Appendix D
Final Cover Geotextile Design Calculations

TASK

Design the proposed nonwoven cushion geotextile above the 40 mil LLDPE cap in the proposed final cover system at West Hawaii Sanitary Landfill (WHSL) for burst resistance, tensile strength, and puncture resistance.

REFERENCES

1. Koerner, Robert M. Designing with Geosynthetics. Prentice Hall: New Jersey. 4th ed. 1997.
2. Giroud, J.P. (1984) "Designing with Geotextiles", Mater. Const. (Paris), Vol. 14, No. 82, pp. 257-272; *and Geotextiles and Geomembranes, Definitions, Properties and Designs*, IFAI Publ., St. Paul, MN, 1984.

ASSUMPTIONS

1. Loading Condition:

   It is assumed that the equipment operating on the final cap during placement of the erosion layer will be the worst-case scenario for evaluation of the nonwoven geotextile. Equipment expected to operate on the final cap will include a low ground pressure (LGP) bulldozer and off-highway dump trucks. The dump trucks are expected to provide the highest ground pressure (assume tire inflation pressure of 100 psi). Typical procedure is to have three (3) feet of cover for areas where dump trucks will operate over liner. Assuming the reduction in tire ground pressure through the erosion layer is negligible, the maximum pressure on the geotextile from the equipment and erosion layer can be calculated as follows:

   $$p' = (100 \text{ psi}) + (3 \text{ ft})(105 \text{ pcf})(1 \text{ sf} / 144 \text{ sq. in.}) \approx 103 \text{ psi}$$

2. The erosion layer will be a ½" minus crushed gravel / aggregate.

CALCULATIONS

1. Burst Resistance

Burst resistance is the geotextile's ability to prevent it from being pushed into voids in the materials above it. Per Giroud (Reference 2), the required geotextile burst resistance can be calculated as follows:

$$T_{reqd} = \tfrac{1}{2} p' d_v [f(\varepsilon)]$$

Where:

T_{reqd}	=	required geotextile burst strength
p'	=	stress at the geotextile's surface = 103 psi per Assumption 1
d_v	=	maximum void diameter of the stone $\approx 0.33 d_a$
d_a	=	the average stone diameter = ½ in per Assumption 2
$f(\varepsilon)$	=	strain function of the deformed geotextile
	=	$\tfrac{1}{4} [(2y/b) + (b/2y)]$
b	=	width of opening (or void)

y = deformation into the opening (or void)

The ASTM D3786 (Mullen) burst test is similar to the field situation for determination of the ultimate burst resistance (T_{ult}):

T_{ult} = ½ p_{test} d_{test} [f(ε)]

Where:

p_{test} = burst test pressure
d_{test} = diameter of the burst test device = 30 mm

Per Reference 1, knowing that $T_{allow} = T_{ult} / \Pi RF$, where ΠRF = cumulative reduction factors, an expression for the factor of safety is as follows:

$$FS = \frac{T_{allow}}{T_{reqd}} = \frac{(p_{test} d_{test})}{(\prod RF) p' d_v}$$

The cumulative reduction factors (ΠRF) is calculated as follows:

$\Pi RF = RF_{ID} \times RF_{CR} \times RF_{CD} \times RF_{BD}$

Where:

RF_{ID} = reduction factor for installation damage (assume to be 1.1)
RF_{CR} = reduction factor for creep (assume to be 1.3)
RF_{CD} = reduction factor for chemical degradation (assume to be 1.3)
RF_{BD} = reduction factor for biological degradation (assume to be 1.1)

$\Pi RF = 1.1 \times 1.3 \times 1.3 \times 1.1 \approx 2.0$

Assuming a required FS of 1.5, the factor of safety equation is rearranged to solve for the burst test pressure (p_{test}):

$$p_{test} = \frac{(FS)(\prod RF) p' d_v}{d_{test}} = \frac{(1.5)(2.0)(100 psi)(0.33 \times 0.5 in)}{(30 mm)(1 in / 25.4 mm)}$$

p_{test} = 41.9 psi

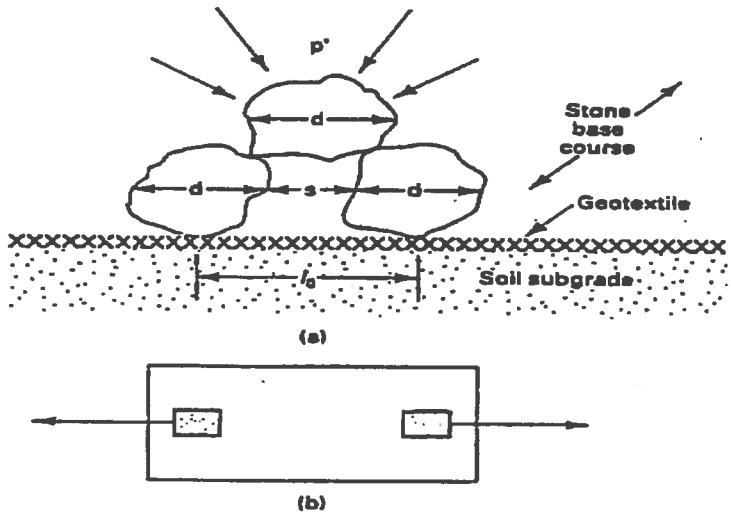
The nonwoven geotextile shall have a minimum ultimate (test) burst pressure of 41.9 psi.

2. Tensile Strength

Figure 2.30 from p.154 of Reference 1 shows a schematic of tensile stress being mobilized by in-plane deformation (see Figure 1 below). This occurs when a geotextile is locked into position by aggregate above it and soil or geomembrane below it. A lateral, or in-plane, tensile stress in the fabric is mobilized when an upper piece of aggregate is forced between two lower pieces that lie against the fabric. This analogy to the grab tensile test can be readily visualized in the

figure. The maximum strain that the fabric will undergo can be estimated as the upper stone wedges itself down to the level of the fabric.

FIGURE 1. SCHEMATIC OF GEOTEXTILE SUBJECTED TO TENSILE FORCES



Using the dimensions shown (where S ≈ d/2) in Figure 1, the maximum strain with no slippage or stone breakage may be calculated:

$$\epsilon = \left(\frac{l_f - l_0}{l_0}\right) x\ (100)$$

$$= \frac{2d - 3d/2}{3d/2} x\ (100)$$

$$= \frac{d/2}{3d/2} x\ (100)$$

$$= 33\%$$

Where:

l_f = final length of the geotextile
l_o = initial length of the geotextile
d = diameter of the aggregate

Grab tensile force being mobilized is related to the pressure exerted on the stone as follows:

T_{reqd} = $p'(d_v)^2[f(\varepsilon)]$ (Reference 2)

Where:

T_{reqd}	=	required grab tensile force
p'	=	applied pressure = 103 psi per Assumption 1
d_v	=	maximum void diameter of the stone ≈ $0.33d_a$
d_a	=	average stone diameter = ½ in per Assumption 2
f(ε)	=	stain function of the deformed geotextile
	=	¼ [(2y/b) + (b/2y)]
b	=	width of stone void (Assume $0.75d_a$)
y	=	deformation into stone void (Assume $0.25d_a$)
f(ε)	=	$0.25 \times [(2 \times 0.25d_a)/(0.75d_a) + (0.75d_a)/(2 \times 0.25d_a)]$
	=	0.54

The ultimate (test) grab tensile strength (T_{ult}) is calculated as follows:

$$T_{ult} = (T_{allow})(\pi RF)$$

Substituting for T_{allow} yields:

$$T_{ult} = (T_{reqd})(FS)(\pi RF)$$

Assuming the same factor (1.5) and cumulative reduction factor (2.0) as Part 1 yields:

$$T_{ult} = (103 \text{ psi})(0.33 \times 0.5 \text{ in})^2(0.54)(1.5)(2.0)$$
$$= 4.5 \text{ lbs}$$

The nonwoven geotextile shall have a minimum ultimate (test) grab tensile strength of 4.5 lbs.

3. Puncture Resistance

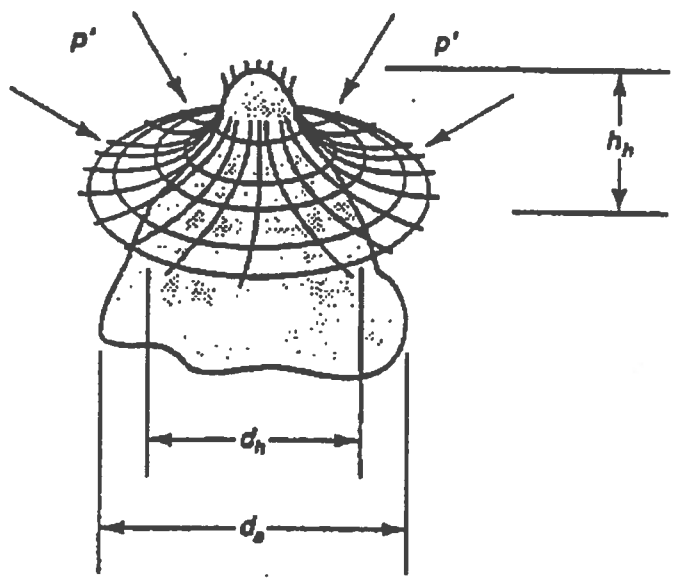
The geotextile must survive the installation process. The following design method is shown schematically in Figure 2 below (Reference 1). The forces acting on the geotextile make this a complex problem, since both radial friction and axial rotation of the fibers against the protrusion are involved. The vertical force exerted on the geotextile (gradually tightening around the protruding object) is:

$$F_{req} = p' d_a^2 S_1 S_2 S_3$$

Where:

F_{req}	=	Required vertical force to be resisted
p'	=	Pressure exerted on the geotextile (103 psi from Assumption 1)
d_a	=	Average diameter of the puncturing aggregate (0.50 in)
S_1	=	Protrusion factor = h_h/d_a (Assumed to be 0.33)
h_h	=	Protrusion height (Assume 1/3 d_a)
S_2	=	Scale factor to adjust ASTM D4833 test value (which uses an 8.0 mm diameter puncturing probe) to the actual puncturing object = d_{probe} / d_a = [8.0 mm x (1 in / 25.4 mm)] / (0.50 in) = 0.63
S_3	=	Shape factor to adjust flat puncture probe of ASTM D4833 to actual shape of puncturing object = $1 - A_p/A_c$ (A_p/A_c values range from 0.8 for Ottawa sand, 0.7 for run-of-bank gravel, 0.4 for crushed rock, and 0.3 for shot rock) = 1 – 0.4 = 0.6 for crushed rock

FIGURE 2. DESIGN SCHEMATIC FOR GEOTEXTILE PUNCTURE RESISTANCE



Assuming the same factor (1.5) and cumulative reduction factor (2.0) as Part 1, the ultimate (test) puncture strength is calculated as follows:

$$F_{ULT} = p' d_a^2 S_1 S_2 S_3 (FS)(\Pi RF)$$
$$= (103 \text{ psi})(0.50 \text{ in})^2(0.33)(0.63)(0.6)(1.5)(2.0)$$
$$= 9.7 \text{ lbs}$$

The nonwoven geotextile shall have a minimum ultimate (test) puncture strength of 9.7 lbs.

SUMMARY

The nonwoven separator/cushion geotextile installed above the 40 mil LLDPE liner in the proposed final cover system at WHSL shall meet the following minimum test values:

Property	Test Method	Minimum Required Test Value
Mullen Burst Resistance	ASTM D3786	41.9 psi
Grab Tensile Strength	ASTM D4632	4.5 lbs
Puncture	ASTM D4833	9.7 lbs

Product data sheets for several nonwoven geotextiles provided as Attachment 1 of this calculation brief show that these requirements are met by currently available nonwoven geotextiles.

Attachment 1

Product Data Sheets for Nonwoven Geotextiles

PRODUCT DATA SHEET

GEOTEX® 1601

GEOTEX 1601 is a polypropylene, staple fiber, needlepunched non woven geotextile produced by Propex and will meet the following Minimum Average Roll Values (MARV) when tested in accordance with the methods listed below. The fibers are needled to form a stable network that retains dimensional stability relative to each other. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.

GEOTEX 1601 conforms to the property values listed below.[1] Propex performs internal Manufacturing Quality Control (MQC) tests that have been accredited by the Geo synthetic Accreditation Institute - Laboratory Accreditation Program (GAI-LAP).

		MARV[2]	
PROPERTY	TEST METHOD	ENGLISH	METRIC
Mechanical			
Tensile Strength (Grab)	ASTM D-4632	380 lbs	1691 N
Elongation	ASTM D-4632	50%	50%
Puncture	ASTM D-4833	240 lbs	1068 N
CBR Puncture	ASTM D-6241	1025 lbs	4559 N
Mullen Burst	ASTM D-3786	750 psi	5170 kPa
Trapezoidal Tear	ASTM D-4533	150 lbs	668 N
Endurance			
UV Resistance	ASTM D-4355	70%	70%
Hydraulic			
Apparent Opening Size (AOS)[3]	ASTM D-4751	100 US Std. Sieve	0.150 mm
Permittivity	ASTM D-4491	0.7 sec^{-1}	0.7 sec^{-1}
Water Flow Rate	ASTM D-4491	50 gpm/ft^2	2037 $l/min/m^2$
Roll Sizes		15 ft x 300 ft	4.57 m x 91.5 m

NOTES:

1. The property values listed above are effective 08/2006 and are subject to change without notice.
2. Values shown are in weaker principal direction. Minimum average roll values (MARV) are calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported.
3. Maximum average roll value.

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GSE STANDARD PRODUCTS

Product Data Sheet

GSE Nonwoven Geotextiles

GSE Nonwoven Geotextiles is a family of polypropylene, staple fiber, nonwoven, needlepunched geotextiles. Manufactured using an advanced manufacturing and quality system, these products are the most uniform and consistent nonwoven, needlepunched geotextile currently available in the industry. GSE combines a fiber selection and approval system with in-line quality control and a state-of-the-art laboratory to ensure that every roll shipped meets customer specifications. The company has performed extensive performance testing to evaluate suitability of its nonwovens for various applications. GSE Nonwoven Geotextiles are available in a range of weights to meet your specific project needs. *These product specifications meet or exceed GRI GT12, GRI GT13 and AASHTO M288.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	NW4	NW6	NW8	NW10	NW12	NW16
Product Code			GEO 0408002	GEO 0608002	GEO 0808002	GEO 1008002	GEO 1208002	GEO 1608002
AASHTO M288 Class			3	2	1	>1	>>1	>>>1
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	90,000 ft²	4 (135)	6 (200)	8 (270)	10 (335)	12 (405)	16 (540)
Grab Tensile Strength, lb (N)	ASTM D 4632	90,000 ft²	120 (530)	170 (755)	220 (975)	260 (1,155)	320 (1,420)	390 (1,735)
Grab Elongation, %	ASTM D 4632	90,000 ft²	50	50	50	50	50	50
Puncture Strength, lb (N)	ASTM D 4833	90,000 ft²	60 (265)	90 (395)	120 (525)	165 (725)	190 (835)	240 (1,055)
Trapezoidal Tear Strength, lb (N)	ASTM D 4533	90,000 ft²	50 (220)	70 (310)	95 (420)	100 (445)	125 (555)	150 (665)
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft²	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)
Permittivity, sec⁻¹	ASTM D 4491	540,000 ft²	1.50	1.50	1.50	1.20	0.80	0.70
Permeability, cm/sec	ASTM D 4491	540,000 ft²	0.22	0.30	0.30	0.30	0.29	0.27
Water Flow Rate, gpm/ft² (l/min/m²)	ASTM D 4491	540,000 ft²	120 (4,885)	110 (4,480)	110 (4,480)	85 (3,460)	60 (2,440)	50 (2,035)
UV Resistance (% retained after 500 hours)	ASTM D 4355	per formulation	70	70	70	70	70	70
Roll Length[1], ft (m)			600 (182)	600 (182)	600 (182)	300 (91)	300 (91)	300 (91)
Roll Width[1], ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Area, ft² (m²)			9,000 (836)	9,000 (836)	9,000 (836)	4,500 (418)	4,500 (418)	4,500 (418)

NOTES:

- The property values listed are in weaker principal direction. All values listed are Minimum Average Roll Values (MARV) except apparent opening size in mm and UV resistance. Apparent opening size (mm) is a Maximum Average Roll Value. UV is a typical value.
- [1]Roll lengths and widths have a tolerance of ±1%.

DS037 NW R08/30/07

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Appendix E
Final Cover HELP Model Evaluation

TASK

To perform a final cover evaluation using the HELP Model to verify that the proposed 40 mil textured (both sides) LLDPE cap has a rate of infiltration less than or equal to that of the WHSL 60 mil textured HDPE bottom liner in accordance with HAR §11-58.1-17(a)(1)(A).

REFERENCES

1. Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07 (November 1, 1997) developed by Environmental Laboratory, USAE Waterways Experiment Station for USEPA Risk Reduction Engineering Laboratory.

2. West Hawaii Sanitary Landfill Permit Drawings, prepared by Harding Lawson Associates, dated August 1993 and revised June 1995.

INPUT DATA

1. Evapotranspiration Data

The default HELP Model data for Honolulu, Hawai`i was used; however, the latitude was adjusted to the site's latitude (N19°54' = N19.90°). The evaporative zone depth of the erosion layer was entered as 12 inches, and a maximum leaf area index of 1 was assumed (poor stand of grass).

2. Precipitation Data

Monthly precipitation data for Years 1998 through 2007 was gathered from the Waikoloa Beach Rt 95.9 National Weather Service Cooperative Station (COOP ID #519144) downloaded from NOAA's National Climatic Data Center (NCDC) website (http://www.ncdc.noaa.gov/oa/ncdc.html). Documentation for the Waikoloa Beach Rt 95.9 cooperative station is included as Attachment 1 of this calculation brief. The station, which is located at 19°55'N / 155°53'W, was the closest station with recent monthly precipitation data to the site, which is located at 19°54'N / 155°52'W. Monthly precipitation data for the past ten (10) years of observation at the station is provided in Table 1 included in Attachment 2 of this calculation brief.

The Synthetic Input option for precipitation data was used to enter the average monthly precipitation values from Table 1. Please note that the default monthly data for San Diego, CA was selected first, as this was the closest city to the site with default synthetic data in the program, and then the average monthly precipitation values from Table 1 were input into the program.

3. Temperature Data

Monthly temperature data for Years 1998 through 2007 was gathered from the Puukohola Heiau 98.1 National Weather Service Cooperative Station (COOP ID #518422) downloaded from NOAA's National Climatic Data Center (NCDC) website (http://www.ncdc.noaa.gov/oa/ncdc.html). Documentation for the Puukohola Heiau 98.1 cooperative station is included as Attachment 1 of this calculation brief. The station, which is located at 20°02'N / 155°49'W, was the closest station with recent monthly precipitation data to the site, which is located at 19°54'N / 155°52'W. Monthly precipitation data for the past ten (10) years of observation at the station is provided in Table 2 included in Attachment 2 of this calculation brief.

The Synthetic Input option for temperature data was used to enter the average monthly precipitation values from Table 2. Please note that the default monthly data for Honolulu, HI was selected first, as this was the closest city to the site with default synthetic data in the program, and then the average monthly precipitation values from Table 2 were input into the program.

4. Solar Radiation Data

The default HELP Model data for Honolulu, Hawai`i was used; however, the latitude was adjusted to the site's latitude (N19°54' = N19.90°).

5. Soil and Design Data

To evaluate the proposed 40 mil textured LLDPE cap against the existing 60 mil textured HDPE bottom liner, three (3) soil cross-sections were input into the HELP Model (see Tables 5-1 thru 5-3). The final cap was evaluated for both the the minimum 5% slope on the plateau and the maximum 10% slope on the sideslopes. The liner was evaluated for the 2% floor slope.

Table 5-1. Final Cap Section (5% Slope)

Layer Description	Thickness (inches)	HELP Model Layer Type	HELP Default Soil Type*	Drainage Slope (%)	Drainage Length (ft)
Erosion Layer	18	2 – Lateral Drainage	21	5	500
40 mil LLDPE	0.04	4 – Flexible Membrane Liner	36		

Table 5-2. Final Cap Section (10% Slope)

Layer Description	Thickness (inches)	HELP Model Layer Type	HELP Default Soil Type*	Drainage Slope (%)	Drainage Length (ft)
Erosion Layer	18	2 – Lateral Drainage	21	10	500
40 mil LLDPE	0.04	4 – Flexible Membrane Liner	36		

Table 5-3. Liner Section (2% Slope)

Layer Description	Thickness (inches)	HELP Model Layer Type	HELP Default Soil Type*	Drainage Slope (%)	Drainage Length (ft)
Protective Layer	12	1 – Vertical Percolation	21		
Leachate Drainage Layer	12	2 – Lateral Drainage	21	2	500
60 mil HDPE	0.04	4 – Flexible Membrane Liner	35		

**HELP Model defaults for soil, waste and geosynthetic materials and default soil texture abbreviations are provided on Tables 3 and 4 in Attachment 1 of this calculation brief.*

The following assumptions were made for the remainder of the Soil and Design Data input in the HELP Model:

- To maintain equivalent sections for comparison, a drainage length of 500-ft was assumed for each section;
- One (1) liner pinhole per acre, one (1) liner installation defect per acre, and a good liner placement quality was assumed for each section;
- Bare ground conditions were assumed for each section; and,
- Calculations were based on a 1.0 acre horizontal plane projection for each section.

CALCULATIONS

The HELP Model output for each of the sections is included as Attachment 3 of this calculation brief. The average annual leakage through the liner for each of the sections is summarized in Table 6. As shown, the proposed 40 mil textured (both sides) LLDPE cap has a rate of infiltration less than or equal to that of the WHSL 60 mil textured HDPE bottom liner.

Table 6. HELP Model Results

Section	Average Annual Infiltration thru Liner (cu. ft. per 1-acre projection)
Final Cap (5% Slope)	2,258
Final Cap (10% Slope)	1,445
Liner (2% Slope)	3,767

Attachment 1

Cooperative Stations Documentation

NCDC / Climate-Radar Data Inventories / Locate Station / Search

Waikoloa Beach Rt 95.9

HI, United States

List Stations in Division HI-06
List Stations in Hawaii County
List Stations within 5, 10, 25, or 50 miles

Type* : **B COOP**
Call Sign/ICS* :
WBAN* :
COOP ID* : **519144**
Climate Division* : **HI-06 - Island of Hawaii**
WMO ID* :
In Service* : **01 Jul 1989 to Present**
Elevation* : **24.4m (80') above s/l**
Lat/Lon* : **19°55'N / 155°53'W**
County* : **Hawaii**

- Data Inventories
- DATA
- Station History
- State Climatologist

Information at Other Sites

- National Weather Service
  - Pacific Region Headquarters
  - Local Weather Conditions
  - Local Weather Forecast
- Sunrise/Sunset

* *Disclaimer*
* *List of NCDC Datasets*
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Data Inventories

Please note that additional data (digital and non-digital) may be available for this station. Contact NCDC if additional details are needed.

Click on the following where available:

- *DAT to obtain digital ascii data (charges may apply),*
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- *INV to view inventory, or*
- *DOC to view documentation*

Surface

DAT INV DOC 3200 -Cooperative Summary Of The Day
DAT INV DOC SOD -Daily Surface Data (TD3200/3210 combined)
DAT INV DOC 3220 -Summary Of The Month (SOM) Cooperative

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Most of these products are publications that have been converted to on-line access. As such, these documents have column headings and are displayed in an easy-to-read format.

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? Record of Climatological Observations
? Annual Climatological Summary
? Storm Data Publication

? Miscellaneous Storm Events in Hawaii County
*All List Storms

Graphs and Other Images

Includes contour maps, time series, NEXRAD radar mosaics, and satellite images.

For additional information and product samples, click on the ? icon next to the desired product.

? National Mosaic Reflectivity Images
? Miscellaneous Satellite Images

CD-ROMs

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? NCDC Cooperative Station Data

Digital ASCII Files

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For additional information and product samples, click on the ? icon next to the desired product.

- ? SOD -Daily Surface Data (TD3200/3210 combined)
- ? 3220 -Summary Of The Month (SOM) Cooperative

Station History

Waikoloa Beach Rt 95.9

Additional Station History Data from MMS

Date Began	Date Ended	Lat/Lon	Elevation meters/feet	COOP ID	WBAN	Call Sign	WMO ID	Type
WAIKOLOA BEACH RT 95.9								
04 Feb 1998	Present	19°55'N / 155°53'W	24.4m / 80'	519144	.	.	.	B COOP
01 Dec 1992	04 Feb 1998	19°55'N / 155°53'W	24.4m / 80'	519144	.	.	.	COOP B
01 Jul 1989	01 Dec 1992	19°55'N / 155°53'W	15.2m / 50'	519144	.	.	.	COOP B

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Puukohola Heiau 98.1

HI, United States

List Stations in Division HI-06
List Stations in Hawaii County
List Stations within 5, 10, 25, or 50 miles

Type* : **COOP AB COOP-A**
Call Sign/ICS* :
WBAN* :
COOP ID* : **518422**
Climate Division* : **HI-06 - Island of Hawaii**
WMO ID* :
In Service* : **01 Dec 1976 to Present**
Elevation* : **40.5m (133') above s/l**
Lat/Lon* : **20°02'N / 155°49'W**
County* : **Hawaii**

- Data Inventories
- DATA
- Station History
- State Climatologist

Information at Other Sites

- National Weather Service
  - Pacific Region Headquarters
  - Local Weather Conditions
  - Local Weather Forecast
- Sunrise/Sunset

* *Disclaimer*
* *List of NCDC Datasets*
* *Please report any Data Errors found.*
* *Note to webmasters: you can link directly to this page.*

Data Inventories

Please note that additional data (digital and non-digital) may be available for this station. Contact NCDC if additional details are needed.

Click on the following where available:

- *DAT to obtain digital ascii data (charges may apply),*
  Please do not order these data if you do not know what a Digital ASCII File is.
- *INV to view inventory, or*
- *DOC to view documentation*

Surface

DAT INV DOC 3200 -Cooperative Summary Of The Day
DAT INV DOC SOD -Daily Surface Data (TD3200/3210 combined)
DAT INV DOC 3220 -Summary Of The Month (SOM) Cooperative

DATA

Additional data products may be available for this station. If you can't find what you are looking for here, please try our Most Popular Products page.

Forms, Publications, and Web Pages
Graphs and Other Images
CD-ROMs
Digital ASCII Files

Forms, Publications, and Web Pages

Most of these products are publications that have been converted to on-line access. As such, these documents have column headings and are displayed in an easy-to-read format.

For additional information and product samples, click on the ? icon next to the desired product.

? Daily/Monthly/Annual Hawaii Pacific Islands Climatological Data
? Record of Climatological Observations
? Annual Climatological Summary
? Storm Data Publication

? Miscellaneous Storm Events in Hawaii County
*All List Storms

Graphs and Other Images

Includes contour maps, time series, NEXRAD radar mosaics, and satellite images.

For additional information and product samples, click on the ? icon next to the desired product.

? National Mosaic Reflectivity Images
? Miscellaneous Satellite Images

CD-ROMs

The following are some of the more popular CD-ROMs that contain data for this station. Others are available that may contain summarized data for this station. A complete list of CD-ROMs is available in the OnLine Store.

For additional information, click on the ? icon next to the desired product.

? NCDC Cooperative Station Data

Digital ASCII Files

These files may or may not contain column headers. In order to use these files, you will need to import them into a spreadsheet or database package for presentation. Please do not order these data if you do not know what a Digital ASCII File is. A sample Digital ASCII File is available for viewing but content varies a great deal depending on your request. Other digital files are available Offline that may contain data for this station.

For additional information and product samples, click on the ? icon next to the desired product.

? SOD -Daily Surface Data (TD3200/3210 combined)
? 3220 -Summary Of The Month (SOM) Cooperative

Station History

Puukohola Heiau 98.1

Additional Station History Data from MMS

Date Began	Date Ended	Lat/Lon	Elevation meters/feet	COOP ID	WBAN	Call Sign	WMO ID	Type
PUUKOHOLA HEIAU 98.1								
15 Jan 2008	Present	20°02'N / 155° 49'W	40.5m / 133'	518422	.	.	.	COOP AB COOP-A
23 Aug 2005	15 Jan 2008	20°02'N / 155° 49'W	42.7m / 140'	518422	.	.	.	AB COOP COOP-A
06 Jun 2002	23 Aug 2005	20°02'N / 155° 49'W	42.7m / 140'	518422	.	.	.	AB COOP
09 Dec 1998	06 Jun 2002	20°02'N / 155° 49'W	42.7m / 140'	518422	.	.	.	AB COOP
17 Jan 1992	09 Dec 1998	20°02'N / 155° 50'W	42.7m / 140'	518422	.	.	.	COOP AB
01 Jan 1982	17 Jan 1992	20°02'N / 155° 50'W	42.7m / 140'	518422	.	.	.	COOP
01 Dec 1976	01 Jan 1982	20°02'N / 155° 50'W	43.0m / 141'	518422	.	.	.	COOP

Top of Page

NCDC / Climate-Radar Data Inventories / Locate Station / Search

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http://www.ncdc.noaa.gov/oa/climate/stationlocator.html
Please send questions or comments about this system to ncdc.webcliserv@noaa.gov
Please see the NCDC Contact Page if you have questions or comments.

Attachment 2

HELP Model Tables

WEST HAWAII SANITARY LANDFILL
CLOSURE AND POST-CLOSURE PLAN
FINAL COVER HELP MODEL EVALUATION
April 2008

EarthTech
A tyco International Ltd Company

TABLE 1. RAINFALL DATA

	RAINFALL (INCHES)												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1998	0.51	0.04	0.00	0.16	0.12	0.33	0.03	0.38	0.08	0.15	0.23	0.05	2.08
1999	1.09	0.32	0.00	0.00	0.12	0.00	0.00	0.00	0.06	0.91	0.05	0.21	2.76
2000	0.52	0.00	1.21	0.00	0.02	0.21	0.07	0.01	0.00	0.00	2.56	0.00	4.60
2001	0.03	0.34	0.15	0.05	0.38	0.17	0.42	0.01	0.07	0.08	3.45	0.01	5.16
2002	3.72	0.68	0.00	2.53	1.32	0.20	0.01	0.34	0.02	1.56	0.30	0.00	10.68
2003	0.56	1.19	1.03	0.28	0.00	0.39	0.21	1.43	0.19	0.02	0.03	1.69	7.02
2004	2.76	3.90	4.28	1.72	4.16	1.37	0.10	2.84	0.89	3.43	1.47	0.04	26.96
2005	3.79	1.75	3.43	0.25	0.07	0.53	0.38	0.24	0.32	0.37	0.27	0.12	11.52
2006	0.92	0.02	1.96	0.00	1.47	0.01	0.02	0.08	0.49	3.02	0.06	0.00	8.05
2007	0.25	1.06	0.10	0.03	0.02	0.23	0.21	0.19	0.55	0.00	0.77	0.00	3.41
AVG	1.42	0.93	1.22	0.50	0.77	0.34	0.15	0.55	0.27	0.95	0.92	0.21	8.22

TABLE 2. TEMPERATURE DATA

	TEMPERATURE (°F)											
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1998	69.5	70.4	72.1	73.3	73.6	73.7	75.4	76.4	76.9	76.0	74.1	72.2
1999	71.0	70.7	72.6	73.0	73.2	75.1	75.3	75.7	75.3	74.2	73.2	71.4
2000	69.7	69.7	71.8	72.7	73.8	75.1	76.3	76.2	75.8	74.7	72.3	69.4
2001	69.7	69.8	71.6	72.8	72.7	73.9	76.1	76.3	73.0	74.5	73.9	72.9
2002	70.7	69.3	71.3	72.7	73.5	75.5	76.6	76.8	76.1	75.6	74.1	72.2
2003	69.8	70.5	71.4	73.1	73.3	75.1	76.2	77.7	76.5	75.9	74.7	72.8
2004	70.4	71.4	71.3	72.6	74.6	75.8	76.5	77.3	76.4	75.8	74.0	72.5
2005	70.2	70.4	70.5	NR	NR	NR	76.9	77.1	77.7	77.0	73.3	71.3
2006	72.2	70.4	71.3	73.2	73.4	75.1	77.6	76.9	77.4	75.7	73.9	72.6
2007	71.3	71.2	72.5	NR	NR	NR	NR	NR	NR	NR	NR	NR
AVG	70.5	70.4	71.6	72.9	73.5	74.9	76.3	76.7	76.1	75.5	73.7	71.9

Notes:

1. Monthly rainfall data taken from the Waikoloa Beach Rt 95.9 National Weather Service Cooperative Station (COOP ID #519144) downloaded 4/11/08 from NOAA's National Climatic Data Center (NCDC) website (http://www.ncdc.noaa.gov/oa/ncdc.html).

2. Monthly temperature data taken from the Puukohola Haiau 98.1 National Weather Service Cooperative Station (COOP ID #518422) downloaded 4/11/08. from NOAA's National Climatic Data Center (NCDC) website (http://www.ncdc.noaa.gov/oa/ncdc.html).

3. NR = No Reading

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Table 3. HELP Model Version 3.07 Defaults for Soil, Waste and Geosynthetic Materials Characteristics

Soil Texture Classification			Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP Default #	USDA	USCS	(vol/vol)	(vol/vol)	(vol/vol)	(cm/sec)
1	CoS	SP	0.417	0.045	0.018	1.0E-02
2	S	SW	0.437	0.062	0.024	5.8E-03
3	FS	SW	0.457	0.083	0.033	3.1E-03
4	LS	SM	0.437	0.105	0.047	1.7E-03
5	LFS	SM	0.457	0.131	0.058	1.0E-03
6	SL	SM	0.453	0.190	0.085	7.2E-04
7	FSL	SM	0.473	0.222	0.104	5.2E-04
8	L	ML	0.463	0.232	0.116	3.7E-04
9	SiL	ML	0.501	0.284	0.135	1.9E-04
10	SCL	SC	0.398	0.244	0.136	1.2E-04
11	CL	CL	0.464	0.310	0.187	6.4E-05
12	SiCL	CL	0.471	0.342	0.210	4.2E-05
13	SC	CH	0.430	0.321	0.221	3.3E-05
14	SiC	CH	0.479	0.371	0.251	2.5E-05
15	C	CH	0.475	0.378	0.265	1.7E-05
16	Barrier Soil		0.427	0.418	0.367	1.0E-07
17	Bentonite Mat (0.6 cm)		0.750	0.747	0.400	3.0E-09
18	Muncipal Waste (900 lb/yd3 or 312 kg/m3)		0.671	0.292	0.077	1.0E-03
19	Municipal Waste (channeling and dead zones)		0.168	0.073	0.019	1.0E-03
20	Drainage Net (0.5 cm)		0.850	0.010	0.005	1.0E+01
21	Gravel		0.397	0.032	0.013	3.0E-01
22	L*	ML*	0.419	0.307	0.180	1.9E-05
23	SiL*	ML*	0.461	0.360	0.203	9.0E-06
24	SCL*	SC*	0.365	0.305	0.202	2.7E-06
25	CL*	CL*	0.437	0.373	0.266	3.6E-06
26	SiCL*	CL*	0.445	0.393	0.277	1.9E-06
27	SC*	CH*	0.400	0.366	0.288	7.8E-07
28	SiC*	CH*	0.452	0.411	0.311	1.2E-06
29	C*	CH*	0.451	0.419	0.332	6.8E-07
30	Coal-Burning Fly Ash*		0.541	0.187	0.047	5.0E-05
31	Coal-Burning Bottom Ash*		0.578	0.076	0.025	4.1E-03
32	Municipal Incinerator Fly Ash*		0.450	0.116	0.049	1.0E-02
33	Fine Copper Slag*		0.375	0.055	0.020	4.1E-02
34	Drainage Net (0.6 cm)		0.850	0.010	0.005	3.3E+01
35	High Density Polyethylene (HDPE)					2.0E-13
36	Low Density Polyethylene (LDPE)					4.0E-13
37	Polyvinyl Chloride (PVC)					2.0E-11
38	Butyl Rubber					1.0E-12

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Table 3. HELP Model Version 3.07 Defaults for Soil, Waste and Geosynthetic Materials Characteristics

Soil Texture Classification			Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP Default #	USDA	USCS	(vol/vol)	(vol/vol)	(vol/vol)	(cm/sec)
39	Chlorinated Polyethylene (CPE)					4.0E-12
40	Hypalon or Chlorosulfonated Polyethylene (CSPE)					3.0E-12
41	Ethylene-Propylene Diene Monomer (EPDM)					2.0E-12
42	Neoprene					3.0E-12

* Moderately Compacted

L:\work\SW\PROJECTS\103556 West Hawaii LF\Closure - Post Closure Plan\[WHSL FC HELP Model tables.xls]Table 3

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Table 4. Default Soil Texture Abbreviations

U.S. Department of Agriculture (USDA)	Definition
G	Gravel
S	Sand
Si	Silt
C	Clay
L	Loam (sand, silt, clay, and humus mixture)
Co	Coarse
F	Fine
Unified Soil Classification System (USCS)	**Definition**
G	Gravel
S	Sand
M	Silt
C	Clay
P	Poorly Graded
W	Well Graded
H	High Plasticity or Compressibility
L	Low Plasticity or Compressibility

Attachment 3

HELP Model Output

Attachment 3-1

HELP Model Output – Final Cap (5% Slope)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:      C:\HELP307\WHRAIN.D4
TEMPERATURE DATA FILE:        C:\HELP307\WHTEMP.D7
SOLAR RADIATION DATA FILE:    C:\HELP307\WHSOLR.D13
EVAPOTRANSPIRATION DATA:      C:\HELP307\WHEVAP.D11
SOIL AND DESIGN DATA FILE:    C:\HELP307\WHFC05.D10
OUTPUT DATA FILE:             C:\HELP307\WHFC05.OUT


TIME:  15:51      DATE:   4/16/2008


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

     TITLE:  WEST HAWAI`I LF - FINAL COVER SYSTEM (5% SLOPE)

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


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


                                  LAYER  1
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER  21
          THICKNESS                  =     18.00    INCHES
          POROSITY                   =      0.3970 VOL/VOL
          FIELD CAPACITY             =      0.0320 VOL/VOL
          WILTING POINT              =      0.0130 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.0193 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.300000012000      CM/SEC
          SLOPE                      =      5.00    PERCENT
          DRAINAGE LENGTH            =    500.0     FEET
```

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 1.80
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

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.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #21 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF 5.% AND
A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	69.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.156	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.764	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.156	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	0.348	INCHES
TOTAL INITIAL WATER	=	0.348	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
HONOLULU HAWAII

STATION LATITUDE	=	19.90	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	0	

END OF GROWING SEASON (JULIAN DATE)	=	367
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	11.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SAN DIEGO CALIFORNIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.42	0.93	1.22	0.50	0.77	0.34
0.15	0.55	0.27	0.95	0.92	0.21

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
70.50	70.40	71.60	72.90	73.50	74.90
76.30	76.70	76.10	75.50	73.70	71.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII
AND STATION LATITUDE = 19.90 DEGREES

WARNING: SOLAR RADIATION FOR YEAR 1974 USED WITH PRECIPITATION FOR YEAR 1

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.51	0.10	1.70	0.74	0.02	0.32
	0.00	0.00	0.00	0.71	0.58	0.12

RUNOFF	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	0.045	0.533	1.204	0.819	0.126	0.309
	0.007	0.000	0.000	0.432	0.578	0.114
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.0002	0.0092	0.2059	0.0006	0.0002	0.0008
	0.0001	0.0000	0.0000	0.1754	0.0003	0.0009
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.0020	0.0153	0.1047	0.0030	0.0014	0.0031
	0.0008	0.0000	0.0000	0.1027	0.0017	0.0051

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 2	0.000	0.002	0.039	0.000	0.000	0.000
	0.000	0.000	0.000	0.033	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 2	0.000	0.006	0.093	0.000	0.000	0.001
	0.000	0.000	0.000	0.073	0.000	0.000

****

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	4.80	17424.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	4.167	15124.994	86.81
DRAINAGE COLLECTED FROM LAYER 1	0.3936	1428.647	8.20
PERC./LEAKAGE THROUGH LAYER 2	0.239767	870.355	5.00
AVG. HEAD ON TOP OF LAYER 2	0.0063		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

****

WARNING: SOLAR RADIATION FOR YEAR 1975 USED WITH PRECIPITATION FOR YEAR 2

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69	0.30	1.93	0.00	1.06	0.00
	0.00	0.00	0.00	2.36	1.09	0.18
RUNOFF	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	1.109	0.616	1.638	0.135	0.571	0.000
	0.000	0.000	0.000	0.561	0.706	0.182
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.0080	0.1348	0.1075	0.0005	0.3638	0.0000
	0.0000	0.0000	0.0000	1.4999	0.2428	0.0009
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.0133	0.0767	0.0793	0.0020	0.1251	0.0000
	0.0000	0.0000	0.0000	0.2987	0.1333	0.0051

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 2	0.002	0.028	0.020	0.000	0.069	0.000
	0.000	0.000	0.000	0.285	0.048	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 2	0.006	0.069	0.043	0.001	0.201	0.000
	0.000	0.000	0.000	0.731	0.101	0.000

****

****

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.61	31254.303	100.00

RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	5.518	20031.297	64.09
DRAINAGE COLLECTED FROM LAYER 1	2.3582	8560.354	27.39
PERC./LEAKAGE THROUGH LAYER 2	0.733512	2662.647	8.52
AVG. HEAD ON TOP OF LAYER 2	0.0377		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

****

WARNING: SOLAR RADIATION FOR YEAR 1976 USED WITH PRECIPITATION FOR YEAR 3

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.06	2.84	0.91	0.41	1.26	0.06
	0.00	0.00	0.00	5.03	0.71	0.11
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.041	0.000	0.000
EVAPOTRANSPIRATION	1.815	1.381	0.896	0.405	1.135	0.022
	0.037	0.000	0.000	1.575	0.700	0.104
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.1440	1.1476	0.0028	0.0008	0.0716	0.0000
	0.0001	0.0000	0.0000	2.9414	0.0020	0.0010
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.0921	0.3207	0.0108	0.0039	0.0533	0.0000
	0.0009	0.0000	0.0000	0.4728	0.0082	0.0047

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 2	0.027	0.242	0.001	0.000	0.014	0.000
	0.000	0.000	0.000	0.559	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 2	0.062	0.425	0.001	0.000	0.036	0.000
	0.000	0.000	0.000	1.257	0.001	0.000

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.39	48605.703	100.00
RUNOFF	0.041	149.869	0.31
EVAPOTRANSPIRATION	8.070	29294.846	60.27
DRAINAGE COLLECTED FROM LAYER 1	4.3112	15649.694	32.20
PERC./LEAKAGE THROUGH LAYER 2	0.967297	3511.289	7.22
AVG. HEAD ON TOP OF LAYER 2	0.0703		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.006	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1977 USED WITH PRECIPITATION FOR YEAR 4

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MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.79	1.35	1.07	0.51	0.00	0.00
	0.00	0.00	0.79	1.69	1.66	0.14
RUNOFF	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	0.711	1.428	1.031	0.501	0.000	0.000
	0.000	0.000	0.472	1.455	2.010	0.140
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.5984	0.1694	0.0162	0.0019	0.0000	0.0000
	0.0000	0.0000	0.0001	0.0774	0.0173	0.0005
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.1549	0.0785	0.0228	0.0071	0.0000	0.0000
	0.0000	0.0000	0.0005	0.0736	0.0300	0.0032

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 2	0.114	0.034	0.003	0.000	0.000	0.000
	0.000	0.000	0.000	0.015	0.003	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 2	0.309	0.107	0.010	0.001	0.000	0.000
	0.000	0.000	0.000	0.029	0.009	0.000

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.00	32670.010	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.748	28126.736	86.09
DRAINAGE COLLECTED FROM LAYER 1	0.8811	3198.318	9.79
PERC./LEAKAGE THROUGH LAYER 2	0.370509	1344.949	4.12
AVG. HEAD ON TOP OF LAYER 2	0.0142		
CHANGE IN WATER STORAGE	0.000	0.000	0.00

SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1978 USED WITH PRECIPITATION FOR YEAR 5

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.04	0.77	2.04	0.14	0.69	0.00
	0.00	0.00	0.00	2.37	0.82	0.19
RUNOFF	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	0.818	0.549	1.987	0.112	0.747	0.000
	0.000	0.000	0.000	0.626	0.127	0.495
LATERAL DRAINAGE COLLECTED	0.9681	0.0011	0.1408	0.0015	0.0009	0.0000
FROM LAYER 1	0.0000	0.0000	0.0000	1.4393	0.0010	0.2465
PERCOLATION/LEAKAGE THROUGH	0.2534	0.0048	0.0869	0.0053	0.0034	0.0000
LAYER 2	0.0000	0.0000	0.0000	0.3020	0.0041	0.1389

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.184	0.000	0.027	0.000	0.000	0.000
TOP OF LAYER 2	0.000	0.000	0.000	0.274	0.000	0.047
STD. DEVIATION OF DAILY	0.428	0.001	0.068	0.001	0.001	0.000
HEAD ON TOP OF LAYER 2	0.000	0.000	0.000	0.676	0.001	0.110

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.06	32887.805	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	5.462	19826.863	60.29
DRAINAGE COLLECTED FROM LAYER 1	2.7992	10161.001	30.90
PERC./LEAKAGE THROUGH LAYER 2	0.798879	2899.931	8.82
AVG. HEAD ON TOP OF LAYER 2	0.0444		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

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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	1.62	1.07	1.53	0.36	0.61	0.08
	0.00	0.00	0.16	2.43	0.97	0.15
STD. DEVIATIONS	0.64	1.10	0.51	0.29	0.58	0.14
	0.00	0.00	0.35	1.60	0.43	0.04
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000

	0.000	0.000	0.000	0.008	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.018	0.000	0.000

EVAPOTRANSPIRATION

TOTALS	0.900	0.901	1.351	0.394	0.516	0.066
	0.009	0.000	0.094	0.930	0.824	0.207
STD. DEVIATIONS	0.643	0.461	0.452	0.291	0.463	0.136
	0.016	0.000	0.211	0.540	0.704	0.164

LATERAL DRAINAGE COLLECTED FROM LAYER 1

TOTALS	0.3438	0.2924	0.0946	0.0011	0.0873	0.0002
	0.0001	0.0000	0.0000	1.2267	0.0527	0.0500
STD. DEVIATIONS	0.4258	0.4839	0.0856	0.0006	0.1576	0.0003
	0.0001	0.0000	0.0000	1.1711	0.1065	0.1099

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.1031	0.0992	0.0609	0.0043	0.0366	0.0006
	0.0003	0.0000	0.0001	0.2499	0.0355	0.0314
STD. DEVIATIONS	0.1045	0.1284	0.0415	0.0020	0.0543	0.0014
	0.0005	0.0000	0.0002	0.1640	0.0558	0.0601

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0654	0.0613	0.0180	0.0002	0.0166	0.0000
	0.0000	0.0000	0.0000	0.2332	0.0103	0.0095
STD. DEVIATIONS	0.0810	0.1019	0.0163	0.0001	0.0300	0.0001
	0.0000	0.0000	0.0000	0.2227	0.0209	0.0209

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	8.97	(3.044)	32568.4	100.00
RUNOFF	0.008	(0.0185)	29.97	0.092

EVAPOTRANSPIRATION	6.193	(1.6612)	22480.95	69.027
LATERAL DRAINAGE COLLECTED FROM LAYER 1	2.14865	(1.56771)	7799.603	23.94840
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.62199	(0.30508)	2257.834	6.93260
AVERAGE HEAD ON TOP OF LAYER 2	0.035	(0.025)		
CHANGE IN WATER STORAGE	0.000	(0.0000)	0.00	0.000

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.52	9147.600
RUNOFF	0.038	139.5411
DRAINAGE COLLECTED FROM LAYER 1	0.77353	2807.90039
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.096093	348.81702
AVERAGE HEAD ON TOP OF LAYER 2	4.559	
MAXIMUM HEAD ON TOP OF LAYER 2	8.393	
LOCATION OF MAXIMUM HEAD IN LAYER 1 (DISTANCE FROM DRAIN)	38.6 FEET	
SNOW WATER	0.00	0.0000

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2148
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0130

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

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

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	0.3480	0.0193
2	0.0000	0.0000
SNOW WATER	0.000	

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Attachment 3-2

HELP Model Output – Final Cap (10% Slope)

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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:      C:\HELP307\WHRAIN.D4
TEMPERATURE DATA FILE:        C:\HELP307\WHTEMP.D7
SOLAR RADIATION DATA FILE:    C:\HELP307\WHSOLR.D13
EVAPOTRANSPIRATION DATA:      C:\HELP307\WHEVAP.D11
SOIL AND DESIGN DATA FILE:    C:\HELP307\WHFC10.D10
OUTPUT DATA FILE:             C:\HELP307\WHFC10.OUT


TIME:  15:52     DATE:   4/16/2008


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     TITLE:  WEST HAWAI`I LF - FINAL COVER SYSTEM (10% SLOPE)

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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 2 - LATERAL DRAINAGE LAYER
                       MATERIAL TEXTURE NUMBER  21
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.3970 VOL/VOL
          FIELD CAPACITY               =      0.0320 VOL/VOL
          WILTING POINT                =      0.0130 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0193 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.300000012000      CM/SEC
          SLOPE                        =     10.00   PERCENT
          DRAINAGE LENGTH              =    500.0    FEET
```

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 1.80
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

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.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #21 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF 10.% AND
A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	70.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.156	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.764	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.156	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	0.348	INCHES
TOTAL INITIAL WATER	=	0.348	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
HONOLULU HAWAII

STATION LATITUDE	=	19.90	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	0	

END OF GROWING SEASON (JULIAN DATE)	=	367
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	11.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SAN DIEGO CALIFORNIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.42	0.93	1.22	0.50	0.77	0.34
0.15	0.55	0.27	0.95	0.92	0.21

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
70.50	70.40	71.60	72.90	73.50	74.90
76.30	76.70	76.10	75.50	73.70	71.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII
AND STATION LATITUDE = 19.90 DEGREES

WARNING: SOLAR RADIATION FOR YEAR 1974 USED WITH PRECIPITATION FOR YEAR 1

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.51	0.10	1.70	0.74	0.02	0.32
	0.00	0.00	0.00	0.71	0.58	0.12

RUNOFF	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	0.045	0.533	1.204	0.819	0.126	0.309
	0.007	0.000	0.000	0.432	0.578	0.114
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.0004	0.0129	0.2394	0.0010	0.0004	0.0013
	0.0002	0.0000	0.0000	0.2063	0.0005	0.0016
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.0018	0.0117	0.0712	0.0026	0.0012	0.0026
	0.0007	0.0000	0.0000	0.0718	0.0015	0.0045

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 2	0.000	0.001	0.023	0.000	0.000	0.000
	0.000	0.000	0.000	0.020	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 2	0.000	0.005	0.064	0.000	0.000	0.000
	0.000	0.000	0.000	0.051	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	4.80	17424.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	4.167	15124.994	86.81
DRAINAGE COLLECTED FROM LAYER 1	0.4638	1683.584	9.66
PERC./LEAKAGE THROUGH LAYER 2	0.169537	615.418	3.53
AVG. HEAD ON TOP OF LAYER 2	0.0037		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1975 USED WITH PRECIPITATION FOR YEAR 2

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MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69	0.30	1.93	0.00	1.06	0.00
	0.00	0.00	0.00	2.36	1.09	0.18
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.001	0.000	0.000
EVAPOTRANSPIRATION	1.109	0.616	1.638	0.135	0.571	0.000
	0.000	0.000	0.000	0.559	0.704	0.181
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.0151	0.1553	0.1305	0.0009	0.4143	0.0000
	0.0000	0.0000	0.0000	1.6306	0.2825	0.0020
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.0119	0.0505	0.0563	0.0017	0.0745	0.0000
	0.0000	0.0000	0.0000	0.1696	0.0945	0.0057

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 2	0.001	0.016	0.013	0.000	0.040	0.000
	0.000	0.000	0.000	0.156	0.028	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 2	0.006	0.047	0.029	0.000	0.146	0.000
	0.000	0.000	0.000	0.503	0.069	0.000

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.61	31254.303	100.00

RUNOFF	0.001	1.867	0.01
EVAPOTRANSPIRATION	5.514	20014.184	64.04
DRAINAGE COLLECTED FROM LAYER 1	2.6312	9551.385	30.56
PERC./LEAKAGE THROUGH LAYER 2	0.464700	1686.862	5.40
AVG. HEAD ON TOP OF LAYER 2	0.0212		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1976 USED WITH PRECIPITATION FOR YEAR 3

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MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.06	2.84	0.91	0.41	1.26	0.06
	0.00	0.00	0.00	5.03	0.71	0.11
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.052	0.000	0.000
EVAPOTRANSPIRATION	1.822	1.380	0.895	0.406	1.135	0.022
	0.036	0.000	0.000	1.578	0.697	0.103
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.1712	1.2594	0.0052	0.0010	0.0885	0.0000
	0.0004	0.0000	0.0000	3.1273	0.0046	0.0021
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.0665	0.2012	0.0096	0.0028	0.0367	0.0000
	0.0013	0.0000	0.0000	0.2726	0.0080	0.0050

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.016	0.134	0.000	0.000	0.008	0.000
TOP OF LAYER 2	0.000	0.000	0.000	0.300	0.000	0.000
STD. DEVIATION OF DAILY	0.042	0.298	0.001	0.000	0.024	0.000
HEAD ON TOP OF LAYER 2	0.000	0.000	0.000	0.814	0.001	0.001

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.39	48605.703	100.00
RUNOFF	0.052	189.143	0.39
EVAPOTRANSPIRATION	8.074	29310.230	60.30
DRAINAGE COLLECTED FROM LAYER 1	4.6598	16914.969	34.80
PERC./LEAKAGE THROUGH LAYER 2	0.603678	2191.350	4.51
AVG. HEAD ON TOP OF LAYER 2	0.0383		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.013	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1977 USED WITH PRECIPITATION FOR YEAR 4

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MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.79	1.35	1.07	0.51	0.00	0.00
	0.00	0.00	0.79	1.69	1.66	0.14
RUNOFF	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	0.710	1.429	1.025	0.501	0.000	0.000
	0.000	0.000	0.472	1.455	2.013	0.139
LATERAL DRAINAGE COLLECTED FROM LAYER 1	0.7710	0.0789	0.0266	0.0032	0.0000	0.0000
	0.0000	0.0000	0.0002	0.1003	0.0235	0.0012
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.1218	0.0286	0.0183	0.0063	0.0000	0.0000
	0.0000	0.0000	0.0005	0.0534	0.0186	0.0033

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 2	0.074	0.008	0.003	0.000	0.000	0.000
	0.000	0.000	0.000	0.010	0.002	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 2	0.202	0.032	0.008	0.001	0.000	0.000
	0.000	0.000	0.000	0.022	0.007	0.000

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.00	32670.010	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.744	28112.045	86.05
DRAINAGE COLLECTED FROM LAYER 1	1.0047	3647.213	11.16
PERC./LEAKAGE THROUGH LAYER 2	0.250894	910.747	2.79
AVG. HEAD ON TOP OF LAYER 2	0.0081		
CHANGE IN WATER STORAGE	0.000	0.000	0.00

SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1978 USED WITH PRECIPITATION FOR YEAR 5

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.04	0.77	2.04	0.14	0.69	0.00
	0.00	0.00	0.00	2.37	0.82	0.19
RUNOFF	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	0.831	0.551	1.987	0.113	0.746	0.000
	0.000	0.000	0.000	0.626	0.127	0.503
LATERAL DRAINAGE COLLECTED	1.0522	0.0011	0.1677	0.0017	0.0017	0.0000
FROM LAYER 1	0.0000	0.0000	0.0000	1.5652	0.0007	0.2834
PERCOLATION/LEAKAGE THROUGH	0.1567	0.0026	0.0601	0.0037	0.0035	0.0000
LAYER 2	0.0000	0.0000	0.0000	0.1785	0.0019	0.0941

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.101	0.000	0.016	0.000	0.000	0.000
TOP OF LAYER 2	0.000	0.000	0.000	0.150	0.000	0.027
STD. DEVIATION OF DAILY	0.291	0.000	0.047	0.000	0.001	0.000
HEAD ON TOP OF LAYER 2	0.000	0.000	0.000	0.460	0.000	0.080

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.06	32887.805	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	5.485	19911.566	60.54
DRAINAGE COLLECTED FROM LAYER 1	3.0737	11157.378	33.93
PERC./LEAKAGE THROUGH LAYER 2	0.501063	1818.859	5.53
AVG. HEAD ON TOP OF LAYER 2	0.0245		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.540	1960.154	
SOIL WATER AT END OF YEAR	0.540	1960.154	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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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	1.62	1.07	1.53	0.36	0.61	0.08
	0.00	0.00	0.16	2.43	0.97	0.15
STD. DEVIATIONS	0.64	1.10	0.51	0.29	0.58	0.14
	0.00	0.00	0.35	1.60	0.43	0.04
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000

	0.000	0.000	0.000	0.011	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.023	0.000	0.000

EVAPOTRANSPIRATION

TOTALS	0.904	0.902	1.350	0.395	0.516	0.066
	0.009	0.000	0.094	0.930	0.824	0.208
STD. DEVIATIONS	0.645	0.460	0.454	0.291	0.463	0.136
	0.016	0.000	0.211	0.542	0.705	0.167

LATERAL DRAINAGE COLLECTED FROM LAYER 1

TOTALS	0.4020	0.3015	0.1139	0.0015	0.1010	0.0003
	0.0001	0.0000	0.0000	1.3260	0.0623	0.0581
STD. DEVIATIONS	0.4804	0.5390	0.0979	0.0010	0.1792	0.0006
	0.0002	0.0000	0.0001	1.2401	0.1234	0.1260

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.0718	0.0589	0.0431	0.0034	0.0232	0.0005
	0.0004	0.0000	0.0001	0.1492	0.0249	0.0225
STD. DEVIATIONS	0.0675	0.0816	0.0273	0.0018	0.0325	0.0011
	0.0006	0.0000	0.0002	0.0890	0.0395	0.0400

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0385	0.0319	0.0109	0.0002	0.0097	0.0000
	0.0000	0.0000	0.0000	0.1270	0.0062	0.0056
STD. DEVIATIONS	0.0460	0.0572	0.0094	0.0001	0.0172	0.0001
	0.0000	0.0000	0.0000	0.1188	0.0122	0.0121

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	8.97	(3.044)	32568.4	100.00
RUNOFF	0.011	(0.0232)	38.20	0.117

EVAPOTRANSPIRATION	6.197	(1.6594)	22494.60	69.069
LATERAL DRAINAGE COLLECTED FROM LAYER 1	2.36664	(1.68106)	8590.905	26.37807
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.39797	(0.18111)	1444.647	4.43574
AVERAGE HEAD ON TOP OF LAYER 2	0.019	(0.014)		
CHANGE IN WATER STORAGE	0.000	(0.0000)	0.00	0.000

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.52	9147.600
RUNOFF	0.046	167.3976
DRAINAGE COLLECTED FROM LAYER 1	1.04771	3803.18286
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.076322	277.04846
AVERAGE HEAD ON TOP OF LAYER 2	3.111	
MAXIMUM HEAD ON TOP OF LAYER 2	5.990	
LOCATION OF MAXIMUM HEAD IN LAYER 1 (DISTANCE FROM DRAIN)	13.8 FEET	
SNOW WATER	0.00	0.0000

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2146
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0130

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

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

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	0.3480	0.0193
2	0.0000	0.0000
SNOW WATER	0.000	

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Attachment 3-3

HELP Model Output – Liner Section (2% Slope)

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP307\WHRAIN.D4
TEMPERATURE DATA FILE:        C:\HELP307\WHTEMP.D7
SOLAR RADIATION DATA FILE:    C:\HELP307\WHSOLR.D13
EVAPOTRANSPIRATION DATA:      C:\HELP307\WHEVAP.D11
SOIL AND DESIGN DATA FILE:    C:\HELP307\WHBL.D10
OUTPUT DATA FILE:             C:\HELP307\WHBL.OUT


TIME:  16:34     DATE:   4/16/2008


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     TITLE:  WEST HAWAI`I LF - LINER SYSTEM

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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  21
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.3970 VOL/VOL
          FIELD CAPACITY               =      0.0320 VOL/VOL
          WILTING POINT                =      0.0130 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0130 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.300000012000     CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	500.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	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	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #21 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	68.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.156	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.764	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.156	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	0.540	INCHES

TOTAL INITIAL WATER	=	0.540	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
HONOLULU HAWAII

STATION LATITUDE	=	19.90	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	0	
END OF GROWING SEASON (JULIAN DATE)	=	367	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	11.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SAN DIEGO CALIFORNIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.42	0.93	1.22	0.50	0.77	0.34
0.15	0.55	0.27	0.95	0.92	0.21

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
70.50	70.40	71.60	72.90	73.50	74.90
76.30	76.70	76.10	75.50	73.70	71.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII
AND STATION LATITUDE = 19.90 DEGREES

WARNING: SOLAR RADIATION FOR YEAR 1974 USED WITH PRECIPITATION FOR YEAR

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.51	0.10	1.70	0.74	0.02	0.32
	0.00	0.00	0.00	0.71	0.58	0.12
RUNOFF	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	0.045	0.533	1.204	0.819	0.126	0.309
	0.007	0.000	0.000	0.432	0.578	0.114
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.0001	0.0050	0.1478	0.0002	0.0001	0.0003
	0.0001	0.0000	0.0000	0.1246	0.0001	0.0004
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.0022	0.0194	0.1629	0.0033	0.0015	0.0035
	0.0008	0.0000	0.0000	0.1535	0.0019	0.0056

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.000	0.003	0.070	0.000	0.000	0.000
	0.000	0.000	0.000	0.059	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.000	0.007	0.134	0.000	0.000	0.001
	0.000	0.000	0.000	0.105	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	4.80	17424.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	4.167	15124.994	86.81
DRAINAGE COLLECTED FROM LAYER 2	0.2788	1012.006	5.81

PERC./LEAKAGE THROUGH LAYER 3	0.354537	1286.968	7.39
AVG. HEAD ON TOP OF LAYER 3	0.0110		
CHANGE IN WATER STORAGE	0.000	0.029	0.00
SOIL WATER AT START OF YEAR	0.924	3354.073	
SOIL WATER AT END OF YEAR	0.924	3354.102	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1975 USED WITH PRECIPITATION FOR YEAR 2

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69	0.30	1.93	0.00	1.06	0.00
	0.00	0.00	0.00	2.36	1.09	0.18
RUNOFF	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	1.109	0.616	1.638	0.135	0.571	0.000
	0.000	0.000	0.000	0.561	0.706	0.182
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.0033	0.0952	0.0726	0.0003	0.2721	0.0000
	0.0000	0.0000	0.0000	1.2387	0.1757	0.0020
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.0143	0.1200	0.1143	0.0023	0.2162	0.0005
	0.0000	0.0000	0.0000	0.5599	0.1914	0.0129

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.002	0.050	0.034	0.000	0.129	0.000
	0.000	0.000	0.000	0.588	0.086	0.001

STD. DEVIATION OF DAILY	0.006	0.099	0.064	0.001	0.274	0.000
HEAD ON TOP OF LAYER 3	0.000	0.000	0.000	1.049	0.145	0.004

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.61	31254.303	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	5.518	20031.297	64.09
DRAINAGE COLLECTED FROM LAYER 2	1.8599	6751.526	21.60
PERC./LEAKAGE THROUGH LAYER 3	1.231820	4471.505	14.31
AVG. HEAD ON TOP OF LAYER 3	0.0742		
CHANGE IN WATER STORAGE	0.000	-0.029	0.00
SOIL WATER AT START OF YEAR	0.924	3354.102	
SOIL WATER AT END OF YEAR	0.924	3354.073	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1976 USED WITH PRECIPITATION FOR YEAR 3

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.06	2.84	0.91	0.41	1.26	0.06

	0.00	0.00	0.00	5.03	0.71	0.11
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.031	0.000	0.000
EVAPOTRANSPIRATION	1.815	1.381	0.896	0.405	1.135	0.022
	0.037	0.000	0.000	1.574	0.705	0.104
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.0896	0.9447	0.0013	0.0004	0.0467	0.0000
	0.0001	0.0000	0.0000	2.5319	0.0004	0.0004
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.1139	0.5562	0.0123	0.0043	0.0781	0.0000
	0.0010	0.0000	0.0000	0.8930	0.0051	0.0057

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.042	0.496	0.001	0.000	0.022	0.000
	0.000	0.000	0.000	1.201	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.092	0.631	0.001	0.001	0.050	0.000
	0.000	0.000	0.000	1.905	0.000	0.000

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.39	48605.703	100.00
RUNOFF	0.031	113.399	0.23
EVAPOTRANSPIRATION	8.074	29307.531	60.30
DRAINAGE COLLECTED FROM LAYER 2	3.6154	13123.979	27.00
PERC./LEAKAGE THROUGH LAYER 3	1.669640	6060.794	12.47
AVG. HEAD ON TOP OF LAYER 3	0.1469		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.924	3354.073	
SOIL WATER AT END OF YEAR	0.924	3354.073	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1977 USED WITH PRECIPITATION FOR YEAR 4

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.79	1.35	1.07	0.51	0.00	0.00
	0.00	0.00	0.79	1.69	1.66	0.14
RUNOFF	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	0.710	1.422	1.016	0.505	0.000	0.000
	0.000	0.000	0.471	1.454	2.014	0.137
LATERAL DRAINAGE COLLECTED	0.3338	0.2747	0.0143	0.0004	0.0000	0.0000
FROM LAYER 2	0.0000	0.0000	0.0001	0.0468	0.0119	0.0004
PERCOLATION/LEAKAGE THROUGH	0.1783	0.2219	0.0394	0.0050	0.0000	0.0000
LAYER 3	0.0000	0.0000	0.0010	0.0970	0.0410	0.0055

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.158	0.139	0.007	0.000	0.000	0.000
TOP OF LAYER 3	0.000	0.000	0.000	0.022	0.006	0.000
STD. DEVIATION OF DAILY	0.437	0.294	0.018	0.001	0.000	0.000
HEAD ON TOP OF LAYER 3	0.000	0.000	0.000	0.039	0.013	0.001

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT

PRECIPITATION	9.00	32670.010	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.729	28054.531	85.87
DRAINAGE COLLECTED FROM LAYER 2	0.6824	2477.171	7.58
PERC./LEAKAGE THROUGH LAYER 3	0.589063	2138.299	6.55
AVG. HEAD ON TOP OF LAYER 3	0.0277		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.924	3354.073	
SOIL WATER AT END OF YEAR	0.924	3354.073	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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WARNING: SOLAR RADIATION FOR YEAR 1978 USED WITH PRECIPITATION FOR YEAR 5

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.04	0.77	2.04	0.14	0.69	0.00
	0.00	0.00	0.00	2.37	0.82	0.19
RUNOFF	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	0.827	0.550	1.988	0.115	0.747	0.000
	0.000	0.000	0.000	0.626	0.126	0.499
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.7760	0.0003	0.0970	0.0004	0.0004	0.0000
	0.0000	0.0000	0.0000	1.1150	0.0725	0.1776
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.4373	0.0039	0.1308	0.0036	0.0040	0.0000
	0.0000	0.0000	0.0000	0.4662	0.0936	0.2038

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.368	0.000	0.046	0.000	0.000	0.000
	0.000	0.000	0.000	0.529	0.036	0.084
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.631	0.001	0.095	0.001	0.001	0.000
	0.000	0.000	0.000	0.999	0.090	0.153

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.06	32887.805	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	5.478	19883.414	60.46
DRAINAGE COLLECTED FROM LAYER 2	2.2393	8128.645	24.72
PERC./LEAKAGE THROUGH LAYER 3	1.343179	4875.740	14.83
AVG. HEAD ON TOP OF LAYER 3	0.0886		
CHANGE IN WATER STORAGE	0.000	0.000	0.00
SOIL WATER AT START OF YEAR	0.924	3354.073	
SOIL WATER AT END OF YEAR	0.924	3354.073	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.006	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.62	1.07	1.53	0.36	0.61	0.08
	0.00	0.00	0.16	2.43	0.97	0.15
STD. DEVIATIONS	0.64	1.10	0.51	0.29	0.58	0.14
	0.00	0.00	0.35	1.60	0.43	0.04
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.006	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.014	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.901	0.900	1.348	0.396	0.516	0.066
	0.009	0.000	0.094	0.929	0.826	0.207
STD. DEVIATIONS	0.643	0.458	0.455	0.291	0.463	0.136
	0.016	0.000	0.211	0.540	0.706	0.166
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.2406	0.2640	0.0666	0.0003	0.0639	0.0001
	0.0000	0.0000	0.0000	1.0114	0.0521	0.0362
STD. DEVIATIONS	0.3288	0.3964	0.0603	0.0001	0.1181	0.0001
	0.0000	0.0000	0.0000	1.0113	0.0753	0.0791
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.1492	0.1843	0.0919	0.0037	0.0600	0.0008
	0.0004	0.0000	0.0002	0.4339	0.0666	0.0467
STD. DEVIATIONS	0.1767	0.2256	0.0635	0.0010	0.0934	0.0015
	0.0005	0.0000	0.0005	0.3240	0.0790	0.0879

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.1141	0.1376	0.0316	0.0002	0.0303	0.0000
	0.0000	0.0000	0.0000	0.4798	0.0256	0.0172
STD. DEVIATIONS	0.1560	0.2082	0.0286	0.0000	0.0560	0.0001
	0.0000	0.0000	0.0000	0.4797	0.0369	0.0375

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	8.97	(3.044)	32568.4	100.00
RUNOFF	0.006	(0.0140)	22.68	0.070
EVAPOTRANSPIRATION	6.193	(1.6559)	22480.35	69.025
LATERAL DRAINAGE COLLECTED FROM LAYER 2	1.73517	(1.32612)	6298.665	19.33982
PERCOLATION/LEAKAGE THROUGH LAYER 3	1.03765	(0.54734)	3766.661	11.56540
AVERAGE HEAD ON TOP OF LAYER 3	0.070	(0.054)		
CHANGE IN WATER STORAGE	0.000	(0.0000)	0.00	0.000

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.52	9147.600
RUNOFF	0.031	110.9363
DRAINAGE COLLECTED FROM LAYER 2	0.45030	1634.59302
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.111123	403.37509
AVERAGE HEAD ON TOP OF LAYER 3	6.622	
MAXIMUM HEAD ON TOP OF LAYER 3	10.932	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	87.1 FEET	
SNOW WATER	0.00	0.0000

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2150
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0130

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

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

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	0.1560	0.0130
2	0.3840	0.0320
3	0.0000	0.0000
SNOW WATER	0.000	

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Apr. 14,2008 01:49 PM (page 1)

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