9 m x 814 mm) | 2,500 lbs. (1130 kg) | 3 3/4“ (100 mm) | 20' x 3.5" O.D. (6.1 m x 89 mm) | XXH |
| BENTOMAT 200R | 16' x 24" (4.9 m x 610 mm) | 2,650 lbs. (1204 kg) | 3 3/4“ (100 mm) | 20' x 3.5" O.D. (6.1 m x 89 mm) | XXH |
| BENTOMAT CLT | 16' x 26" (4.9 m x 660 mm) | 2,650 lbs. (1204 kg) | 3 3/4“ (100 mm) | 20' x 3.5" O.D. (6.1 m x 89 mm) | XXH |
| BENTOMAT CL | 16' x 25" (4.9 m x 635 mm) | 2,650 lbs. (1204 kg) | 3 3/4“ (100 mm) | 20' x 3.5" O.D. (6.1 m x 89 mm) | XXH |
| BENTOMAT 600 CL | 16' x 25" (4.9 m x 635 mm) | 2,700 lbs. (1227 kg) | 3 3/4“ (100 mm) | 20' x 3.5" O.D. (6.1 m x 89 mm) | XXH |

# BENTOMAT®

## GEOSYNTHETIC CLAY LINERS

FIGURE 1 -SPREADER BAR ASSEMBLY



## 2.5

When installing over certain geosynthetic materials, a 4 wheel, all-terrain vehicle (ATV) can be used to deploy the GCL. An ATV can be driven directly on the GCL provided that no sudden stops, starts, or turns are made.

## 2.6

Additional equipment needed for installation of CETCO GCLs includes:

- ► Utility knife and spare blades (for cutting the GCL)
- ► Granular bentonite for end-of-roll GCL seams and for sealing around structures and details
- ► Waterproof tarpaulins (for temporary cover on installed material as well as for stockpiled rolls)
- ► Optional flat-bladed vise grips (for positioning the GCL panel by hand)

## 2.7

The CETCO EASY ROLLER™ GCL Deployment System is a preferred method of installing geosynthetic clay liners. Use of the EASY ROLLER system eliminates the need for spreader bars and heavy core pipes. Installation speed and worker safety are also significantly increased. For further details, contact CETCO.

FIGURE 2 - HOOK MOUNT

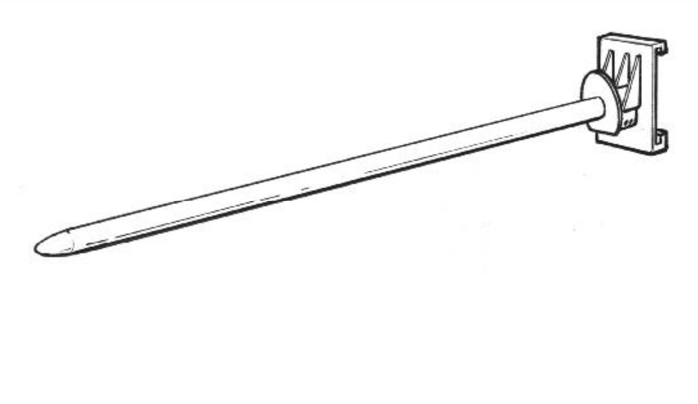


FIGURE 3 - FORK MOUNT (WITH FORK POCKETS)

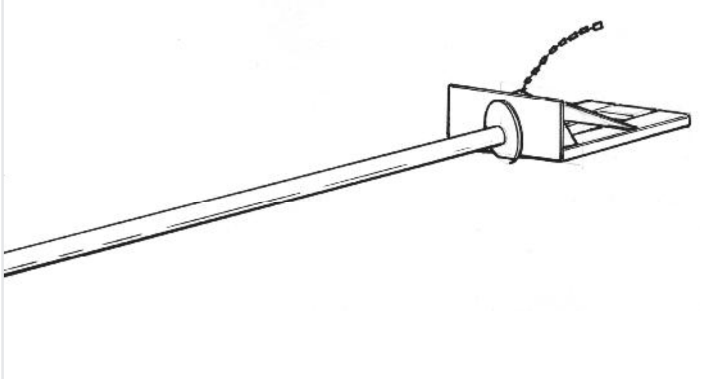
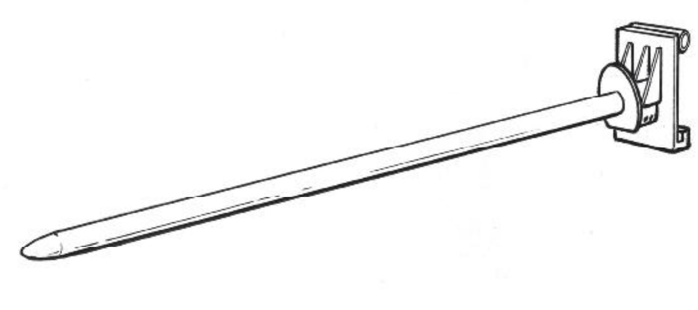


FIGURE 4 - PIN MOUNT



# SECTION 3
# SHIPPING, UNLOADING, & STORAGE

### 3.1
All lot and roll numbers should be recorded and compared to the packing list. Each roll of GCL should also be visually inspected during unloading to determine if any packaging has been damaged. Damage, whether obvious or suspected, should be recorded and the affected rolls marked.

### 3.2
Major damage suspected to have occurred during transit should be reported to the carrier and to CETCO immediately. The nature of the damage should also be indicated on the bill of lading, with specific lot and roll numbers noted. Accumulation of some moisture within roll packaging is normal and does not damage the product.

### 3.3
The party directly responsible for unloading the GCL should refer to this manual prior to shipment to ascertain the appropriateness of their unloading equipment and procedures. Unloading and on-site handling of the GCL should be supervised.

### 3.4
In most cases, CETCO GCLs are delivered on flatbed trucks. There are three methods of unloading: core pipe and spreader bar, slings, or stinger bar. To unload the rolls from the flat-bed using a core pipe and spreader bar, first insert the core pipe through the core tube. Secure the lifting chains or straps to each end of the core pipe and to the spreader bar mounted on the lifting equipment. Hoist the roll straight up and make sure its weight is evenly distributed so that it does not tilt or sway when lifted.

### 3.5
All CETCO GCLs are delivered with two 2’x 12’ (50 mm x 3.65 mm) Type V polyester endless slings on each roll. Before lifting, check the position of the slings. Each sling should be tied off in the choke position, approximately one third (1/3) from the end of the roll. Hoist the roll straight up so that it does not tilt or sway when lifted.

### 3.6
In some cases, GCL rolls will be stacked in three pyramids on flatbed trucks. If slings are not used, rolls will require unloading with a stinger bar and extendible boom fork lift. Spreader bars will not work in this situation because of the limited access between the stacks of GCL. Three types of stingers are available from CETCO, a hook mount, fork mount and pin mount (Figures 2-4). To unload, guide the stinger through the core tube before lifting the GCL roll and removing the truck.

### 3.7
An extendable boom fork lift with a stinger bar is required for unloading vans. Rolls in the nose and center of the van should first be carefully pulled toward the door using the slings provided on the rolls.

### 3.8
Rolls should be stored at the job site away from high-traffic areas but sufficiently close to the active work area to minimize handling. The designated storage area should be flat, dry, and stable. Moisture protection of the GCL is provided by its packaging; however, based on expected weather conditions, an additional tarpaulin or plastic sheet may be required for added protection during prolonged outdoor storage.

### 3.9
Rolls should be stacked in a manner that prevents them from sliding or rolling. This can be accomplished by chocking the bottom layer of rolls. Rolls should be stacked no higher than the height at which they can be safely handled by laborers (typically no higher than four layers of rolls). Rolls should never be stacked on end.

# SECTION 4
# SUBGRADE PREPARATION

### 4.1
Subgrade surfaces consisting of granular soils or gravels are not acceptable due to their large void fraction and puncture potential. In applications where the GCL is the only barrier, subgrade soils should have a particle-size distribution of at least 80 percent finer than the #60 sieve (0.25 mm). In other applications, subgrade soils should range between fines and 1 inch (25 mm). In high-head applications (greater than 1 foot or 30.48 cm), CETCO recommends a membrane-laminated GCL (BENTOMAT CLT, BENTOMAT CL, or BENTOMAT 600 CL).

### 4.2
When the GCL is placed over an earthen subgrade, the subgrade surface must be prepared in accordance with the project specifications. The engineer’s approval of the subgrade must be obtained prior to installation. The finished surface should be firm and unyielding, without abrupt elevation changes, voids, cracks, ice, or standing water.

# BENTOMAT®

## GEOSYNTHETIC CLAY LINERS

### 4.3

The subgrade surface must be smooth and free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign matter that could contact the GCL. The subgrade should be rolled with a smooth-drum compactor to remove any wheel ruts greater than 1 inch in depth, footprints, or other abrupt grade changes. Furthermore, all protrusions extending more than 0.5 inch (12 mm) from the subgrade surface shall be removed, crushed, or pushed into the surface with a smooth-drum compactor. The GCL may be installed on a frozen subgrade, but the subgrade soil in the unfrozen state should meet the above requirements.

## SECTION 5
## INSTALLATION

### 5.1

GCL rolls should be taken to the work area of the site in their original packaging. The orientation of the GCL (i.e., which side faces up) may be important if the GCL has two different types of geosynthetics. Check with the project engineer to determine if there is a preferred installation orientation for the GCL. If no specific orientation is required, allow the roll to unwind from the bottom rather than pulling from the top (Figure 5A). The arrow sticker on the plastic sleeve indicates the direction that the GCL will naturally unroll when placed on the ground (Figure 6). Prior to deployment, the packaging should be carefully removed without damaging the GCL.

### 5.2

Equipment which could damage the GCL should not be allowed to travel directly on it. Therefore, acceptable installation may be accomplished whereby the GCL is unrolled in front of backwards-moving equipment (Figure 7). If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.

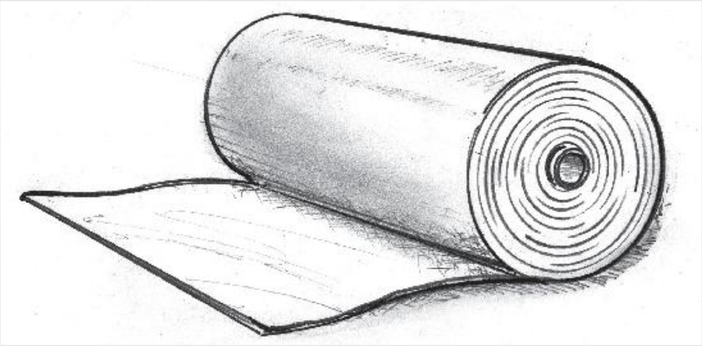
### 5.3

If sufficient access is available, GCL may be deployed by suspending the roll at the top of the slope, with a group of laborers pulling the material off of the roll, and down the slope (Figure 8).

### 5.4

GCL rolls should not be released on the slope and allowed to unroll freely by gravity.

FIGURE 5 A & B
“NATURAL’ ORIENTATION (5A)



TOP OF THE ROLL (5B)

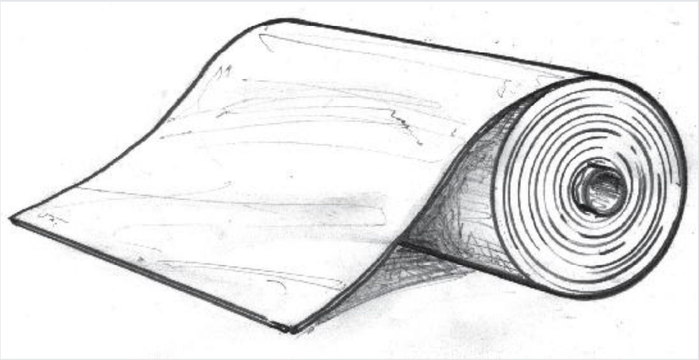


FIGURE 6 - DIRECTION TO UNROLL GCL ON GROUND PER FIGURE 5A

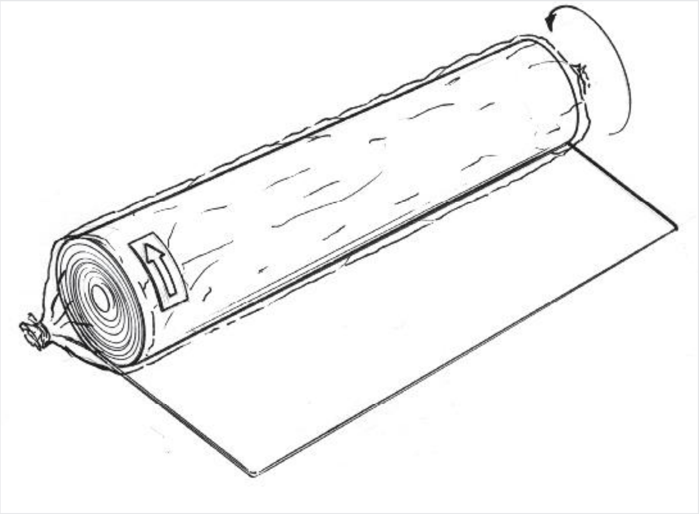


FIGURE 7 - TYPICAL BENTOMAT® INSTALLATION TECHNIQUE

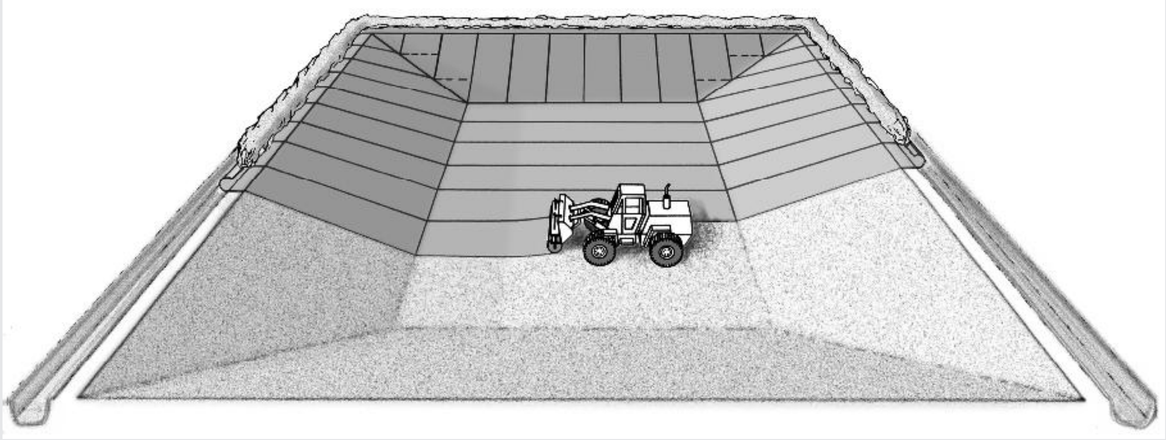
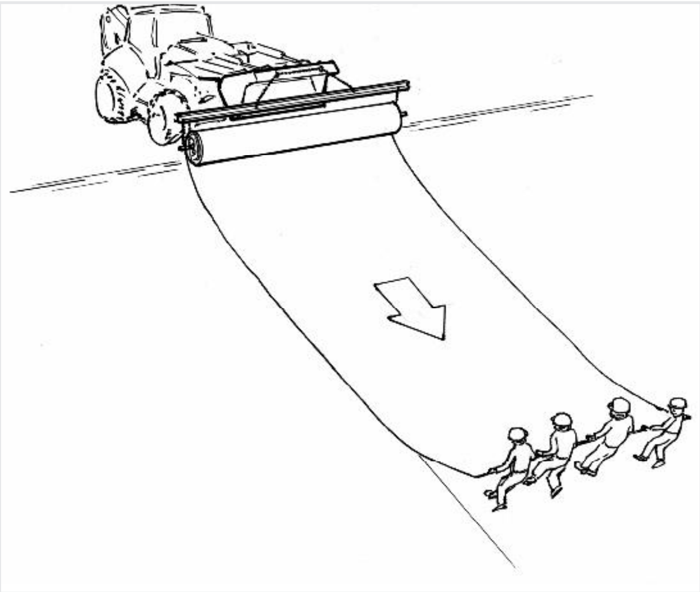


FIGURE 8 - UNROLLING BENTOMAT



## 5.5

Care must be taken to minimize the extent to which the GCL is dragged across the subgrade to avoid damage to the bottom surface of the GCL. Care must also be taken when adjusting BENTOMAT CLT panels to avoid damage to the geotextile surface of one panel of GCL by the textured sheet of another panel of GCL. A temporary geosynthetic subgrade cover commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement.

## 5.6

The GCL should be placed so that seams are parallel to the direction of the slope. End-of-panel seams should also be located at least 3 ft (1 m) from the toe and crest of slopes steeper than 4H:1V. End-of-roll seams on slopes should be used only if the liner is <u>not</u> expected to be in tension.

## 5.7

All GCL panels should lie flat, with no wrinkles or folds, especially at the exposed edges of the panels. When BENTOMAT geosynthetic clay liners with SUPERGROOVE® is repositioned, it should be gripped inside the SUPERGROOVE by folding the edge.

## 5.8

The GCL should not be installed in standing water or during rainy weather. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material. CETCO recommends that premature hydration be evaluated on a case-by-case basis. The project engineer, CQA inspector, and CETCO TR-312 should be consulted for specific guidance if premature hydration occurs. The type of GCL, duration of exposure, degree of hydration, location in the liner system, and expected bearing loads should all be considered.

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## GEOSYNTHETIC CLAY LINERS

In many instances, a needlepunch reinforced GCL may not require removal/replacement if the following are true:

- ► The geotextiles have not been separated, torn, or otherwise damaged
- ► There is no evidence that the needlepunching between the two geotextiles has been compromised
- ► The GCL does not leave deep indentations when stepped upon
- ► Overlapped seams with bentonite enhancement (see Section 7) are intact

### 5.9

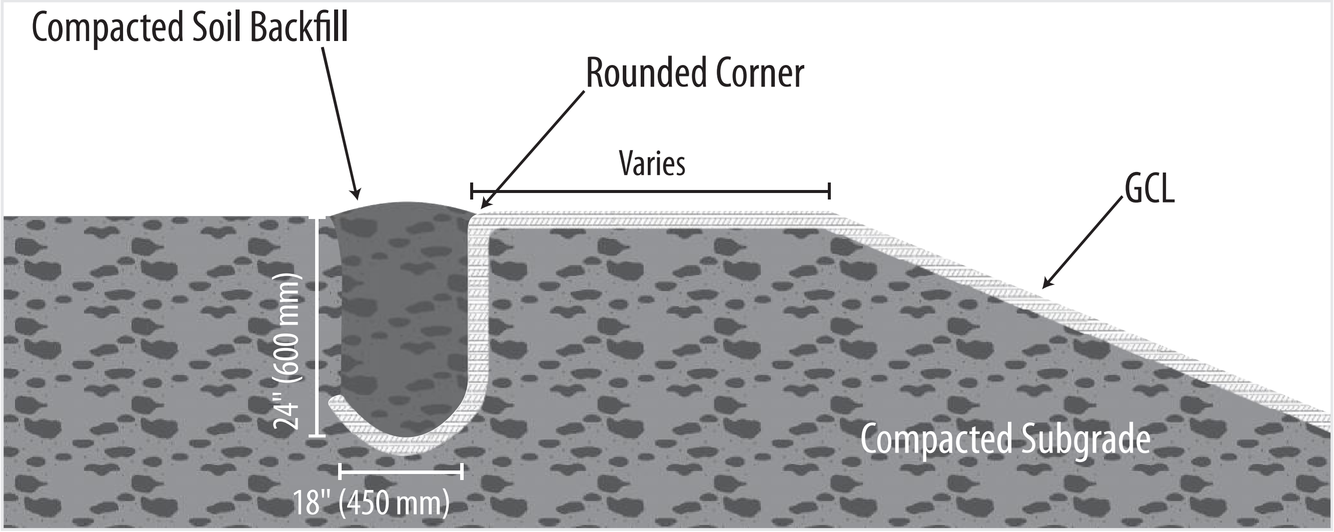
For the convenience of the installer, hash marks are placed on BENTOMAT goesynthetic clay liners every 5' (1.5 m) of length.

## SECTION 6
## ANCHORAGE

### 6.1

If required by the project drawings, the end of the GCL roll should be placed in an anchor trench at the top of a slope. The front edge of the trench should be rounded to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed or compacted into the floor of the trench.

FIGURE 9 - TYPICAL ANCHOR TRENCH DESIGN



### 6.2

If a trench is used for anchoring the end of the GCL, soil backfill should be placed in the trench to provide resistance against pullout. The size and shape of the trench, as well as the appropriate backfill procedures should be in accordance with the project drawings and specifications. Typical dimensions are shown in Figure 9.

### 6.3

The GCL should be placed in the anchor trench such that it covers the entire trench floor but does not extend up the rear trench wall.

### 6.4

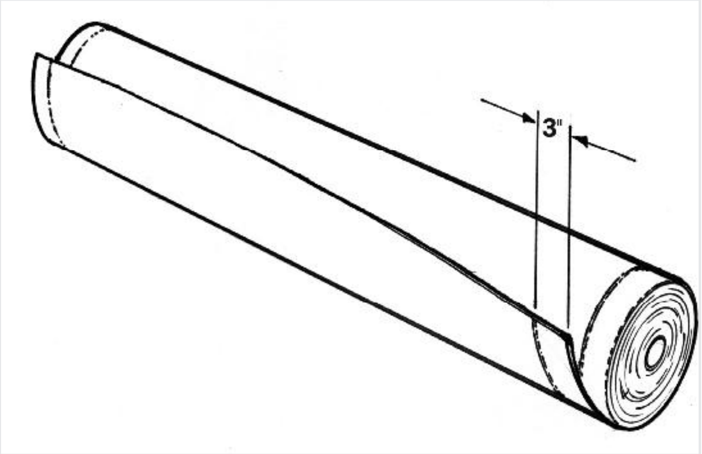
Sufficient anchorage may alternately be obtained by extending the end of the GCL roll back from the crest of the slope, and placing cover soil. The length of this "runout" anchor should be prepared in accordance with project drawings and specifications.

## SECTION 7
## SEAMING

### 7.1

GCL seams are constructed by overlapping adjacent panel edges and ends. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. BENTOMAT 200R, BENTOMAT ST, BENTOMAT DN, and BENTOMAT SDN have SUPERGROOVE® which provides self-seaming capabilities in their longitudinal overlaps, and therefore do not require supplemental bentonite. However, for pond applications, supplemental bentonite must be used in longitudinal seams, regardless of the CETCO GCL.

**FIGURE 10 - SUPERGROOVE®**



### 7.2

Longitudinal seams should be overlapped a minimum of 6 inches (150 mm) for BENTOMAT geosynthetic clay liners. For high-head applications (greater than 1 foot or 20.48 cm) involving BENTOMAT CL, BENTOMAT CLT, or BENTOMAT 600 CL, a minimum longitudinal seam overlap of 12 inches (300 mm) and supplemental bentonite (per Section 7.6) is recommended.

### 7.3

End-of-panel overlapped seams should be overlapped 24 inches (600 mm) for BENTOMAT geosynthetic clay liners.

### 7.4

End-of-panel overlapped seams are constructed such that they are shingled in the direction of the grade to prevent runoff from entering the overlap zone. End-of-panel seams on slopes are permissible, provided adequate slope stability analysis has been conducted (i.e., the GCL is not expected to be in tension). Bentonite-enhanced seams are required for all BENTOMAT end-of-panel overlapped seams.

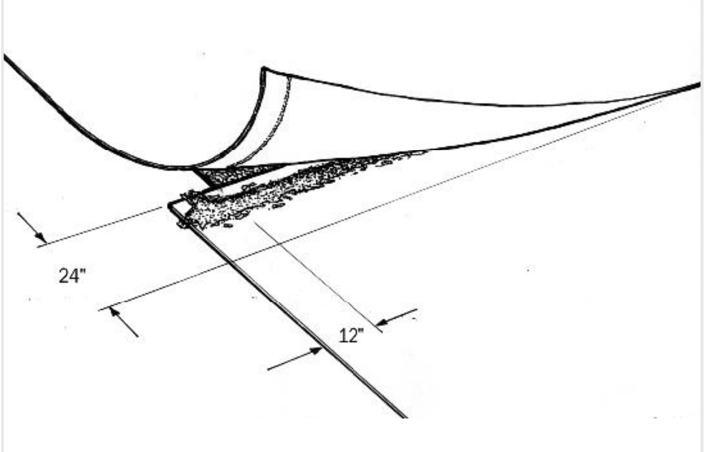
### 7.5

BENTOMAT end-of-panel, bentonite-enhanced, overlapped seams are constructed first by overlapping the adjacent panels, exposing the underlying panel, and then applying a continuous bead or fillet of granular sodium bentonite 12" from the edge of the underlying panel (Figure 11). The minimum application rate at which the bentonite is applied is one-quarter pound per linear foot (0.4 kg/m).

### 7.6

If longitudinal bentonite enhanced seams are required for BENTOMAT 200R, BENTOMAT ST, BENTOMAT DN, or BENTOMAT SDN, they are constructed by overlapping the adjacent panels a minimum 6 inches (150 mm), exposing the underlying edge, and applying a continuous bead of granular bentonite approximately 3 inches (75 mm) from the edge. For pond applications involving BENTOMAT CL or BENTOMAT CLT, longitudinal seams are constructed by overlapping adjacent panels by 12 inches (300 mm), exposing the underlying edge, and applying a continuous bead of bentonite approximately 6 inches (150 mm) from the edge. The minimum application rate for the granular bentonite is one quarter pound per linear foot (0.4 kg/m).

**FIGURE 11**
**BENTOMAT END-OF-PANEL OVERLAPPED SEAM**



## SECTION 8
## SEALING AROUND PENETRATIONS AND STRUCTURES

### 8.1

Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid irregular tearing of the geotextile components of the GCL during the cutting process.

### 8.2

The GCL should be sealed around penetrations and structures embedded in the subgrade in accordance with Figures 12 through 14. Granular bentonite shall be used liberally (approximately 0.25 lbs/ln. ft. or 0.4 kg/m) to seal the GCL to these structures.

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## GEOSYNTHETIC CLAY LINERS

FIGURE 12 A CROSS-SECTION OF A HORIZONTAL PIPE PENETRATION

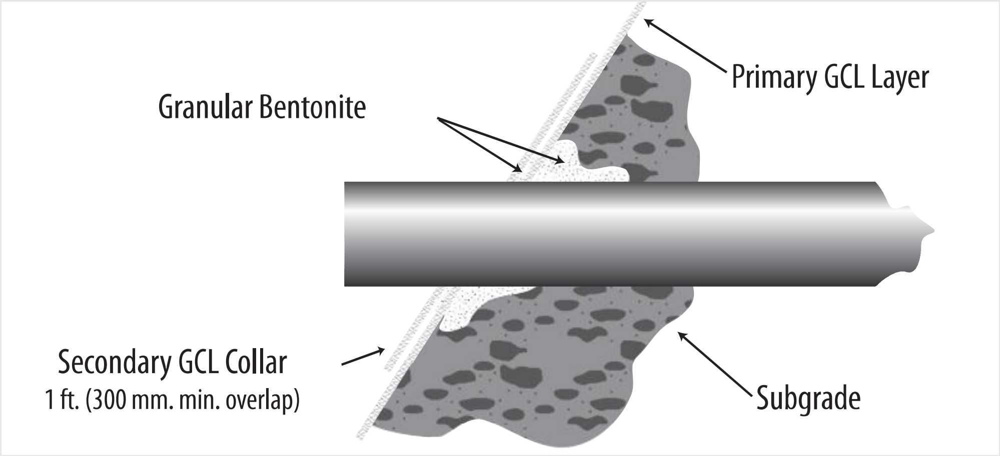


FIGURE 12 B ISOMETRIC VIEW OF A COMPLETED HORIZONTAL PIPE PENETRATION

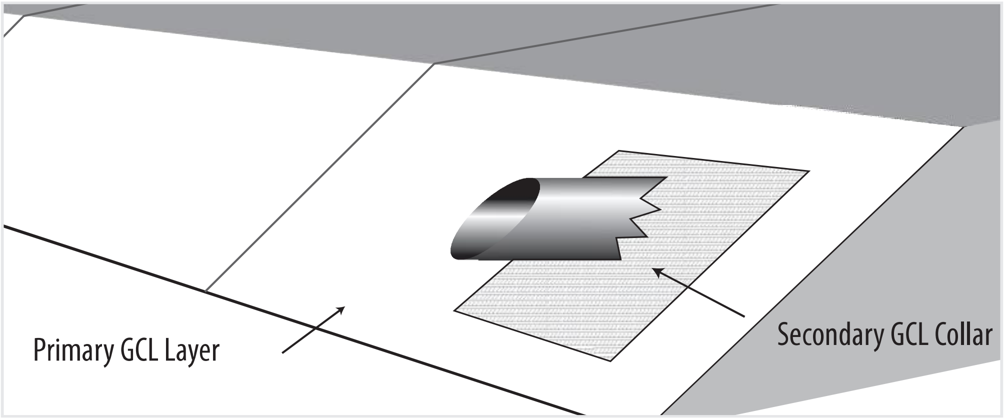


FIGURE 13 A CROSS-SECTION OF A VERTICAL PENETRATION

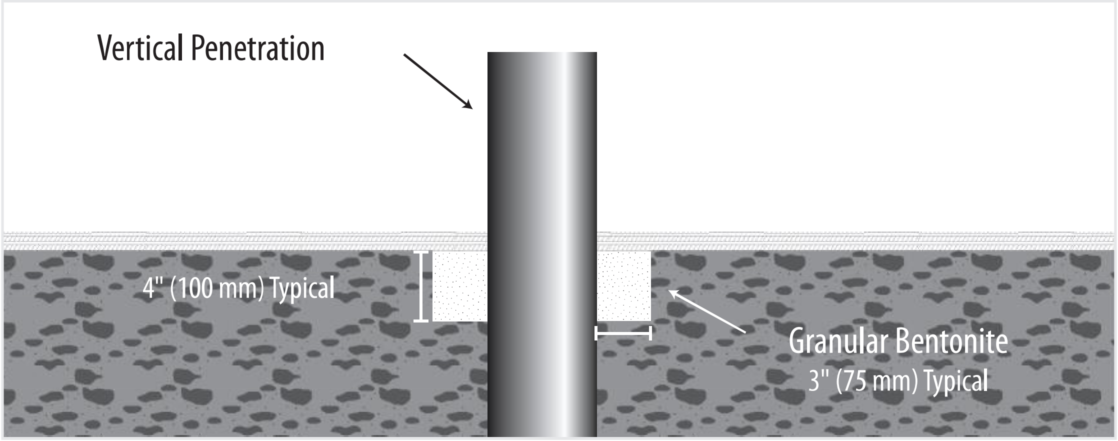


FIGURE 13B ISOMETRIC VIEW OF THE COMPLETED VERTICAL PENETRATION

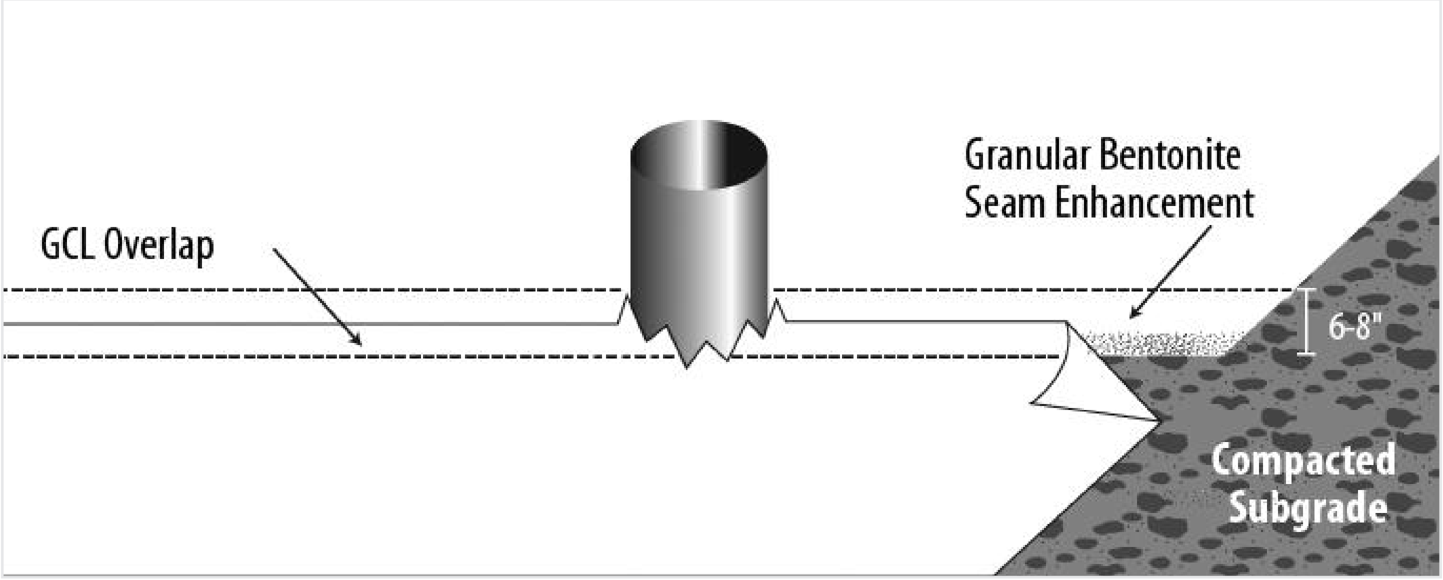
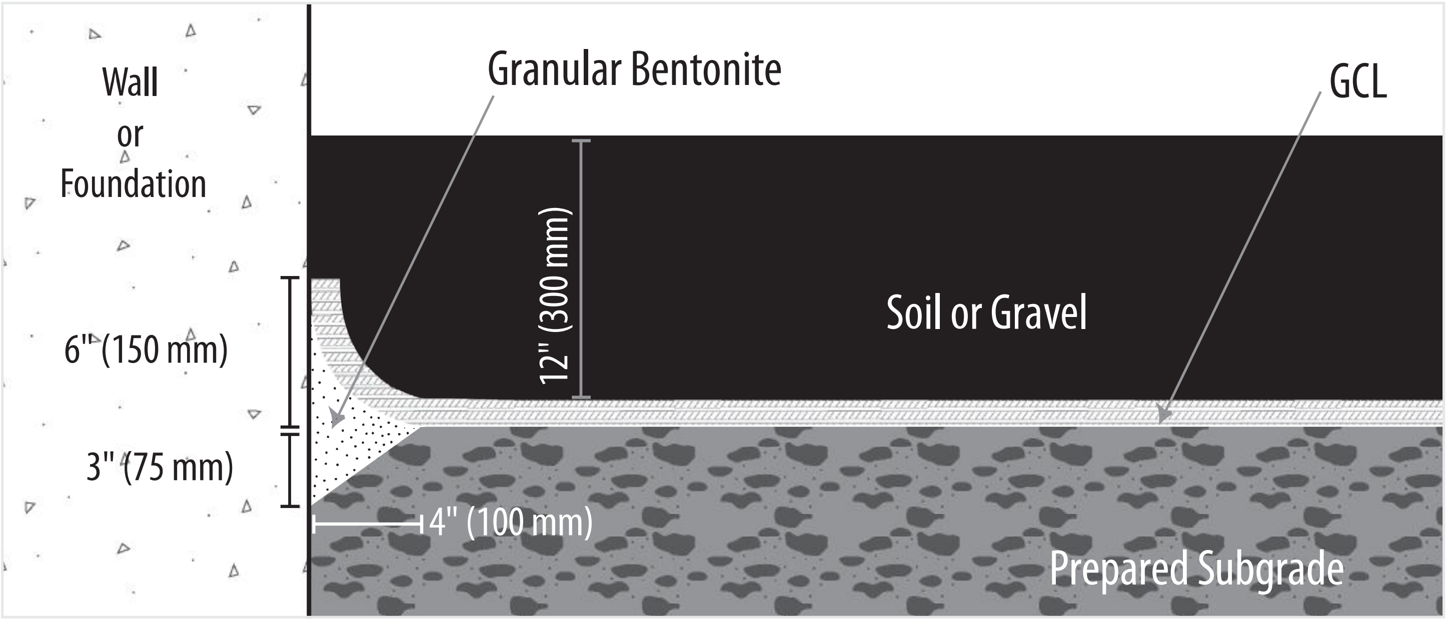


FIGURE 14 CROSS-SECTION OF GCL SEAL AGAINST AN EMBEDDED STRUCTURE OR WALL



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## GEOSYNTHETIC CLAY LINERS

### 8.3

When the GCL is placed over a horizontal pipe penetration, a "notch" should be excavated into the subgrade around the penetration (Figure 12a). The notch should then be backfilled with granular bentonite. A secondary collar of GCL should be placed around the penetration, as shown in Figure 12b. It is helpful to first trace an outline of the penetration on the GCL and then cut a "star" pattern in the collar to enhance the collar's fit to the penetration. Granular bentonite should be applied between the primary GCL layer and the secondary GCL collar.

### 8.4

Vertical penetrations are prepared by notching into the subgrade as shown in Figure 13a. The penetration can be completed with two separate pieces of GCL as shown in Figure 13b. Alternatively, a secondary collar can be placed as shown in Figure 12a or 12b.

### 8.5

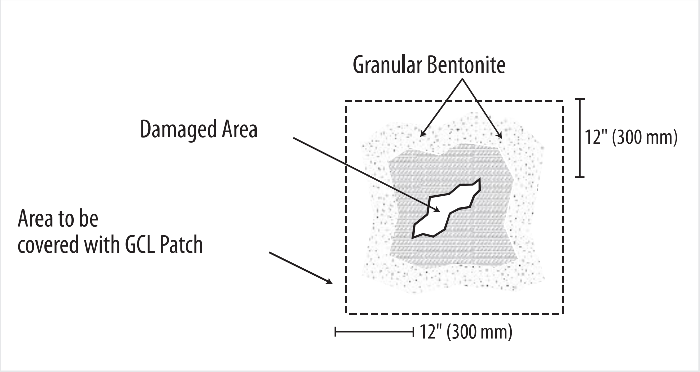
When the GCL is terminated at a structure or wall that is embedded into the subgrade on the floor of the containment area, the subgrade should be notched, as described in Sections 8.3 and 8.4. The notch is filled with granular bentonite; the GCL should be placed over the notch and up against the structure (Figure 14). Connection to the structure can be accomplished by placement of soil or stone backfill in this area. When structures or walls are at the top of a slope, additional detailing may be required. Contact CETCO for specific guidance.

## SECTION 9
## DAMAGE REPAIR

### 9.1

If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area (Figure 15). The patch should be cut to size such that a minimum overlap of 12 inches (300 mm) is achieved around all parts of the damaged area. Granular bentonite should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue to affix the patch in place so that it is not displaced during cover placement. Smaller patches may be tucked under the damaged area to prevent patch movement.

FIGURE 15 DAMAGE REPAIR BY PATCHING



## SECTION 10
## COVER PLACEMENT

### 10.1

The final thickness of soil cover on the GCL varies with the application. A minimum cover layer must be at least 1 foot (300 mm) thick to provide confining stress to the GCL, eliminate the potential for seam separation and prevent damage by equipment, erosion, etc.

### 10.2

Cover soils should be free of angular stones or other foreign matter that could damage the GCL. Cover soils should be approved by the engineer with respect to particle size, uniformity, and chemical compatibility. Consult CETCO if cover soils have high concentrations of calcium (e.g. limestone, dolomite, gypsum, seashell fragments).

### 10.3

Recommended cover soils should have a particle size distribution ranging between fines and 1 inch (25 mm), unless a cushioning geotextile is specified.

### 10.4

Soil cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 1 foot (300 mm) of cover soil should be maintained between the equipment tires/tracks and the GCL at all times during the covering process. In high-traffic areas such as on roadways, a minimum thickness of 2 feet (600 mm) is required.

### 10.5

Soil cover should be placed in a manner that prevents the soil from entering the GCL overlap zones. Soil cover should be pushed up on slopes, not down slopes, to minimize tensile forces on the GCL.

### 10.6

When a textured geomembrane is installed over the GCL, a temporary geosynthetic covering known as a slip sheet or rub sheet should be used to minimize friction during placement and to allow the textured geomembranes to be more easily moved into its final position.

### 10.7

Cyclical wetting and drying of GCL covered only with geomembrane can cause overlap separation. Soil cover should be placed promptly whenever possible. Geomembranes should be covered with a white geotextile and/or operations layer without delay to minimize the intensity of wet-dry cycling. If there is the potential for unconfined cyclic wetting and drying over an extended period of time, the longitudinal seam overlaps should be increased based on the project engineer's recommendation.

### 10.8

To avoid seam separation, the GCL should not be put in excessive tension by the weight or movement of textured geomembrane on steep slopes. If there is the potential for unconfined geomembrane expansion and contraction over an extended period of time, the longitudinal seam overlaps should be increased based upon the project engineer's recommendation.

## SECTION 11
## HYDRATION

### 11.1

Hydration is usually accomplished by natural rainfall and/or absorption of moisture from soil. However, in cases where the containment of non-aqueous liquid is required, it may be necessary to hydrate the covered GCL with water prior to use.

### 11.2

If manual hydration is necessary, water can be introduced by flooding the covered lined area or using a sprinkler system. If flooding, care must be taken to diffuse the energy of the water discharge so that the cover material is not displaced.

### 11.3

If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material.

As discussed in Section 5.8, in many instances a needlepunch reinforced GCL may not require removal/replacement if the following are true:

- ► The geotextiles have not been separated, torn or otherwise damaged
- ► There is no evidence that the needlepunching between the two geotextiles has been compromised
- ► The GCL does not leave deep indentations when stepped upon
- ► Any overlapped seams with bentonite enhancement (see Section 7) are intact

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