



MAJOR PERMIT MODIFICATION Greater Lebanon Refuse Authority Phase II Expansion Permit Modification PADEP Permit No. 101544

VOLUME 3 of 3

Prepared for:

Greater Lebanon Refuse Authority
1610 Russell Road
Lebanon, Pennsylvania 17046

Prepared by:

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July 2018

File No. 02215800.05

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MAJOR PERMIT MODIFICATION

GREATER LEBANON REFUSE AUTHORITY Phase II Expansion Permit Modification PADEP Permit No. 101544

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FORM 14

OPERATION PLAN - PHASE II

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 14, reference the item number and identify the date prepared. The "date prepared/revised" on any attached sheets should match the "date prepared/revised" on this page.

General References: Chapters 273 and 277

SECTION A. SITE IDENTIFIER

Applicant/permittee: Greater Lebanon Refuse Authority

Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

SECTION B. TYPE OF FACILITY

☒ Municipal Waste Landfill ☐ Construction/Demolition Waste Landfill

SECTION C. GENERAL OPERATING DESCRIPTION

Based on the required maps and grids for a facility of this type, describe the:

1. Proposed landfill method and procedures that are to be established and followed for the life of the proposed site. Include daily procedures, inspection and monitoring of incoming waste, and daily closing procedures.
2. Sequence of landfilling activity, including the proposed filling schedule.
3. Type of landfill activity to be conducted at the proposed site.
4. Proposed engineering techniques.

SECTION D. SPECIFIC FEATURES

Describe the method and schedule for construction, operation, modification, use, maintenance and removal of the following unless their retention is proposed for postclosure land use:

1. Dams, embankments, ditches and other impoundments that are to be located on the proposed site, and adjacent total property owned by the applicant.
2. Borrow pits, soil storage and handling areas and structures that are to be located on the proposed site, total property or adequate properties off-site,
3. Scales and weigh stations, if required for municipal waste landfills.
4. Water and air pollution control facilities that are in any way related to the proposed facility.
5. Erosion control facilities to minimize the discharge of sediment from the proposed permitted site, total property, or associated properties off-site.
6. Equipment storage, maintenance, and other buildings.
7. Access roads that are to be located on the proposed permitted site, total property or associated properties off-site.
See narrative.

SECTION E. PERSONNEL TRAINING

Describe training procedures to be conducted for the handling and disposal of special handling waste.
See narrative.

SECTION F. CONSTRUCTION SCHEDULE

Describe the construction schedule in relation to the grid coordinate system for signs and markers. For a municipal waste landfill, also describe the sequence of operation relating to the grid coordinate system. Explain where uniform permanent physical markers will be placed, how these physical markers will be maintained and of what materials the markers will be constructed. Further, explain how the proposed disposal area perimeter will be distinguished from the perimeter of the total property. What will be written on the required sign, what will it be constructed of, and where will it be located?

See narrative.

SECTION G. SITE PREPARATION

Describe the site preparation plan/schedule for disposal of solid waste at the proposed facility. Include the following:

1. Identify the maximum and average daily weight or volume of waste to be accepted at the proposed site, and a detailed justification of these volumes.
See narrative.
2. For a municipal waste landfill, describe the method of compliance relating to measurement of waste. If 30,000 or more cubic yards of solid waste is expected to be accepted in a calendar year by this proposed facility for disposal, it must be weighed. The operator of this scale must be a licensed public weighmaster. Explain how the scale will be inspected and maintained to assure accuracy. If the proposed facility is not required to have a scale, explain how the waste will be accurately measured when it is received at the proposed facility.
See narrative.
3. For a demolition/construction waste landfill, describe the method of compliance relating to measurement of waste. Explain how this waste type will be accurately measured by weight or volume prior to unloading.
See narrative.

SECTION H. WATER QUALITY PROTECTION

Describe a plan that is consistent with basic limitations relating to operating requirements.

1. Has written approval been given by this Department for background groundwater monitoring? ☐ Yes ☒ No
If yes, what date _____
If not, explain.
Background water quality submitted in Phase I.
2. Has background groundwater monitoring begun? ☒ Yes ☐ No
If no, what is the expected date _____
If yes, when February 2016
3. How will the operator prevent unapproved special handling wastes and/or residual wastes from being accepted and disposed of at the site? How will the operator handle and dispose of approved special handling waste(s), and what specific measures will be taken to prevent exposure to landfill personnel, haulers and others? Explain.
See narrative.
4. How will the operator prevent hazardous and explosive wastes, and liquids from being accepted and disposed of at the site?
See narrative.
5. Is leachate recirculation planned? ☐ Yes ☒ No
If yes, explain.
What is ultimate disposition of leachate?

SECTION I. OPERATING HOURS

Provide the proposed operating hours of the facility. See narrative.

SECTION J. ACCESS PLAN

Describe the Access Road Plan, including designs, cross sections and specifications. Indicate design load limits, and identify maximum anticipated loading to be encountered.

1. Explain how the access roads and parking and maneuvering areas will be designed, constructed and maintained to prevent erosion and sediment to streams or runoff.
2. Will streams or waterways be crossed? ☐ Yes ☒ No
If yes, explain how the requirements of Chapter 105 will be met.
Has an application been filed for a Chapter 105 permit? ☐ Yes ☒ No
3. Describe the drainage system for temporary and permanent roads and parking and maneuvering areas to be located at the proposed facility.
See narrative.
4. Describe the materials to be used on permanent or temporary roads and parking and maneuvering areas at the proposed facility:
☒ paved asphalt
☒ gravel
☐ cinders
☐ other equivalent material - explain:
Will the grade of any access road be greater than 12% ☐ Yes ☒ No
If yes, explain.
5. Describe the locations, widths and methods of maintenance for all access roads to be located on the proposed permitted facility, and on the entire property.
See narrative.

SECTION K. ACCESS CONTROL PLAN

Describe the Access Control Plan, including:

1. Use and locations of fencing and barriers to control access. Include heights, dimensions and construction materials. Fences are required around impoundments, leachate collection and treatment systems and gas processing facilities, if these facilities have not been included within the site fence.
2. Site security provisions.
3. Describe the facility sign that will be placed at the junction of each access road and public road.

SECTION L. NUISANCE MINIMIZATION AND CONTROL PLAN

Describe the Nuisance Control Plan, and include details regarding the methods by which the operator will perform regular, frequent and comprehensive inspections to evaluate the effectiveness of the plan for Vectors, Odors, Noise, Dust, Litter, and Other Public Nuisances. The plan needs to include the following items:

1. An inventory and map of areas at the facility that has the potential to cause nuisances
 - Dominate wind direction
 - Hauling, truck staging, and radiation staging areas
 - Leachate and gas management components
 - Disposal areas, intermediate covered areas, anchor trenches, and trash relocation activities
 - Landfill cell construction, fill and capping sequences
 - Landfill siting and position to nearby residences

2. Description of nuisance related monitoring or response activities

- Organization flow chart with each person's duties and responsibilities with regard to this plan
- Notification list for the facility and respective agencies
- A description of how the facility will be operated to eliminate off-site nuisances
 - a. Monitoring frequency and locations
 - b. Inspections for odorous loads
 - c. Monitoring and inspections of the landfill's gas/odors controls
 - d. Dust suppression
- A description of internal and external communication and alarms

3. Describe the facilities meteorological monitoring program

- Meteorological weather station location
- Data to be collected
- Activities limited by the weather and the facilities threshold

4. Detailed plan for preventative maintenance and nuisance controls

- Description and location of portable/temporary odor controls
- Preventative nuisance measures used during the facilities construction
- Description of the nuisance suppression program and the location of any fixed odor controls
- Procedures for handling nuisance prone waste
- Dust minimization plan
- Employee and contractor training
- Inspection frequency for odor management equipment
- Emergency equipment

5. Provide specific countermeasures that will be undertaken by the facility in the event of a nuisance for:

- Dust suppression from hauling, waste placement, or processing activities
- Odors
- Vectors
- Landfill gas detection
- Litter
- Litter during windy conditions

6. Provide any additional information as requested by the Department, Host Municipality, or Host County.

SECTION M. LITTER CONTROL PLAN

Describe the Litter Control Plan, and explain how the operator will prevent litter from blowing or becoming deposited off-site, including:

1. The types, locations and maintenance procedures for litter fences to be used at the proposed facility.
2. The frequency of litter pick up and disposal.

SECTION N. SALVAGING

Explain if salvaging will occur on-site during hours of operation and non-operation. If yes, describe the methods of control over salvaging, and how salvaging will occur without interfering in the operation of the landfill. Further, describe the methods for on site movement and storage of salvaged materials, as well as off-site storage and transportation of salvaged materials.

SECTION O. AIR QUALITY CONTROL

Describe the methods to control dust, and minimize and control air pollution at the proposed facility from exceeding any ambient air quality standards.

SECTION P. WASTE PLACEMENT

1. Initial procedures for placement of waste on the liner system.
2. An explanation of the location(s) of unloading area(s) at the proposed facility, and methods by which loaded collection vehicles will be directed to unload promptly at these areas. Waste cannot be unloaded where continuous or intermittent contact would occur with the groundwater table.
3. Procedures for and the degree of compaction of solid waste. Describe the number and thickness of lifts, and explain how solid waste will be spread and compacted in layers.
See narrative.
4. Describe how the working face will be managed, and:
 - (i) compacted and covered on a daily basis for municipal waste landfills, and;
See narrative.
 - (ii) kept to a size which can easily be compacted for Construction/Demolition waste landfills;
See narrative.
 - (iii) how water that contacts the working face will be contained, and not combined, with surface water runoff.
See narrative.

SECTION Q. DAILY COVER

For a municipal waste landfill, describe the frequency of placement, composition, design requirements, storage duration and location(s), maintenance(including revegetation and erosion/sedimentation controls),and thickness of approved daily cover to be placed on exposed solid waste at the proposed site. Include a quality assurance plan.

SECTION R. INTERMEDIATE COVER

Describe the frequency of placement, composition, design requirements, storage duration and location(s), maintenance, and thickness of approved intermediate cover to be placed on partial or completed lifts at the proposed site. Explain how slopes, not to exceed 50%, will be maintained, covered, compacted, and revegetated to control erosion and sedimentation. Include a quality assurance plan and identify procedures to establish intermediate elevations.

SECTION S. FINAL COVER SCHEDULE

Describe the time period that approved final cover will be placed on the proposed site, the methods by which final cover will be placed, and composition and design requirements, including:

1. A cap (comprised of a uniform and compacted one (1) foot layer of clay or synthetic type material, if approved).
See narrative.
2. A drainage layer to prevent erosion and transmit flow of surface water.
See narrative.
3. A uniform and compacted layer of soil at least two (2) feet in thickness.
See narrative.

SECTION T. FINAL COVER CHARACTERIZATION

Describe the characteristics of final cover, including:

1. physical properties of final cover,
See narrative.
2. capability of controlling fires,
See narrative.
3. load bearing capacity,
See narrative.
4. capability of supporting vegetation,
See narrative.
5. prevention of nuisances,
See narrative.
6. Include a quality assurance plan, and identify procedures to establish final elevation.
See narrative.

SECTION U. FINAL CONFIGURATION

Describe the grade of the final slopes of the proposed facility, detailing design, installation, maintenance, slope stability, erosion control, compaction, seeding, revegetation, percolation rates, and surface runoff.

What will the maximum grade of the final surface be? 33%

What will the average grade of the final surface be? _____

Are terraces to be used on the final surface? ☒ Yes ☐ No

If yes, describe design, construction, grades and maintenance of the terraces.

See narrative.

Describe the drainage ditches that will be constructed in each horizontal terrace to convey flow of surface water.

See narrative.

Form 14 – Operation Plan – Phase II
Form 2540-PM-BWM0011, Rev. 6/2006
Greater Lebanon Refuse Authority (Permit No. 101544)
Heilmandale Expansion

C. GENERAL OPERATING DESCRIPTION

Based on the required maps and grids for a facility of this type, describe the:

- 1. Proposed landfill method and procedures that are to be established and followed for the life of the proposed site. Include daily procedures, inspections and monitoring of incoming waste, and daily closing procedures.**

The GLRA landfill has been permitted and operated for many years, and this submittal represents an expansion of the landfill. Landfill development will be by the area fill method as well as excavation and liner installation in stages. For further information, refer to the attached Operations Plan (**Attachment 14-A**).

- 2. Sequence of landfilling activity, including proposed filling schedule.**

Landfill pads will be constructed generally in numerical sequence as shown in the permit drawings. It is anticipated that the expansion area will be constructed over the course of approximately 10 to 15 years.

- 3. Type of landfill activity to be conducted at the proposed site.**

The sequence of landfilling activity is shown on the permit drawings, including the phased construction of the stormwater management plan, access roads, pad construction, leachate management systems, etc.

- 4. Proposed engineering techniques.**

The proposed engineering techniques, as outlined in the permit drawings, call for the excavation of soils and subsoils for use as cover material. Waste materials that are encountered will be disposed in a double-lined area of the landfill. These materials may be screened to recover soil material for use as daily cover. Following excavation to the elevations shown on the permit drawings and placement of subgrade fill as required, the liner and leachate collection systems will be installed. Additionally, stormwater management, access roads and leachate transmission features will be constructed.

Construction will be completed according to accepted engineering techniques with testing completed per the Construction Quality Assurance Plan and specifications (Form J). Each pad will be certified per the solid waste regulations.

D. SPECIFIC FEATURES

Describe the method and schedule for construction, operation, modification, use, maintenance and removal of the following unless their retention is proposed for postclosure land use:

- 1. Dams, embankments, ditches and other impoundments that are to be located on the proposed site, and adjacent total property owned by the applicant.**
The stormwater management facilities shown on the permit drawings will be constructed per the schedule shown on the drawings, and maintained as indicated in the written plan of operation. For further information, refer to the attached Operations Plan (**Attachment 14-A**).
- 2. Borrow pits, soil storage and handling areas and structures that are to be located on the proposed site, total property or adequate properties off-site.**
Refer to the attached Operations Plan (**Attachment 14-A**).
- 3. Scales and weigh stations, if required for municipal waste landfills.**
The existing scalehouse will continue to be used to weigh refuse vehicles, and will be maintained as necessary. The scale may be removed during site closure.
- 4. Water and air pollution control facilities that are in any way related to the proposed facility.**
Refer to the Permit Drawings, Form 25 – Leachate Management, Form G – Air Resource Protection, and the attached Operations Plan (**Attachment 14-A**).
- 5. Erosion control facilities to minimize the discharge of sediment from the proposed permitted site, total property, or associated properties off-site.**
Erosion and sedimentation control facilities will be constructed and maintained per the permit drawings and the Form I – Soil Erosion and Sedimentation Controls.
- 6. Equipment storage, maintenance and other buildings.**
This permit modification does not propose any additional buildings. The existing maintenance facility provides for equipment storage and maintenance, an employee lounge, conference rooms and offices. The facility will be utilized during active operations and during the post-closure period.
- 7. Access roads that are to be located on the proposed permitted site, total property or associated properties off-site.**
Refer to the attached Operations Plan (**Attachment 14-A**) and permit drawings.

E. PERSONNEL TRAINING

Describe training procedures to be conducted for the handling and disposal of special handling waste.

See Waste Acceptance Plan – Training (Section 4.A) in the attached Operations Plan (**Attachment 14-A Operations Plan**).

F. CONSTRUCTION SCHEDULE

Describe the construction schedule in relation to the grid coordinate system for signs and markers. For a municipal waste landfill, also describe the sequence of operation relating to the grid coordinate system. Explain where uniform permanent physical markers will be placed, how these physical markers will be maintained and of what materials the markers will be constructed. Further, explain how the proposed disposal area perimeter will be distinguished from the perimeter of the total property. What will be written on the required sign, what will it be constructed of, and where will it be located?

The construction schedule in relation to the grid coordinate system is as follows:

- a. Control points for both horizontal and vertical control have been established on site, and are shown on the permit drawings. These control points include existing steel pin point corners, concrete monuments, and existing steel well casings. Additional permanent concrete monuments will be field located and installed based on the coordinate system and datum of these points. This permanent physical survey control system consists of a minimum of two deep seated concrete monuments extending below the frost line and tied to the site grid control system. The monuments have been located on the site in areas which will allow for manual siting and will not be disturbed by ongoing activities. Additional monuments will be established as vertical control benchmarks, tied to both site elevations and USGS control points. The perimeter of a disposal area will be marked before beginning municipal waste disposal within the expansion area.

Waste placement will be referenced to site grid location by landfill personnel on a daily basis by recording the alpha-numeric disposal location per the grid location of the day's working area according to the grid system shown on the plans.

- b. As each pad and the piping system and related support facilities are constructed, the grid coordinate system will be used for stake-out and as-built preparation.
- c. The disposal area perimeter will initially be field surveyed and staked for construction. Following construction, the limits of the landfilled area will be delineated by perimeter markers as shown on the permit drawings, which will be located at approximately 200 foot intervals.
- d. A sign identifying the site, site address, permit number and related rules is located near the facility entrance.

G. SITE PREPARATION

Describe the site preparation plan/schedule for disposal of solid waste at the proposed facility. Include the following:

1. **Identify the maximum and average daily weight or volume of waste to be accepted at the proposed site, and a detailed justification of these volumes.**

Refer to the attached Operations Plan (**Attachment 14-A**).

2. **For a municipal waste landfill, describe the method of compliance relating to the measurement of waste. If 30,000 or more cubic yards of solid waste is expected to be accepted in a calendar year by this proposed facility for disposal, it must be weighed. The operator of this scale must be a licensed public weighmaster. Explain how the scale will be inspected and maintained to assure accuracy. If the proposed facility is not required to have a scale, explain how the waste will be accurately measured when it is received at the proposed facility.**

Refer to the attached Operations Plan (**Attachment 14-A**).

3. **For a demolition/construction waste landfill, describe the method of compliance relating to the measurement of waste. Explain how this waste type will be accurately measured by weight or volume prior to unloading.**

Not applicable.

H. WATER QUALITY PROTECTION

Describe a plan that is consistent with basic limitations relating to operating requirements.

1. **Has written approval been given by this Department for background groundwater monitoring?**

Background groundwater monitoring results are included in the Phase I – Form 8 – Baseline Groundwater Analyses.

2. **Has background water quality monitoring begun?**

Background groundwater monitoring results are included in the Phase I – Form 8 – Baseline Groundwater Analyses. Background water quality monitoring was completed during first and second quarter 2016.

3. **How will the operator prevent unapproved special handling waste and/or residual waste from being accepted and disposed of at the site? How will the operator handle and dispose of approved special handling waste(s), and what specific measures will be taken to prevent exposure to landfill personnel, haulers and others? Explain.**

Refer to the attached Operations Plan (**Attachment 14-A**).

4. **How will the operator prevent hazardous and explosive wastes, and liquids from being accepted and disposed of at the site?**

Refer to the attached Operations Plan (**Attachment 14-A**).

5. **Is leachate recirculation planned? What is the ultimate disposition of leachate?**

Leachate recirculation will only be competed as an emergency procedure. Leachate will be discharged to the County of Lebanon sanitary sewer system.

I. OPERATING HOURS

Provide the proposed operating hours of the facility.

Refer to the attached Operations Plan (**Attachment 14-A**).

J. ACCESS PLAN

Describe the Access Road Plan, including designs, cross sections and specifications. Indicate design load limits, and identify maximum anticipated loading to be encountered.

- 1. Explain how the access roads and parking and maneuvering areas will be designed, constructed and maintained to prevent erosion and sediment to streams or runoff.**
The Access Road Plan is shown on the Permit Drawings. Refer to the Form I – Soil Erosion & Sedimentation Controls.

- 2. Will streams and waterways be crossed? If yes, explain how the requirements of Chapter 105 will be met.**

Refer to the Form I – Soil Erosion & Sedimentation Controls.

- 3. Describe the drainage system for temporary and permanent roads and parking and maneuvering areas to be located at the proposed facility.**

Refer to the Form I – Soil Erosion & Sedimentation Controls.

- 4. Describe the materials to be used on permanent or temporary roads and maneuvering areas at the proposed facility**

Refer to the Permit Drawings for details regarding roads. Refer to the Form I – Soil Erosion & Sedimentation Controls.

- 5. Describe the locations, widths and methods of maintenance for all access roads to be located on the proposed permitted facility, and on the entire property.**

Refer to the Permit Drawings for details regarding roads. Refer to the Form I – Soil Erosion & Sedimentation Controls. Roads will be maintained as necessary to provide all-weather accessibility.

K. ACCESS CONTROL PLAN

Describe the Access Control Plan, including:

- 1. Use and locations of fencing and barriers to control access. Include heights, dimensions and construction materials. Fences are required around impoundments, leachate collection and treatment systems and gas processing facilities, (if the facility will accept putrescible waste), if the facilities have not been included within the site fence.**

Refer to the attached Operations Plan (**Attachment 14-A**).

- 2. Site security provisions.**

Refer to the attached Operations Plan (**Attachment 14-A**).

- 3. Describe the facility sign that will be placed at the junction of each access road and public road.**

Refer to the attached Operations Plan (**Attachment 14-A**).

L. NUISANCE MINIMIZATION AND CONTROL PLAN

Describe the Nuisance Control Plan, and include details regarding the methods by which the operator will perform regular, frequent and comprehensive inspections to evaluate the effectiveness of the plan for Vectors, Odors, Noise, Dust, Litter, and Other Public Nuisances. The plan needs to include the following items:

1. An inventory and map of areas at the facility that has the potential to cause nuisances

- **Dominate wind direction**
- **Hauling, truck staging, and radiation staging areas**
- **Leachate and gas management components**
- **Disposal areas, intermediate covered areas, anchor trenches, and trash relocation activities**
- **Landfill cell construction, fill and capping sequences**
- **Landfill siting and position to nearby residences**

Refer to Nuisance Minimization and Control Plan included in the attached Operations Plan (**Attachment 14-A**).

2. Description of nuisance related monitoring or response activities

- **Organization flow chart with each person's duties and responsibilities with regard to this plan**
- **Notification list for the facility and respective agencies**
- **A description of how the facility will be operated to eliminate off-site nuisances**
 - a. **Monitoring frequency and locations**
 - b. **Inspections for odorous loads**
 - c. **Monitoring and inspections of the landfill's gas/odors controls**
 - d. **Dust suppression**
- **A description of internal and external communication and alarms**

Refer to Nuisance Minimization and Control Plan included in the attached Operations Plan (**Attachment 14-A**).

3. Describe the facilities meteorological monitoring program

- **Meteorological weather station location**
- **Data to be collected**
- **Activities limited by the weather and the facilities threshold**

Refer to the Form 54, submitted to PADEP in 2005.

4. Detailed plan for preventative maintenance and nuisance controls.

- **Description and location of portable/temporary odor controls**
- **Preventative nuisance measures used during the facilities construction**

- **Description of the nuisance suppression program and the location of any fixed odor controls**
- **Procedures for handling nuisance prone waste**
- **Dust minimization plan**
- **Employee and contractor training**
- **Inspection frequency for odor management equipment**
- **Emergency equipment**

Refer to Nuisance Minimization and Control Plan included in the attached Operations Plan (**Attachment 14-A**).

5. Provide specific countermeasures that will be undertaken by the facility in the event of a nuisance for:

- **Dust suppression from hauling, waste placement, or processing activities**
- **Odors**
- **Vectors**
- **Landfill gas detection**
- **Litter**
- **Litter during windy conditions**

Refer to Nuisance Minimization and Control Plan included in the attached Operations Plan (**Attachment 14-A**).

6. Provide any additional information as requested by the Department, Host Municipality, or Host County

Not applicable, no additional information was requested.

M. LITTER CONTROL PLAN

Describe the Litter Control Plan, and explain how the operator will prevent litter from blowing or becoming deposited off-site, including:

1. The types, locations and maintenance procedures for litter fences to be used at the proposed facility.

Refer to the Nuisance Minimization and Control Plan included in the attached Operations Plan (**Attachment 14-A**).

2. The frequency of litter pick up and disposal.

Refer to the Nuisance Minimization and Control Plan included in the attached Operations Plan (**Attachment 14-A**).

N. SALVAGING

Explain if salvaging will occur on-site during hours of operation and non-operation. If yes, describe the methods of control over salvaging, and how salvaging will occur without interfering in the operation of the landfill. Further, describe the methods for on site movement and storage of salvaged materials, as well as off-site storage and transportation of salvaged materials

No salvaging will occur.

O. AIR QUALITY CONTROL

Describe the methods to control dust, and minimize and control air pollution at the proposed facility from exceeding any ambient air quality standards.

Refer to the Form G(A) – Air Resources Protection – Dust Emissions Estimate and Control Plan and the Form G(B) – NMOC Emissions Estimate and Control Plan.

P. WASTE PLACEMENT

1. Initial procedures for placement of waste on the liner system.

Refer to the attached Operations Plan (**Attachment 14-A**).

2. An explanation of the location(s) of unloading area(s) at the proposed facility, and methods by which loaded collection vehicles will be directed to unload promptly at these areas. Waste cannot be unloaded where continuous or intermittent contact would occur with the groundwater table.

Refer to the attached Operations Plan (**Attachment 14-A**).

3. Procedures for and the degree of compaction of solid waste. Describe the number and thickness of lifts, and explain how solid waste will be spread and compacted in layers.

Refer to the attached Operations Plan (**Attachment 14-A**).

4. Describe how the working face will be managed, and:

- (i) compacted and covered on a daily basis for municipal waste landfills, and;**
- (ii) how water that contacts the working face will be contained, and not combined, with surface water runoff.**

Refer to the attached Operations Plan (**Attachment 14-A**).

Q. DAILY COVER

Describe the frequency of placement, composition, design requirements, storage duration and location(s), maintenance (including revegetation and erosion/sedimentation controls),

and thickness of approved daily cover to be placed on exposed solid waste at the proposed site. Include a quality assurance plan.

Refer to the attached Operations Plan (**Attachment 14-A Operations Plan**).

R. INTERMEDIATE COVER

Describe the frequency of placement, composition, design requirements, storage duration and location(s), maintenance, and thickness of approved intermediate cover to be placed on partial or completed lifts at the proposed site. Explain how slopes, not to exceed 50%, will be maintained, covered, compacted, and revegetated to control erosion and sedimentation. Include a quality assurance plan and identify procedures to establish intermediate elevations.

Refer to the attached Operations Plan (**Attachment 14-A Operations Plan**).

S. FINAL COVER SCHEDULE

Describe the time period that approved final cover will be placed on the proposed site, the methods by which final cover will be placed, and composition and design requirements, including:

- 1. A cap (comprised of a uniform and compacted one (1) foot layer of clay or synthetic type material, if approved).**
- 2. A drainage layer to prevent erosion and transmit flow of surface water.**
- 3. A uniform and compacted layer of soil at least two (2) feet in thickness.**

Refer to the attached Operations Plan (**Attachment 14-A Operations Plan**) and the Form 24 – Liner System – Phase II.

T. FINAL COVER CHARACTERIZATION

Describe the characteristics of final cover, including:

- 1. physical properties of final cover,**
- 2. capability of controlling fires,**
- 3. load bearing capacity,**
- 4. capability of supporting vegetation,**
- 5. prevention of nuisances,**
- 6. Include a quality assurance plan, and identify procedures to establish final elevation.**

Refer to the Form J – Soils Information – Phase II and the Form 24 – Liner System – Phase II.

U. FINAL CONFIGURATION

Describe the grade of the final slopes of the proposed facility, detailing design, installation, maintenance, slope stability, erosion control, compaction, seeding, revegetation, percolation rates, and surface runoff.

What will the maximum grade of the final surface be?

What will the average grade of the final surface be?

Are terraces to be used on the final surface? If yes, describe design, construction, grades and maintenance of terraces.

Describe the drainage ditches that will be constructed in each horizontal terrace to convey flow of surface water.

Refer to the Permit Drawings, Form J – Soils Information – Phase II and the Form 24 – Liner System – Phase II.

FORM 14 – ATTACHMENT A

Operations Plan



Operations Plan

Presented to:

Greater Lebanon Refuse Authority (Permit No. 101544)

Greater Lebanon Refuse Authority
1610 Russell Road
Lebanon, PA 17046

Presented by:

SCS ENGINEERS
22 Denver Road, Suite E
Denver, PA 17517
(610) 382-3050

July 2018
File No. 02215800.05

Offices Nationwide
www.scsengineers.com

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1 DAILY OPERATIONS

1.A OPERATING HOURS

The proposed operating hours for incoming refuse delivery to the facility are:

Monday through Friday:	7:00 a.m. to 4:00 p.m.
Saturday:	8:00 a.m. to noon

1.B WASTE DISPOSAL LIMITS AND MEASUREMENT

The average and maximum daily waste receipt volumes will remain the same as currently approved: 750 tons per day maximum daily average and 1,100 tons per day maximum.

GLRA weighs solid waste as it is received. The scale used to weigh solid waste when it is received is a 70 foot long, 80 ton capacity scale which meets the requirements of the Measures Act of 1965 (73 P.S. 1651-1692), and the regulations thereunder. The operator of the scale will be a licensed public weighmaster under the Public Weighmasters Act (73 P.S. 1771-1796) and the regulations thereunder.

1.C ACCESS CONTROL

A sign at the junction of the access road and Russell Road identifies the Greater Lebanon Refuse Authority (GLRA) Landfill. It is constructed of a durable, weather-resistant material and is at least 3 feet by 4 feet in size with a light background and contrasting letters and numbers of a minimum height of 3 inches that can be easily seen and read. The existing sign will remain in use. Additional signage will be placed at the gated entrance to the Heilmandale Expansion area to direct waste vehicles to the existing entrance to weigh-in. Vehicles will then be directed by signage to the Heilmandale Expansion disposal area.

A gate will be maintained at potential vehicular access points to block unauthorized access to the site when an attendant is not on duty, including the main access road and alternative access off of Russell Road. GLRA has constructed and will maintain a 6 foot fence around the site, including impoundments, leachate collection and treatment systems and gas processing facilities, sufficient to prevent unauthorized access. Access to the site will be limited to those times when an attendant is on duty.

Visitors must sign into the facility and be escorted. During non-operational hours, entrances are closed with a security gate. Waste vehicles will be directed to the existing entrance to weigh-in, then across Russell Road to the Heilmandale Expansion area. The entrance to the Heilmandale Expansion area will be controlled with an attendant or security gate that limits access to those vehicles that have been weighed-in.

1.D ACCESS ROADS

Maintenance will include regrading the surface, adding road material as needed, and regrading adjacent ditches/swales. In general, the repairs will be made to maintain an all-weather roadway

Access roads are designed, constructed and maintained to prevent erosion and to minimize sediment to streams or runoff outside the site. The access road has a drainage system that is compatible with the natural drainage system, structurally stable and will pass safely the peak flow from a 25-year, 24-hour precipitation event. For roads that are used or in existence for more than 30 days, the drainage system will include sloped or crowned road surfaces, cross drains or culverts, stabilized ditches, erosion resistant surfacing, sediment traps and other appropriate sediment control measures as required. The access road from Russell Road to the scale is paved with asphalt or concrete. The access road will be capable of withstanding the 84,000 load limits projected by GLRA. The maximum sustained grade of an access road will not exceed 12 percent. GLRA will maintain a minimum cartway of twenty-two feet for two-way traffic. The access road negotiable by loaded collection vehicles will be provided from the entrance gate of the facility across the scale and to each unloading area, treatment facility or impoundment located on the site. Groundwater monitoring points and other monitoring points will be provided access.

Access roads will be constructed on dry and stable areas. Prior to the construction of a road, topsoil will be removed and immediately used as final cover, or stored on a stable site and protected against erosion and compaction. Disturbed areas adjacent to a road will be vegetated or otherwise stabilized to minimize erosion. The access road will be maintained to control dust and to prevent or control the tracking of mud on and off the site. The access road has been constructed and will be maintained to allow the orderly egress and ingress of vehicular traffic when the facility is in operation, including during inclement weather.

1.E EQUIPMENT

GLRA will maintain on the site equipment necessary for the operation of the facility in accordance with the permit. Standby equipment will be located on the site or at a place where it can be available within 24 hours. If a breakdown of equipment occurs, the operator will utilize standby equipment as necessary.

1.F SALVAGING

Salvaging of materials from the working face will not be allowed. As required by Act 101, GLRA will place containers for the delivery of recyclables to the site. These containers are near the scale off of Russell Road.

1.G RECORD KEEPING

Records keeping will be done on forms supplied by the Department of Environmental Resources and will be consistent with 273.311(b), 273.312, and 273.313. Specific information to be recorded will include:

1. Type and quantities of waste received.
2. The portion of the landfill used - referring by coordinates to the area used.
3. Deviations from operating plans and specifications.

No hazardous waste, or liquids will be accepted at the site. No residual waste or pathological infectious or chemotherapeutic waste will be accepted without first submitting the appropriate "Industrial Waste Disposal at Permitted Landfill Site" Forms for approval by the Department, and receiving written approval.

2 COMPACTION AND COVER

2.A UNLOADING AND COMPACTION

An attendant or signage will direct vehicles to the unloading area, where the operator will allow collection vehicles to unload waste at the toe of the working face. As waste is dumped from the trucks, it will be spread and compacted by multiple passes of a compactor in layers that typically do not exceed two feet in depth.

The working face will be kept to a size which can be readily compacted and covered daily with available equipment. Spotters will remove items larger than 15 inches from the initial 8 foot lift of residential type waste to be placed directly over the protective cover, unless bales are utilized in this lift. Bales will be inspected to remove protruding objects which could penetrate the drainage layer. Dumped waste will be inspected for unapproved waste as described in **Section 4**.

2.B BORROW AREAS

Borrow areas on site are limited to the areas to be excavated for pad installation as shown on the permit drawings. Off-site soils will be purchased from approved sources operated by commercial contractors who will be responsible for securing necessary Department permits and operating pursuant to Department regulations.

2.C SOIL STOCKPILES

Soil stockpiling will take place in future pad areas, and within the limits of the existing and proposed soil borrow areas located across Heilmandale Road; and during site operation, soils will be excavated and hauled to the stockpile areas, revegetated as necessary, and removed from the stockpiles for use as daily, intermediate, and final cover. Stockpile maintenance includes prompt revegetation, and the “active” side of the piles will generally be kept to the interior side of the pile to minimize visibility to the public. Stockpiles located outside of the stormwater management system will have silt fence installed.

2.D TOPSOIL STORAGE

Topsoil will be removed in a separate layer prior to preparation of an area for disposal or other surface disturbances. If topsoil or other materials removed are not promptly redistributed as cover, they will be stockpiled, temporarily vegetated and protected from wind and water erosion.

2.E DAILY COVER

A uniform and compacted cover of the approved daily cover material at least six inches in thickness or foam and meeting the requirements of 25 PA 273.232 will be placed on exposed solid waste at the end of each working day or at the end of every 24 hours, whichever interval is less. A 5-day supply of cover material will be maintained on the site. GLRA is currently approved to use foam, tarps and auto shredder fluff as alternate daily covers.

2.F INTERMEDIATE COVER AND SLOPES

A uniform and compacted intermediate cover meeting the requirements of 25 PA 273.233 will be placed within seven days of waste disposal on the following:

1. Each partial lift for which GLRA intends to place no additional waste for 6 months.
2. Each partial or completed lift that represents final permitted elevations for that part of the facility.

If soil or soil-like material is used, the intermediate cover layer will be at least 12 inches thick.

A five-day supply of cover material will be maintained on the site. Areas on which intermediate cover has been placed, and on which neither waste nor final cover is placed within 30 days thereafter, will be temporarily revegetated and protected against erosion and sedimentation. Intermediate slopes constructed during daily landfilling activities may not exceed 50 percent.

2.G FINAL COVER AND GRADING

GLRA will place final cover meeting the requirements of 25 PA 273.234 within one year after disposal in the final lift ceases or as soon thereafter as weather permits unless a later period is necessary to protect the cap and drainage layer from differential settlement of waste at the facility.

GLRA will not leave final slopes that have a grade exceeding 33 percent, including slopes between benched terraces. Terraces will be maintained, including the removal of sediment and including maintaining a ditch along the inside of each terrace as shown in the plans.

Further information regarding the Final Cover layer is provided in the Permit Drawings, Form J – Soils Information – Phase II and the Form 24 – Liner System – Phase II.

2.H REVEGETATION

Revegetation requirements are provided in the Form H - Revegetation.

3 EROSION AND SEDIMENTATION CONTROL

Detailed information on erosion and sediment controls is provided in the Form I - Erosion and Sediment Controls.

When rills or gullies deeper than nine inches form, they will be filled or graded and reseeded. Rills or gullies of less than nine inches will be stabilized and reseeded if the rill or gullies are disruptive to the approved post closure land use or may result in additional erosion and sedimentation.

3.A SEDIMENTATION PONDS

Surface drainage from the disturbed area will be passed through a sedimentation pond before leaving the site. Sedimentation ponds and other treatment facilities will be maintained until removal of the ponds and facilities is approved by PADEP. The ponds are designed, constructed and maintained to prevent short circuiting to the maximum extent possible.

Sediment in the basins will be removed when the sediment reaches the sediment clean-out elevation as indicated by the basin marker, or sooner. These facilities will be permanently left on site following closure.

3.B DISCHARGE STRUCTURES

Discharge from dams, ponds, embankments, impoundments and diversions will be controlled by energy dissipaters, riprap channels or other devices as necessary to reduce erosion, to prevent deepening or enlargement of stream channels and to minimize disturbance to surface and groundwater.

4 WASTE ACCEPTANCE PLAN

In operating the GLRA landfill, its employees have the responsibility of carefully and properly managing wastes. Every employee must be alert to prevent wastes that are defined as hazardous from being disposed of at the landfill and for certain that special wastes are specifically approved for disposal at the site. Each employee must be able to recognize and identify any questionable waste that arrives at the landfill, and to respond properly.

Potential residual or special handling waste must undergo testing and analysis prior to disposal. No hazardous waste may be disposed of at the site. This approval process has two basic purposes:

1. To determine the proper method of management for the waste.
2. To confirm that the site is designed to properly dispose of or handle the waste.

Once a residual/special waste has been identified, analyzed and approved by PADEP, it may be accepted. Note that special handling may be a part of the approval process.

4.A TRAINING

Employees will be trained to be on the lookout for questionable or hazardous waste. Questionable wastes can arrive at the sanitary landfill anytime - brought by anyone in any size or type of load. The GLRA personnel training courses (and refresher courses) will also describe what handling precautions will be taken with each special wastes. Employees will be trained in the following areas.

Identifying Questionable Waste

Employees will be trained to look for:

- Vehicle type - vacuum/tank trucks - name on side
- New customers - ask what they're carrying
- Warning labels on containers; drums, buckets, cans, boxes, crates
- leaking loads, sludges or semi-solids, powders, liquids of any kind, or oily wastes
- Containers: boxes, cans, crates, drums - anything that could contain hazardous or questionable waste

Proper Response if Employees Identify a Questionable Waste:

What should be done at the gate or scale:

1. Don't allow the customer to unload.
2. Obtain driver's name and vehicle license number.
3. Obtain company name, address and location of where the waste came from
4. Obtain name and telephone number of the company's representative.

5. Direct driver to park in the holding area.
6. Contact your supervisor immediately and give him/her all information.

NOTE: Do not accept any load with unusual or unfamiliar paperwork. Contact the supervisor immediately and don't sign anything.

What employees should do if someone is unloading within the facility:

1. Stop them from unloading.
2. Follow the steps listed above.
3. Isolate and secure the immediate area if necessary.
4. Contain the material if it is a type of waste that could spread.
5. Contact your supervisor.

4.B APPROVAL PROCESS FOR POTENTIALLY RESIDUAL/SPECIAL HANDLING WASTES

GLRA does not require approval for wastes generated from:

- general households
- landscape waste
- construction debris (not containing asbestos)

While not being considered hazardous, most industrially-generated wastes will require special approval - and are then called, residual wastes. If PADEP approves a residual waste as suitable for disposal at the GLRA landfill, additional approval or disposal procedures may be appropriate. Special handling instructions will be given, if required.

Approval Process for Special/Residual Wastes

Waste not clearly identified above needs approval by PADEP for disposal at the GLRA landfill. These wastes are any solid or semi-solid material, and associated containers generated as a direct or indirect result of a manufacturing process or from the removal of contaminant(s) from the air, water or land. Analysis of these wastes must be approved by a certified laboratory prior to receipt at the GLRA Landfill. This includes but is not limited to industrial process waste, hospital wastes and pollution control waste.

The approval process, briefly outlined, generally involves the forwarding of the prescribed paperwork (PADEP Forms) and a representative sample of the waste for laboratory analysis. Upon receipt of lab results, disposal approval is indicated by the assignment of a GLRA Waste Code, and approval is sought from PADEP if necessary.

Approval/Denial: If the Landfill or PADEP does not approve a waste material for management by GLRA, no Waste Code will be issued for the waste. The reasons for non-approval of the

waste will be communicated to the generator. Waste materials for which no waste code is issued will not be received at the landfill.

Non-Hazardous (Special Waste Manifest): All special waste that receive approval will require a non-hazardous waste manifest. This manifest is to be completed by the generator and transporter, then sent with the driver of each load. The landfill checker will then complete the destination section and give the driver a copy. Another copy will go back to the generator to verify final destination. One copy will be permanently filed at the landfill office. No special waste will be accepted without a non-hazardous manifest. The final copy of the manifest will be given to the spotter or operator at the working face by the driver prior to unloading.

Waste Discrepancy/Rejected Load Report: This report will be completed when:

- A. A special waste arrives without a non-hazardous waste manifest;
- B. A special waste arrives and the waste material does match the description on the non-hazardous waste manifest;
- C. A special waste arrives and the non-hazardous waste manifest information is not complete or incorrect.

The report will then be permanently filed at the landfill office.

Radioactive Wastes: It is GLRA's policy to prohibit the disposal of any radioactive material at its landfill, except where specifically allowed by state and federal law.

Handling Precautions: When the landfill desires a special waste for disposal, it will forward the paperwork to the PADEP with all necessary background data to obtain approval for disposal. Along with analysis and approval, the Forms will contain recommendations for protective measures during transport, handling and disposal of the waste during its review. The PADEP may comment on the handling precautions

The special waste manifest accompanying the waste must include the specific handling precautions, if any, prescribed by the GLRA and PADEP. The manifest will be carried by the driver and copies distributed to GLRA personnel.

5 NUISANCE MINIMIZATION AND CONTROL PLAN

Greater Lebanon Refuse Authority (GLRA) has established a Nuisance Minimization and Control Plan to minimize and control hazards or nuisances that may arise from the handling and disposal of solid waste, collection and treatment of leachate, and the generation, collection, and distributions of methane gas. The following plan outlines GLRA's actions in relating to the prevention and mitigation of conditions that may cause a nuisance to the surrounding community and neighbors.

The site superintendent will be responsible for maintaining routine nuisance control inspections to detect potential nuisances to the neighborhood. The superintendent will also maintain a log of complaints from residents and/or DEP relative to legitimate nuisances, and will take steps to eliminate those nuisances if possible.

5.A ODORS

Measures to control odors have been identified and are controlled at the source before they become a nuisance. Odors will be controlled by the prompt placement of cover soils, the use of odor neutralizing sprays, the collection of landfill gas, and by the routine inspection to identify and correct and situation which causes or contributes to odors.

5.B DUST AND MUD

Dust control measures will be employed so to not cause or contribute to any exceedance of ambient air quality standards. Water from the mobile water tank truck, or other dust suppressants, will be used to control fugitive dust. A power sweeper will be used to control the accumulation of mud on paved roadways. Daily logs of each vehicle's usage shall be maintained. Open burning will not be conducted at the facility.

5.C NOISE

Noise will be controlled by insuring that all equipment is operated with the required muffler systems functioning properly, and in the manner intended by the manufacturer. Equipment will be operated in the appropriate gear to minimize racing the engine(s), and at speed limits appropriate to site conditions.

5.D VECTORS

GLRA will minimize the attraction, harborage or breeding of vector by placement of daily, intermediate and final cover. Twice monthly inspections and necessary measures by licensed extermination services will be contracted for if there is any evidence of vector infestation. Additionally, standing or ponded water will be prevented or minimized at the site.

GLRA has a Canada Goose Depredation Permit (No. 00000001A) from the Department of the Interior US Fish and Wildlife Services. The depredation order provides the facility regulatory

authorization to destroy resident Canada goose nests and eggs on the property when necessary to resolve or prevent injury to people, property, or other interests. The order does not authorize the killing of any other migratory bird species or destruction of any nest or eggs other than those of resident Canada geese.

5.E LITTER

GLRA utilizes portable litter fences on the active landfill area that can be positioned downwind to control litter during windy conditions. The landfill supervisor will observe the wind direction and daily weather forecast so the portable litter fencing is placed in the best locations to collect any windblown trash. The fences may be moved if the wind direction changes. At the end of each day litter will be collected from the litter fences and disposed of at the working face.

Incoming waste hauling vehicles must be tarped and remain tarped until they reach the disposal area. Once the waste truck is unloaded the driver must ensure that waste has been discharged. At least once a week or more in necessary, litter crews will collect any paper or waste found on the inside access roads. Crews collect the litter in garbage bags and dispose of them at the working face. Should litter from a wind event occur and deposit litter on the site roads or a site perimeter public road a crew will be dispatched to that area.

Fences or other barriers sufficient to control blowing litter will be located in the immediate operating area downwind from the working face. Fences or other barrier will be constructed of mesh, snow fencing or other material approved by the PADEP. Litter will be collected from the site boundary, roadways, tree line barriers and other barriers weekly, and disposed or stored unless a different frequency is approved by PADEP. In generally, litter control includes:

- Perimeter fence - chain link or similar type
- Snow fencing or equivalent in general fill area (from time to time location changes)
- Active fill area kept to smallest working face as practical.
- Power sweeper to be used on paved roads.
- Laborers to pick up isolated wind-blown litter

Form 18
Water Quality
Monitoring System



FORM 18 WATER QUALITY MONITORING SYSTEM PHASE II

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 18, reference the item number and identify the date prepared. The "date prepared/revised" on any attached sheets needs to match the "date prepared/revised" on this page.

General References: Sections 273.281-273.283, 277.281-277.283, 279.233, 281.254, 283.233

SECTION A. SITE IDENTIFIER

Applicant/permittee: Greater Lebanon Refuse Authority

Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

SECTION B. FACILITY INFORMATION

County: Lebanon

Township or Municipality: North Lebanon and North Annville Townships

Anniversary Date (mm/dd/yyyy): _____

Owner/Operator: Greater Lebanon Refuse Authority

Address: 1610 Russell Road, Lebanon, PA 17042

Phone: 717-867-5790

Consultant: SCS Engineers

Address: 22 Denver Road, Suite E, Denver, PA 17517

Phone: 610-382-3050

Driller: AAA Quality Wells & Pumps, Inc. License Number: 1271

Address: Box 117, Schaeffer Road, Lebanon, PA 17042

Phone: 717-274-2584

To be submitted on completion of Ground Water Monitoring System and prior to Phase II approval.

SECTION C. GENERAL MONITORING INFORMATION (Attach Additional Sheets As Needed)

Total Number of Monitoring Points (including wells, springs, etc.) see Water Quality Monitoring Plan

Number of Upgradient Wells see Water Quality Monitoring Plan

Number of Downgradient Wells see Water Quality Monitoring Plan

Number of leachate detection monitoring points see Water Quality Monitoring Plan

Number of monitoring points other than wells or leachate detection monitoring points see Water Quality Monitoring Plan

Description of other monitoring points see Water Quality Monitoring Plan

Number of water-bearing zones monitored see Water Quality Monitoring Plan

Characterization of water-bearing zones monitored (thickness, lithology, grain size, etc.) see Form 7 - Hydrogeologic Information

Name and Date of Topographic Map _____

DEP topographic map code: _____

SECTION D. MONITORING POINT GEOGRAPHIC AND HYDROGEOLOGIC DESCRIPTORS

ALL MONITORING POINTS MUST HAVE AN ASSOCIATED LATITUDE AND LONGITUDE DETERMINED ACCURATELY TO THE NEAREST ONE TENTH OF A SECOND (DD' MM' SS.S'). USE ABBREVIATIONS/ CODES LISTED ON PAGE 4 WHERE APPROPRIATE.

When additional space is needed use copies of this format.

Monitoring Point Number ⁽¹⁾	M-0L6 (D)	M-008A (D)	M-010A (D)	M-011 (D)
Latitude	40° 22' 24"	40° 22' 13"	40° 22' 22"	40° 22' 10"
Longitude	76° 29' 33"	76° 29' 17"	76° 29' 3"	76° 29' 10"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR	AR	AR	AR
Completion Date (mm/dd/yyyy)	06/09/1994	06/04/1996	12/01/1994	04/30/1976
Total Depth (ft.)	48	45	80	27
Depth to Bottom of Casing (ft.)	48	45	80	27
Ground Surface Elevation		483.60	519	485.20
Measuring Point Elevation ⁽⁷⁾		485.54	522.22	487.78
Method of Measuring Elevation ⁽⁹⁾				
Measuring Point Description ⁽¹⁰⁾	TWC	TWC	TWC	TWC
Exposed Casing - above ground surface (ft.)	2	2.5	2	2.5
Well Casing Material ⁽¹¹⁾	PVC	PVC	PCV	PVC
Well Casing Diameter (in.)	4	4	4	4
Monitoring Point Number ⁽¹⁾	M-0L6 (D)	M008A (D)	M-010A (D)	M-011 (D)
Depth to top of screened Interval (ft)	8	15	50	5
Depth to bottom of screened Interval (ft)	48	45	80	27
Screen Slot Size (in.)		0.020	0.020	
Screen Material Type ⁽¹¹⁾	PVC	PVC	PVC	PVC
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾				
Interval Grouted (Depth Range, ft.)				
Grout Type ⁽¹³⁾				
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)	6	6	6	6
Protective Casing Material ⁽¹¹⁾	SS	SS	SS	SS

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)	Y	Y	Y	Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

SECTION D. MONITORING POINT GEOGRAPHIC AND HYDROGEOLOGIC DESCRIPTORS (Continued)

Definitions and abbreviations/codes are listed below:

- (1) Number all monitoring points consecutively and permanently. The number should be followed by a 'U' or 'D' to designate upgradient or downgradient.
- (2) Surveyed by Datum (SD), USGS Quad Sheet (UQ).
- (3) Well (W), Spring (S), Boring (B), Well/Boring (WB), Stream (ST).
- (4) Detection (D), Assessment (A), Corrective Action (C).
- (5) Give reference to Code Number.
- (6) Air Rotary (AR), Mud Rotary (MD), Reverse Rotary (RR), Water Rotary (WR), Hollow Stem Continuous - flight auger (HS), Solid Stem Continuous - flight auger (SS), Air Drill with Casing Hammer (AD), Other (OT).
- (7) Ft/MSL.
- (8) Unless otherwise indicated, the measuring point is assumed to be top of inner casing (well casing), ft/MSL.
- (9) Surveyed by datum (SD), USGS Quad (UQ), Altimeter (AL), Surveyed by temporary location (ST), Other (OT).
- (10) Top of protective casing (TPC), Top of well casing (TWC), Top of land surface (LS), Other (OT).
- (11) PVC (PV), Teflon (TE), Stainless Steel (SS), Other (OT).
- (12) Clean Quartz Sand (CQ), Silica (S), Glass Beads (GB), Fabric (F), Gravel (GR), Other (OT).
- (13) Cement (C), Sodium Bentonite (SB), Cement & Bentonite Mixture (CBM), Calcium Bentonite (CB), Other (OT).
- (14) Bladder Pump (BLA), Bailer (BAI), Submersible Pump (SUB), Centrifugal (CEN), Turbine (TUR), Other (OTH).
- (15) Inspection (IN), Fire (F), Domestic (D), Sanitary Facilities (SF), Public Supply (PS), Oil and Gas (OG), Residential (R), Industrial (ID), Livestock/Agric. (LA), Irrigation (IR).
- (16) Gamma (GA), Lithologic (LI), Drillers (DR), Electric (EL), Neutron (NE), Caliper (CA), Other (OT).
- (17) Flowmeter (F), Stop Watch (SW)



FORM 18 WATER QUALITY MONITORING SYSTEM PHASE II

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Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

SECTION B. FACILITY INFORMATION

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Township or Municipality: North Lebanon and North Annville Townships

Anniversary Date (mm/dd/yyyy): _____

Owner/Operator: Greater Lebanon Refuse Authority

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Phone: 717-867-5790

Consultant: SCS Engineers

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Phone: 610-382-3050

Driller: AAA Quality Wells & Pumps, Inc. License Number: 1271

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Total Number of Monitoring Points (including wells, springs, etc.) see Water Quality Monitoring Plan

Number of Upgradient Wells see Water Quality Monitoring Plan

Number of Downgradient Wells see Water Quality Monitoring Plan

Number of leachate detection monitoring points see Water Quality Monitoring Plan

Number of monitoring points other than wells or leachate detection monitoring points see Water Quality Monitoring Plan

Description of other monitoring points see Water Quality Monitoring Plan

Number of water-bearing zones monitored see Water Quality Monitoring Plan

Characterization of water-bearing zones monitored (thickness, lithology, grain size, etc.) see Form 7 - Hydrogeologic Information

Name and Date of Topographic Map _____

DEP topographic map code: _____

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Monitoring Point Number ⁽¹⁾	M-004 (U)	M-020 (U)	M-020B (U)	M-035 (U)
Latitude	40° 22' 05"	40° 22' 32"	40° 22' 27"	40° 21' 56"
Longitude	76° 29' 05"	76° 29' 12"	76° 29' 03"	76° 29' 09"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR		AR	AR
Completion Date (mm/dd/yyyy)	04/30/1976		12/02/1994	04/18/1989
Total Depth (ft.)	72	70	63	60
Depth to Bottom of Casing (ft.)	64	20	63	20
Ground Surface Elevation	544.2		506	518
Measuring Point Elevation ⁽⁷⁾	548.43		509.17	519.52
Method of Measuring Elevation ⁽⁹⁾	OT		OT	OT
Measuring Point Description ⁽¹⁰⁾	TWC		TWC	TWC
Exposed Casing - above ground surface (ft.)	4.23	1.94	3	1.52
Well Casing Material ⁽¹¹⁾	PVC	PVC	SS	PVC
Well Casing Diameter (in.)	4	6	4	6
Monitoring Point Number ⁽¹⁾	M-004 (U)	M-020 (U)	M-020B (U)	M-035 (U)
Depth to top of screened Interval (ft)	46	15	18	
Depth to bottom of screened Interval (ft)	64	20	63	
Screen Slot Size (in.)	0.1		0.020	
Screen Material Type ⁽¹¹⁾			PVC	
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾	GR		GR	
Interval Grouted (Depth Range, ft.)				
Grout Type ⁽¹³⁾				
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)	6		6	10
Protective Casing Material ⁽¹¹⁾	OT		SS	SS

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)	Y		Y	Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

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- (5) Give reference to Code Number.
- (6) Air Rotary (AR), Mud Rotary (MD), Reverse Rotary (RR), Water Rotary (WR), Hollow Stem Continuous - flight auger (HS), Solid Stem Continuous - flight auger (SS), Air Drill with Casing Hammer (AD), Other (OT).
- (7) Ft/MSL.
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- (10) Top of protective casing (TPC), Top of well casing (TWC), Top of land surface (LS), Other (OT).
- (11) PVC (PV), Teflon (TE), Stainless Steel (SS), Other (OT).
- (12) Clean Quartz Sand (CQ), Silica (S), Glass Beads (GB), Fabric (F), Gravel (GR), Other (OT).
- (13) Cement (C), Sodium Bentonite (SB), Cement & Bentonite Mixture (CBM), Calcium Bentonite (CB), Other (OT).
- (14) Bladder Pump (BLA), Bailer (BAI), Submersible Pump (SUB), Centrifugal (CEN), Turbine (TUR), Other (OTH).
- (15) Inspection (IN), Fire (F), Domestic (D), Sanitary Facilities (SF), Public Supply (PS), Oil and Gas (OG), Residential (R), Industrial (ID), Livestock/Agric. (LA), Irrigation (IR).
- (16) Gamma (GA), Lithologic (LI), Drillers (DR), Electric (EL), Neutron (NE), Caliper (CA), Other (OT).
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Name and Date of Topographic Map _____

DEP topographic map code: _____

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Monitoring Point Number ⁽¹⁾	M-011 B (D)	M-012 (D)	M-017 (D)	M-017 D (D)
Latitude	40° 22' 11"	40° 22' 14"	40° 22' 21"	40° 22' 21"
Longitude	76° 29' 14"	76° 29' 27"	76° 29' 32"	76° 29' 32"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR			
Completion Date (mm/dd/yyyy)	10/21/1988			10/19/1987
Total Depth (ft.)	81	33	29	45
Depth to Bottom of Casing (ft.)	81	33	29	45
Ground Surface Elevation	485.2			
Measuring Point Elevation ⁽⁷⁾	487.2			
Method of Measuring Elevation ⁽⁹⁾				
Measuring Point Description ⁽¹⁰⁾	TWC			
Exposed Casing - above ground surface (ft.)	2	3.5	1.42	
Well Casing Material ⁽¹¹⁾		SS		
Well Casing Diameter (in.)	?	6	6	
Monitoring Point Number ⁽¹⁾	M-011 B (D)	M-012 (D)	M-017 (D)	M-017 D (D)
Depth to top of screened Interval (ft)	??	13	12	
Depth to bottom of screened Interval (ft)	??	33	29	
Screen Slot Size (in.)				
Screen Material Type ⁽¹¹⁾				
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾				
Interval Grouted (Depth Range, ft.)				
Grout Type ⁽¹³⁾				
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)	6			
Protective Casing Material ⁽¹¹⁾	SS			

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)	Y	Y	Y	Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

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Monitoring Point Number ⁽¹⁾		M-022B (D)	M-022C (D)	M-024 (D)
Latitude		40° 22' 17"	40° 22' 17"	40° 22' 06"
Longitude		76° 29' 28"	76° 29' 28"	76° 29' 27"
Method of measurement for Lat/Long ⁽²⁾		SD	SD	SD
Type of Monitoring Point ⁽³⁾		W	W	W
Monitoring Point Function ⁽⁴⁾		D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾				AR
Completion Date (mm/dd/yyyy)		01/28/1988	01/11/1988	01/09/1991
Total Depth (ft.)		33	56.5	40
Depth to Bottom of Casing (ft.)		16	56	40
Ground Surface Elevation				465
Measuring Point Elevation ⁽⁷⁾				467.49
Method of Measuring Elevation ⁽⁹⁾				OT
Measuring Point Description ⁽¹⁰⁾				TWC
Exposed Casing - above ground surface (ft.)				8
Well Casing Material ⁽¹¹⁾		SS	PVC	PVC
Well Casing Diameter (in.)		6	4	4
Monitoring Point Number ⁽¹⁾		M-022B (D)	M-022C (D)	M-024 (D)
Depth to top of screened Interval (ft)				5
Depth to bottom of screened Interval (ft)				40
Screen Slot Size (in.)				
Screen Material Type ⁽¹¹⁾				PVC
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾				GR
Interval Grouted (Depth Range, ft.)				
Grout Type ⁽¹³⁾				
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)			6	8
Protective Casing Material ⁽¹¹⁾			SS	SS

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)			Y	Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

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DEP topographic map code: _____

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Monitoring Point Number ⁽¹⁾	M-034D (D)	M-036 (D)	M-036D (D)	M-039 (D)
Latitude	40° 21' 51.1"	40° 22' 01.2"	40° 22' 01.2"	40° 22' 09.3"
Longitude	76° 29' 18.4"	76° 29' 31.4"	76° 29' 31.4"	76° 29' 25.5"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR	AR	AR	AR
Completion Date (mm/dd/yyyy)	07/08/2002	04/17/1989	05/02/1995	06/05/1990
Total Depth (ft.)	200	40	85	45
Depth to Bottom of Casing (ft.)	60	40	85	45
Ground Surface Elevation		457.4	474.85	460
Measuring Point Elevation ⁽⁷⁾		458.86	476.48	461.3
Method of Measuring Elevation ⁽⁹⁾		OT	OT	OT
Measuring Point Description ⁽¹⁰⁾		TWC	TWC	TWC
Exposed Casing - above ground surface (ft.)		1.46	2	3
Well Casing Material ⁽¹¹⁾	SS	PVC	PVC	PVC
Well Casing Diameter (in.)	6	4	6	4
Monitoring Point Number ⁽¹⁾	M-034D (D)	M-036 (D)	M-036D (D)	M-039 (D)
Depth to top of screened Interval (ft)		20		5
Depth to bottom of screened Interval (ft)		40		45
Screen Slot Size (in.)		0.02		
Screen Material Type ⁽¹¹⁾		PVC		PVC
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾		GR		GR
Interval Grouted (Depth Range, ft.)	0-60			
Grout Type ⁽¹³⁾	CBM			
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)		6	6	6
Protective Casing Material ⁽¹¹⁾		SS	SS	SS

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)		Y		Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

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- (4) Detection (D), Assessment (A), Corrective Action (C).
- (5) Give reference to Code Number.
- (6) Air Rotary (AR), Mud Rotary (MD), Reverse Rotary (RR), Water Rotary (WR), Hollow Stem Continuous - flight auger (HS), Solid Stem Continuous - flight auger (SS), Air Drill with Casing Hammer (AD), Other (OT).
- (7) Ft/MSL.
- (8) Unless otherwise indicated, the measuring point is assumed to be top of inner casing (well casing), ft/MSL.
- (9) Surveyed by datum (SD), USGS Quad (UQ), Altimeter (AL), Surveyed by temporary location (ST), Other (OT).
- (10) Top of protective casing (TPC), Top of well casing (TWC), Top of land surface (LS), Other (OT).
- (11) PVC (PV), Teflon (TE), Stainless Steel (SS), Other (OT).
- (12) Clean Quartz Sand (CQ), Silica (S), Glass Beads (GB), Fabric (F), Gravel (GR), Other (OT).
- (13) Cement (C), Sodium Bentonite (SB), Cement & Bentonite Mixture (CBM), Calcium Bentonite (CB), Other (OT).
- (14) Bladder Pump (BLA), Bailer (BAI), Submersible Pump (SUB), Centrifugal (CEN), Turbine (TUR), Other (OTH).
- (15) Inspection (IN), Fire (F), Domestic (D), Sanitary Facilities (SF), Public Supply (PS), Oil and Gas (OG), Residential (R), Industrial (ID), Livestock/Agric. (LA), Irrigation (IR).
- (16) Gamma (GA), Lithologic (LI), Drillers (DR), Electric (EL), Neutron (NE), Caliper (CA), Other (OT).
- (17) Flowmeter (F), Stop Watch (SW)



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Facility ID (as issued by DEP): 101544

SECTION B. FACILITY INFORMATION

County: Lebanon

Township or Municipality: North Lebanon and North Annville Townships

Anniversary Date (mm/dd/yyyy): _____

Owner/Operator: Greater Lebanon Refuse Authority

Address: 1610 Russell Road, Lebanon, PA 17042

Phone: 717-867-5790

Consultant: SCS Engineers

Address: 22 Denver Road, Suite E, Denver, PA 17517

Phone: 610-382-3050

Driller: AAA Quality Wells & Pumps, Inc. License Number: 1271

Address: Box 117, Schaeffer Road, Lebanon, PA 17042

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To be submitted on completion of Ground Water Monitoring System and prior to Phase II approval.

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Total Number of Monitoring Points (including wells, springs, etc.) see Water Quality Monitoring Plan

Number of Upgradient Wells see Water Quality Monitoring Plan

Number of Downgradient Wells see Water Quality Monitoring Plan

Number of leachate detection monitoring points see Water Quality Monitoring Plan

Number of monitoring points other than wells or leachate detection monitoring points see Water Quality Monitoring Plan

Description of other monitoring points see Water Quality Monitoring Plan

Number of water-bearing zones monitored see Water Quality Monitoring Plan

Characterization of water-bearing zones monitored (thickness, lithology, grain size, etc.) see Form 7 - Hydrogeologic Information

Name and Date of Topographic Map _____

DEP topographic map code: _____

SECTION D. MONITORING POINT GEOGRAPHIC AND HYDROGEOLOGIC DESCRIPTORS

ALL MONITORING POINTS MUST HAVE AN ASSOCIATED LATITUDE AND LONGITUDE DETERMINED ACCURATELY TO THE NEAREST ONE TENTH OF A SECOND (DD' MM' SS.S'). USE ABBREVIATIONS/ CODES LISTED ON PAGE 4 WHERE APPROPRIATE.

When additional space is needed use copies of this format.

Monitoring Point Number ⁽¹⁾	M-038 (D)	M-033 (D)	M-033D (D)	M-034a (D)
Latitude	40° 22' 06"	40° 21' 50.9"	40° 21' 50.9"	40° 21' 51.1"
Longitude	76° 29' 27"	76° 29' 22.2"	76° 29' 22.2"	76° 29' 18.4"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR	AR	AR	AR
Completion Date (mm/dd/yyyy)	05/0/1990	04/18/1989	05/28/1991	07/08/2002
Total Depth (ft.)	136	50	90	51
Depth to Bottom of Casing (ft.)	50	21	52	26
Ground Surface Elevation	466	482	482	
Measuring Point Elevation ⁽⁷⁾	468.02	483.13	484	490.6
Method of Measuring Elevation ⁽⁹⁾		OT	OT	
Measuring Point Description ⁽¹⁰⁾	TWC	TWC	TWC	TWC
Exposed Casing - above ground surface (ft.)	8	1.13	2	
Well Casing Material ⁽¹¹⁾	PVC	PVC	PVC	SS
Well Casing Diameter (in.)	6	6	6	4
Monitoring Point Number ⁽¹⁾	M-038 (D)	M-033 (D)	M-033D (D)	M-034a (D)
Depth to top of screened Interval (ft)				26
Depth to bottom of screened Interval (ft)				51
Screen Slot Size (in.)				0.02
Screen Material Type ⁽¹¹⁾				OT
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾				S
Interval Grouted (Depth Range, ft.)				
Grout Type ⁽¹³⁾				CBM
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)	8	8	8	
Protective Casing Material ⁽¹¹⁾	SS	SS	SS	

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)	Y	Y	Y	
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

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- (11) PVC (PV), Teflon (TE), Stainless Steel (SS), Other (OT).
- (12) Clean Quartz Sand (CQ), Silica (S), Glass Beads (GB), Fabric (F), Gravel (GR), Other (OT).
- (13) Cement (C), Sodium Bentonite (SB), Cement & Bentonite Mixture (CBM), Calcium Bentonite (CB), Other (OT).
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Applicant/permittee: Greater Lebanon Refuse Authority

Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

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Anniversary Date (mm/dd/yyyy): _____

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Total Number of Monitoring Points (including wells, springs, etc.) see Water Quality Monitoring Plan

Number of Upgradient Wells see Water Quality Monitoring Plan

Number of Downgradient Wells see Water Quality Monitoring Plan

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Number of monitoring points other than wells or leachate detection monitoring points see Water Quality Monitoring Plan

Description of other monitoring points see Water Quality Monitoring Plan

Number of water-bearing zones monitored see Water Quality Monitoring Plan

Characterization of water-bearing zones monitored (thickness, lithology, grain size, etc.) see Form 7 - Hydrogeologic Information

Name and Date of Topographic Map _____

DEP topographic map code: _____

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Monitoring Point Number ⁽¹⁾	M-039D (D)	M-040 (D)	M-040D (D)	M-050 (D)
Latitude	40° 22' 09.3"	40° 22' 09.7"	40° 22' 09.7"	40° 22' 08.9"
Longitude	76° 29' 25.5"	76° 29' 21.3"	76° 29' 21.2"	76° 29' 12.3"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR	AR	AR	AR
Completion Date (mm/dd/yyyy)	06/05/1990	01/30/91	01/30/91	07/27/2008
Total Depth (ft.)	160	40	66	75
Depth to Bottom of Casing (ft.)	50	40	50	43
Ground Surface Elevation	459	468	468	
Measuring Point Elevation ⁽⁷⁾	461.31	470.49	470.22	
Method of Measuring Elevation ⁽⁹⁾	OT	OT	OT	
Measuring Point Description ⁽¹⁰⁾	TWC	TWC	TWC	
Exposed Casing - above ground surface (ft.)	2.5	2.5	2.22	2.5
Well Casing Material ⁽¹¹⁾	PVC	PVC	PVC	PVC
Well Casing Diameter (in.)	6	4	6	4
Monitoring Point Number ⁽¹⁾	M-039D (D)	M-040 (D)	M-040D (D)	M-050 (D)
Depth to top of screened Interval (ft)		5		8
Depth to bottom of screened Interval (ft)		40		43
Screen Slot Size (in.)				
Screen Material Type ⁽¹¹⁾				
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾		GR		OT
Interval Grouted (Depth Range, ft.)				
Grout Type ⁽¹³⁾				
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)	8	6	8	6
Protective Casing Material ⁽¹¹⁾	SS	SS	SS	SS

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)	Y	Y	Y	Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

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Monitoring Point Number ⁽¹⁾	M-050D (D)	M-051 (D)	M-051D (D)	M-052 (D)
Latitude	40° 22' 08.9"	40° 22' 03.1"	40° 22' 03.1"	40° 21' 57.9"
Longitude	76° 29' 12.4"	76° 29' 28.8"	76° 29' 28.8"	76° 29' 30.2"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR	AR	AR	AR
Completion Date (mm/dd/yyyy)	07/27/2008	05/05/1995	05/05/1995	08/31/1998
Total Depth (ft.)	75	60	100	55
Depth to Bottom of Casing (ft.)	53	60	70	55
Ground Surface Elevation		474.9	475.13	
Measuring Point Elevation ⁽⁷⁾		477.6	477.2	
Method of Measuring Elevation ⁽⁹⁾		OT	OT	
Measuring Point Description ⁽¹⁰⁾		TWC	TWC	
Exposed Casing - above ground surface (ft.)	2.5	2	2	2.9
Well Casing Material ⁽¹¹⁾	PVC	pvc	PVC	PVC
Well Casing Diameter (in.)	6	4	6	4
Monitoring Point Number ⁽¹⁾	M-050D (D)	M-051 (d)	M-051D (D)	M-052 (D)
Depth to top of screened Interval (ft)		25		15
Depth to bottom of screened Interval (ft)		60		55
Screen Slot Size (in.)		0.02		0.02
Screen Material Type ⁽¹¹⁾		PVC		PVC
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾		GR		GR
Interval Grouted (Depth Range, ft.)	0-53	0-24	0-70	0-17
Grout Type ⁽¹³⁾	C	C	C	
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)	10	6	6	8
Protective Casing Material ⁽¹¹⁾	SS	SS	SS	SS

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)	Y	Y	Y	Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

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- (17) Flowmeter (F), Stop Watch (SW)



FORM 18 WATER QUALITY MONITORING SYSTEM PHASE II

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Applicant/permittee: Greater Lebanon Refuse Authority

Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

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County: Lebanon

Township or Municipality: North Lebanon and North Annville Townships

Anniversary Date (mm/dd/yyyy): _____

Owner/Operator: Greater Lebanon Refuse Authority

Address: 1610 Russell Road, Lebanon, PA 17042

Phone: 717-867-5790

Consultant: SCS Engineers

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Phone: 717-274-2584

To be submitted on completion of Ground Water Monitoring System and prior to Phase II approval.

SECTION C. GENERAL MONITORING INFORMATION (Attach Additional Sheets As Needed)

Total Number of Monitoring Points (including wells, springs, etc.) see Water Quality Monitoring Plan

Number of Upgradient Wells see Water Quality Monitoring Plan

Number of Downgradient Wells see Water Quality Monitoring Plan

Number of leachate detection monitoring points see Water Quality Monitoring Plan

Number of monitoring points other than wells or leachate detection monitoring points see Water Quality Monitoring Plan

Description of other monitoring points see Water Quality Monitoring Plan

Number of water-bearing zones monitored see Water Quality Monitoring Plan

Characterization of water-bearing zones monitored (thickness, lithology, grain size, etc.) see Form 7 - Hydrogeologic Information

Name and Date of Topographic Map _____

DEP topographic map code: _____

SECTION D. MONITORING POINT GEOGRAPHIC AND HYDROGEOLOGIC DESCRIPTORS

ALL MONITORING POINTS MUST HAVE AN ASSOCIATED LATITUDE AND LONGITUDE DETERMINED ACCURATELY TO THE NEAREST ONE TENTH OF A SECOND (DD' MM' SS.S'). USE ABBREVIATIONS/ CODES LISTED ON PAGE 4 WHERE APPROPRIATE.

When additional space is needed use copies of this format.

Monitoring Point Number ⁽¹⁾	M-052D (D)	M-053 (D)	M-053D (D)	M-054 (D)
Latitude	40° 21' 57.9"	40° 21' 56.6"	40° 21' 56.7"	40° 21' 54.2"
Longitude	76° 29' 30.2"	76° 29' 24.7"	76° 29' 24.9"	76° 29' 24.3"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR	AR	AR	AR
Completion Date (mm/dd/yyyy)	08/31/1998	09/01/1998	09/01/1998	02/21/2003
Total Depth (ft.)	97	60	102	60
Depth to Bottom of Casing (ft.)	60	60	65	20
Ground Surface Elevation				
Measuring Point Elevation ⁽⁷⁾				
Method of Measuring Elevation ⁽⁹⁾				
Measuring Point Description ⁽¹⁰⁾				
Exposed Casing - above ground surface (ft.)	2.5	2.5	1.5	
Well Casing Material ⁽¹¹⁾	PVC	PVC	PVC	PVC
Well Casing Diameter (in.)	6	4	6	4
Monitoring Point Number ⁽¹⁾	M-052D (D)	M-053 (D)	M-053D (D)	M-054 (D)
Depth to top of screened Interval (ft)		20		20
Depth to bottom of screened Interval (ft)		60		60
Screen Slot Size (in.)		0.02		0.02
Screen Material Type ⁽¹¹⁾		PVC		PVC
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾		GR		S
Interval Grouted (Depth Range, ft.)	0-60	0-20	0-65	0-18
Grout Type ⁽¹³⁾	C	OT	C	OT
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)	8	8	8	
Protective Casing Material ⁽¹¹⁾	SS	SS	SS	

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)	Y		Y	
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

SECTION D. MONITORING POINT GEOGRAPHIC AND HYDROGEOLOGIC DESCRIPTORS (Continued)

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- (4) Detection (D), Assessment (A), Corrective Action (C).
- (5) Give reference to Code Number.
- (6) Air Rotary (AR), Mud Rotary (MD), Reverse Rotary (RR), Water Rotary (WR), Hollow Stem Continuous - flight auger (HS), Solid Stem Continuous - flight auger (SS), Air Drill with Casing Hammer (AD), Other (OT).
- (7) Ft/MSL.
- (8) Unless otherwise indicated, the measuring point is assumed to be top of inner casing (well casing), ft/MSL.
- (9) Surveyed by datum (SD), USGS Quad (UQ), Altimeter (AL), Surveyed by temporary location (ST), Other (OT).
- (10) Top of protective casing (TPC), Top of well casing (TWC), Top of land surface (LS), Other (OT).
- (11) PVC (PV), Teflon (TE), Stainless Steel (SS), Other (OT).
- (12) Clean Quartz Sand (CQ), Silica (S), Glass Beads (GB), Fabric (F), Gravel (GR), Other (OT).
- (13) Cement (C), Sodium Bentonite (SB), Cement & Bentonite Mixture (CBM), Calcium Bentonite (CB), Other (OT).
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- (17) Flowmeter (F), Stop Watch (SW)



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Phone: 717-867-5790

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To be submitted on completion of Ground Water Monitoring System and prior to Phase II approval.

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Total Number of Monitoring Points (including wells, springs, etc.) see Water Quality Monitoring Plan

Number of Upgradient Wells see Water Quality Monitoring Plan

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Number of water-bearing zones monitored see Water Quality Monitoring Plan

Characterization of water-bearing zones monitored (thickness, lithology, grain size, etc.) see Form 7 - Hydrogeologic Information

Name and Date of Topographic Map _____

DEP topographic map code: _____

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When additional space is needed use copies of this format.

Monitoring Point Number ⁽¹⁾	M-054D (D)	M-022B (D)	M-022C (D)	M-024 (D)
Latitude	40° 21' 54.2"	40° 22' 17"	40° 22' 17"	40° 22' 06"
Longitude	76° 29' 24.3"	76° 29' 28"	76° 29' 28"	76° 29' 27"
Method of measurement for Lat/Long ⁽²⁾	SD	SD	SD	SD
Type of Monitoring Point ⁽³⁾	W	W	W	W
Monitoring Point Function ⁽⁴⁾	D	D	D	D
USGS Aquifer Code ⁽⁵⁾				

MONITORING WELL INFORMATION

Drilling Method ⁽⁶⁾	AR			AR
Completion Date (mm/dd/yyyy)	02/21/2003	01/28/1988	01/11/1988	01/09/1991
Total Depth (ft.)	150	33	56.5	40
Depth to Bottom of Casing (ft.)	20	16	56	40
Ground Surface Elevation				465
Measuring Point Elevation ⁽⁷⁾				467.49
Method of Measuring Elevation ⁽⁹⁾				OT
Measuring Point Description ⁽¹⁰⁾				TWC
Exposed Casing - above ground surface (ft.)				8
Well Casing Material ⁽¹¹⁾	PVC	SS	PVC	PVC
Well Casing Diameter (in.)	4	6	4	4
Monitoring Point Number ⁽¹⁾	M-054D (D)	M-022B (D)	M-022C (D)	M-024 (D)
Depth to top of screened Interval (ft)	20			5
Depth to bottom of screened Interval (ft)	60			40
Screen Slot Size (in.)	0.02			
Screen Material Type ⁽¹¹⁾	PVC			PVC
Packing Material Diameter (in.)				
Packing Material Type ⁽¹²⁾	S			GR
Interval Grouted (Depth Range, ft.)	0-18			
Grout Type ⁽¹³⁾	OT			
Annular Thickness of Grout (in.)				
Protective Casing Diameter (in.)			6	8
Protective Casing Material ⁽¹¹⁾			SS	SS

MONITORING WELL INFORMATION (Continued)

Protective Casing Grout Type ⁽¹³⁾				
Concrete Collar Placed - 3 foot minimum diameter				
Locking Cap (Y/N)			Y	Y
Sampling Device ⁽¹⁴⁾				
Dedicated Sampling Device (Y/N)				
Sample Pump Capacity (gpm)				
Sample Port Diameter (in.)				
Dedicated Bailer (Y/N)				
Use of Water Other Than Monitoring ⁽¹⁵⁾				
Type of Well Logs ⁽¹⁶⁾				
Type of Pump Used for Aquifer Testing ⁽¹⁴⁾				
Pump Capacity for Aquifer Test (GPM)				
Depth to Aquifer Test Pump (ft.)				
GPM Pumped or Bailed for Test Intake (ft.)				
Static Water Level-Initial for Pump Test ⁽⁷⁾				
Final Water Level for Pump Test ⁽⁷⁾				
Monitoring Point Number ⁽¹⁾				
Drawdown for Aquifer Test (ft.)				
Length of Aquifer Test (min.)				
Date of Aquifer Test (mm/dd/yyyy)				
Specific Capacity (gpm/ft)				
Transmissivity (gpd/ft)				
Storage Coefficient				
Hydraulic Conductivity (gpd/ft ²)				
SPRING INFORMATION				
Monitoring Point Number ⁽¹⁾				
Discharge Point Elevation ⁽⁷⁾				
Perennial (Y/N)				
Flow Rate (gpm)				
Method of Measurement ⁽¹⁷⁾				
Date of Measurement (mm/dd/yyyy)				
Sampling Method (grab (G), composited (C))				

SECTION D. MONITORING POINT GEOGRAPHIC AND HYDROGEOLOGIC DESCRIPTORS (Continued)

Definitions and abbreviations/codes are listed below:

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ATTACHMENT A

WATER QUALITY MONITORING SYSTEM PLAN



**Greater Lebanon Refuse Authority
Solid Waste Facilities
#100825 and #101544
Lebanon, Pennsylvania**

Water Quality Monitoring Plan

Presented to:

Greater Lebanon Refuse Authority



1610 Russell Road
Lebanon, Pennsylvania 17046
(717) 867-5790

Presented by:

SCS ENGINEERS

11260 Roger Bacon Drive, Suite 300
Reston, VA 20190
(703) 471-6150

July 12, 2018

File No. 02215800.05, Task 3

Offices Nationwide
www.scsengineers.com

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1 Site Map

Appendix

A Analytical Parameters

1 INTRODUCTION

1.1 PURPOSE

This Water Quality Monitoring Plan (Plan) documents procedures and instructions necessary to implement a groundwater and surface water monitoring program for the Greater Lebanon Refuse Authority Landfill (Permit #100825 and 101544), located in Lebanon, Pennsylvania. This Plan was prepared in accordance with 25 Pennsylvania (Pa.) Code 273.152 and 25 Pa. Code 273.281-285 measure and assess water quality.

1.2 MONITORING PROGRAM

1.2.1 Groundwater

In accordance with 25 Pa. Code 273.152 and 273.282, the groundwater monitoring well network for the active landfill (Shilling Farm Expansion Area and future piggy-back Heilmandale Expansion Area, Permit #101544) and closed landfills (Permit #100825) is structured as shown below.

- **Upgradient Shallow Groundwater Monitoring Wells (5):** M-4, M-10A, M-20, M-20B, and M-35
- **Downgradient Paired (Shallow/Deep) Groundwater Monitoring Wells (15 Sets):** M-12/M-12D, M-17, M-17D, M-22B/M-22C, M-24/M-38, M-33/M-33D, M-34a/M-34D, M-36/M-36D, M-39/M-39D, M-40/M-40D, M-50/M-50D, M-51/M-51D, M-52/M-52D, M-53/M-53D, M-54/M-54D, M-57/M-57D, and M-58/M-58D
- **Downgradient Shallow Groundwater Monitoring Well (1):** M-12

Several additional shallow and deep wells are utilized to help describe groundwater flow: M-8A, M-11, M-11B, M-16, M-18, M-18D, M-23A, M-45, M-45D, M-48, and M-48D

Upon initiation of construction activities associated with piggy-backing activities in the future Heilmandale Expansion Area, the following wells will require abandonment: M-0L6, M-14, M-14D, M-21, M-22A, M-44, M-44D, M-46, M-47, and M-47D.

Upon completion of construction activities associated of piggy-backing activities in the future Heilmandale Expansion Area, the following wells will be installed: M-12D, M-57, and M-57D.

A network of contiguous landowner monitoring wells is structured as follows: CLO-001, CLO-004, CLO-006, CLO-009, CLO-019, CLO-021, CLO-022, CLO-026, CLO-0028, CLO-029, and CLO-030.

A site map illustrating the groundwater monitoring well locations and approximate contiguous landowner well locations is included as **Figure 1**.

1.2.2 Surface Water

In accordance with 25 Pa. Code 273.282 (a) (5), Union Canal and an unnamed tributary are sampled as a component of this Plan. The four, distinct and reproducible surface water monitoring locations are identified as LOC-001, LOC-002, LOC-003, and LOC-004 as shown on **Figure 1**.

1.2.3 Leachate

The leak detection zone monitoring locations for the active landfill (Shilling Farm Expansion Area) include: LDZ-001, LDZ-002, LDZ-003, LDZ-004, LDZ-006, and LDZ-007. The leak detection zone monitoring locations for the future piggy-back Heilmandale Expansion Area include: LDZ-008 and LDZ-010. The leachate collection system monitoring location for the entire site is known as TANK-100.

1.2.4 Analytical Parameters

The required parameters and sampling frequency associated with this monitoring program are summarized on **Tables 1-1** and **1-2**.

Table 1-1. Groundwater and Surface Water Monitoring Program Summary

Sample Locations	Monitoring Frequency	Parameter Group: Parameter ¹
Groundwater Monitoring Wells Contiguous Landowner Wells Surface Water Monitoring Locations	Quarterly	Water Quality Indicators/Other (11): Alkalinity-Total, Ammonia-Nitrogen, Bicarbonate, Chemical Oxygen Demand, Chloride, Fluoride, Nitrate-Nitrogen, Sulfate, Total Dissolved Solids, Total Organic Carbon, Total Phenols
		Total and Dissolved² Metals (6): Calcium, Iron, Magnesium, Manganese, Potassium, and Sodium
		Volatile Organic Compounds (15): 1,1,1-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dibromoethane, 1,2-Dichloroethane, cis-1,2-Dichloroethene, Benzene, Ethyl Benzene, Methylene Chloride, Tetrachloroethene, Trichloroethene, trans-1,2-Dichloroethene, Toluene, Vinyl chloride, and Xylene
		Field Measurement (1): Turbidity
		Field and Laboratory Measurements (4): pH, and Specific Conductance

Table 1-1. Groundwater and Surface Water Monitoring Program Summary

Sample Locations	Monitoring Frequency	Parameter Group: Parameter ¹
Groundwater Monitoring Wells	Annually	Total and Dissolved² Metals (10): Arsenic, Barium, Cadmium, Chromium, Copper, Lead, Mercury, Selenium, Silver, and Zinc
Contiguous Landowner Wells		Volatile Organic Compounds (22): 1,1,1,2-Tetrachloroethane, 1,1,2,2-Tetrachloroethane, 1,1,2-Trichloroethane, 1,2,3-Trichloropropane, 1,2-Dichlorobenzene, 1,2-Dichloropropane, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 4-Methyl-2-pentanone, Allyl chloride, Bromoform, Bromomethane, Carbon tetrachloride, Chlorobenzene, Chloroethane, Chloromethane, cis-1,3-Dichloropropene, Dibromochloromethane, Dichlorodifluoromethane, Methyl ethyl ketone, trans-1,3-Dichloropropene, and Trichlorofluoromethane
Surface Water Monitoring Locations		

Notes:

1. Parameter lists are based on the requirements of 25 Pa. Code 273.284 and Form 19 Municipal Waste Landfill Quarterly and Annual Water Quality Analyses
2. Samples collected for dissolved metals will be filtered in the field.

Table 1-2. Leachate Monitoring Program Summary

Sample Locations	Monitoring Frequency	Parameter Group: Parameter ¹
Leachate Collection System Location	Daily	Discharge Flow Volume
	Quarterly	Water Quality Indicators (7): Alkalinity-Total, Ammonia-Nitrogen, Bicarbonate, Chemical Oxygen Demand, Chloride, Sulfate, and Total Organic Carbon
		Total Metals (4): Calcium, Magnesium, Potassium, and Sodium
		Field and Laboratory Measurements (2): pH and Specific Conductance
Leak Detection Zone Monitoring Locations	Weekly	Estimated Discharge Flow Volume
	Quarterly ²	Water Quality Indicators (7): Alkalinity-Total, Ammonia-Nitrogen, Bicarbonate, Chemical Oxygen Demand, Chloride, Sulfate, and Total Organic Carbon
		Total Metals (4): Calcium, Magnesium, Potassium, and Sodium
		Field and Laboratory Measurements (2): pH and Specific Conductance

Table 1-2. Leachate Monitoring Program Summary

Sample Locations	Monitoring Frequency	Parameter Group: Parameter ¹
Leak Detection Zone Monitoring Locations	Annually ³	Water Quality Indicators/Other (5): Fluoride, Nitrate-Nitrogen, Total Dissolved Solids, Total Phenols, and Tritium ⁴
		Total Metals (18): Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, Vanadium, and Zinc
		Field Measurement (1): Turbidity
		Volatile Organic Compounds (50): 1,1,1,2-Tetrachloroethane, 1,1,1-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2,3-Trichloropropane, 1,2-Dibromo-3-chloropropane, 1,2-Dibromoethane, 1,2-Dichlorobenzene, 1,2-Dichloroethane, 1,2-Dichloropropane, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 2-Hexanone, 3-Chloro-1-propene, 4-Methyl-2-pentanone, Acetone, Acrylonitrile, Benzene, Bromochloromethane, Bromodichloromethane, Bromoform, Bromomethane, Carbon disulfide, Carbon tetrachloride, Chlorobenzene, Chloroethane, Chloroform, Chloromethane, cis-1,2-Dichloroethene, cis-1,3-Dichloropropene, Dibromochloromethane, Dibromomethane, Dichlorodifluoromethane, Ethyl Benzene, Iodomethane, Methyl ethyl ketone, Methylene Chloride, Tetrachloroethene, Toluene, trans-1,2-Dichloroethene, trans-1,3-Dichloropropene, trans-1,4-Dichloro-2-butene, Trichloroethene, Trichlorofluoromethane, Styrene, Vinyl acetate, Vinyl chloride, and Xylene

Notes:

1. Parameter lists are based on the requirements of Form 50 Municipal Waste Landfill Leachate Analyses.
2. Any fluid found in any detection zone monitoring point must be sampled during the initial four quarters to establish a baseline fluid composition. Quarterly sampling of the fluid in any detection zone monitoring point is required only when the quarterly flow at that monitoring point exceeds 10 gallons per acre per day (weekly average for the quarter) for the cell(s) served by that monitoring point.
3. If the indicator analyses confirm leachate contamination in the detection zone, the fluid will be analyzed initially within 30 days and thereafter annually.
4. Analysis must be performed during the 4th quarter.

2 SAMPLING PROCEDURES

Samples will be collected and handled in accordance with various EPA guidance documents (see References Section) and procedures described in the following subsections.

2.1 EQUIPMENT SELECTION AND CALIBRATION

Equipment to be utilized for groundwater sampling purposes will meet the requirements of the low-flow sampling method and analytical methods. Sample collection devices will be carefully chosen to minimize the potential for altering the quality of the sample. Teflon and stainless steel are preferred materials, although PVC, HDPE, and other similar materials are considered sufficient for the facility's required analyses.

Field instruments will be calibrated for accurate readings. Calibrations will be conducted with approved standards and in accordance with the manufacturer-supplied manual for each instrument.

2.2 BOTTLE KIT PREPARATION

A sample collection bottle kit will be prepared by the laboratory in accordance with approved analytical methods. A summary of the types of sample containers and sample handling/preservation methods are listed in **Appendix A** for the corresponding parameters. The sample kit will be stored in a clean, laboratory-provided cooler for transport to the site.

2.3 STATIC WATER LEVEL MEASURING

In accordance with 25 Pa. Code 273.284 (3), static water level (aka depth to water) measurements will be collected from each groundwater monitoring well for the entire site during each quarterly monitoring event. Well measurements will be made within the same day using an electronic water level probe and measured to ± 0.01 foot. Groundwater elevations will be calculated by subtracting the static water level from the top of casing elevation for each monitoring well and referenced to mean sea level.

2.4 GROUNDWATER MONITORING WELL PURGING PROCEDURES

Well purging procedures begin upon arrival at the well. The time of arrival and atmospheric and well conditions will be recorded. The water column will be calculated using the difference between the total well depth from the top of casing and the static water level from top of casing. The water column volume can be calculated using the static water level, total well depth, and well diameter.

To properly evacuate stagnant water from the monitoring wells, the wells will be purged at a low flow rate between 100 milliliters per minute (mL/min) and 500 mL/min. The purge rate will be adjusted such that a minimal drawdown of ± 0.3 feet is achieved. The purge rate will be

monitored by using a graduated container to measure the rate and volume being removed. The drawdown will be monitored utilizing a water level indicator or pressure transducer. The total volume actually purged and the time at which purging is terminated will be recorded on the purge log. If a well has an extremely low yield, it will be evacuated to dryness once, although purging to dryness will be avoided by reducing the purge rate. Dry wells and low recharge rates will be noted in the field observations. Purge water resulting from each monitoring event will be properly disposed.

During purging, measurements of dissolved oxygen, oxidation-reduction potential, pH, specific conductivity, temperature, and turbidity will be measured at consistent intervals of two to five minutes depending on the purge rate. Purge water appearance and odor (if any) will be noted and recorded at each interval. Purging will continue until three successive measurements of the indicator parameters meet the stabilization criteria shown on **Table 2-1**. If stabilization does not occur, the well will be purged for a minimum of two hours.

Table 2-1. Indicator Parameter Stabilization Criteria

Indicator Parameter	Stabilization Range
Dissolved Oxygen (DO)	< 0.5 mg/L or +/- 10% (when DO is > 0.5 mg/L)
Oxidation-Reduction Potential	+/- 10 mV
pH	+/- 0.1 s.u.
Specific Conductivity	+/- 3%
Temperature	+/- 3%
Turbidity	< 5 NTU or +/- 10% (when turbidity is > 5 NTUs)

mg/L = milligram per Liter

mV = millivolt

NTU = Nephelometric Turbidity Unit

s.u. = standard unit

2.5 SAMPLE COLLECTION PROCEDURES

2.5.1 Groundwater

Well sampling will occur upon completion of the purging procedures as previously described. The samples will be transferred directly from the sampling device into a container that has been specifically prepared for the preservation and storage of groundwater samples for the specific analytical parameters.

In low yield formations where the well has been purged dry, samples will be collected when recovery is complete. Recovery is deemed complete when the well has recovered at least 80% of the draw down created by the purging. The well will be sampled within twenty-four hours of the completed purging time. If a monitoring well consistently will not supply adequate water for sampling, the condition of the well will be investigated and may be considered for replacement and/or exclusion from the sampling program.

If non-dedicated sampling equipment is utilized, the wells will be sampled beginning with the upgradient wells followed by downgradient wells. If sampling is conducted utilizing only dedicated sampling equipment, the wells may be sampled beginning with the upgradient wells followed by the downgradient wells, but ultimately the sampling order of the monitoring wells is left to the discretion of the field personnel.

Samples collected for dissolved metals will be field filtered using a sterile, unused disposable 0.45 micron filter. Each sample will be filtered with its own individual filter.

2.5.2 Surface Water

Surface water monitoring locations will be collected beginning with the downstream sample locations followed by the successive upstream sample locations. At the time of sample collection, pH, specific conductance, and turbidity will be measured and recorded. In addition, the depth to the creek bottom and flow rate at the surface water monitoring location will be measured following sample collection.

A sample may be collected directly into the sample container when the center of the water is safely accessible by wading or other means. If wading, the sampler should face upstream and collect the sample with limited to no sediment disturbance. The sampler should be careful not to displace the preservative from the pre-preserved sample container. If wading may cause the re-suspension of bottom deposits, a scoop may be used to reach to the center of the water body to collect the sample. The sample shall then be transferred to the sample container.

Samples collected for dissolved metals will be field filtered using a sterile, unused disposable 0.45 micron filter. Each sample will be filtered with its own individual filter.

2.5.3 Leachate

Leachate samples shall be collected in the form of a grab sample taken at the appropriate location. At the time of sample collection, pH, specific conductance, and turbidity will be measured and recorded. A sample may be collected directly into the new, laboratory-provided sampling containers. If a separate sample collection device is needed, samples will be transferred from the device into the sampling containers.

2.6 SAMPLE DOCUMENTATION

2.6.1 Sample Bottle Labeling

The sample containers will be laboratory certified bottles and properly labeled for identification including the following information.

- Sample ID
- Date and Time
- Sample Type – grab or composite
- Analysis Parameter(s)/Method
- Preservative
- Sampler(s)
- Sample Matrix

2.6.2 Field Logs

Field technicians will maintain field logs documenting the following information pertaining to field activities. The field notes will be reviewed quarterly to verify that the monitoring requirements of this Plan are met and to identify unusual circumstances which may affect the implementation of the Plan.

- Personnel
- Site Name/Location
- Date of Sampling Event
- Weather Conditions
- Sample Location Identification
- Casing/Well Diameter
- Well Depth/Depth to Water
- Water Column in Feet
- Arrival/Departure Time
- Volume of One Well Volume
- Total Volume Purged
- Purge/Discharge Rate
- Well Evacuation Method
- Sampling Equipment
- Time of Sample Collection
- Comments on Sampling Event
- Field Analysis Data and Methods
- Purge Start/Completion Time

2.6.3 Chain-of-Custody

Sample transport and handling will be strictly controlled to reduce the opportunity of the samples to be tampered with. Chain-of-Custody control for the samples will consist of the following:

- Sample containers will be securely placed in coolers (iced) and will remain in the continuous possession of the field technician until transfer of the samples to the laboratory.
- If the samples leave the possession of the sampling crew, the sample containers or coolers will be individually sealed to reduce the opportunity for disruption/tampering of the samples during transportation. Chain-of-custody relinquishment will occur with each transfer of cooler possession.
- Upon delivery to the laboratory, samples will be given unique laboratory sample numbers and recorded into a logbook indicating the client, well number, and date and time of delivery. The laboratory director or his/her designee will sign the Chain-of-Custody form(s) and formally receive the samples. The field technician and laboratory director will work together to maintain proper refrigeration of the samples.
- The Chain-of-Custody document will contain the following information:
 - o Client Name
 - o Client Project Name
 - o Client Contact
 - o Client Address
 - o Client Phone/Fax Number/ Email Address
 - o Sampler(s) Name
 - o Sample ID(s)
 - o Sample Dates
 - o Sample Times
 - o Type of Container and Preservative
 - o Number of Containers
 - o Sample Matrix
 - o Sample Type - Grab or Composite
 - o Analysis Parameter(s)/Method
 - o Relinquishment of samples

2.7 QUALITY ASSURANCE/QUALITY CONTROL

2.7.1 Atmospheric Contamination

In the event of rain and/or other adverse conditions, steps must be taken to protect the monitoring well, sampling bottles, and sampling equipment. In the event of a thunderstorm and/or harsh conditions which may compromise field personnel safety and/or the sampling event, the field personnel will decide whether to cease or continue sampling. This information will be relayed to the project manager immediately.

Potential adverse atmospheric impacts must be avoided. Vehicle exhaust, particulates (i.e. dust and plant fallout), rain, or other potential constituents of concern must not be allowed to come into contact with the samples. When maneuvering to the monitoring well site by vehicle, efforts will be made to approach the well from downwind and to park the vehicle downwind of the well. The vehicle's engine will not be running in close proximity to the well. If necessary, clean plastic sheeting will be placed around the monitoring well as well as on the working surface where sample containers or equipment may make contact.

In the event the field technician observes a situation that, in his/her judgment, could compromise the validity of the sampling or the health and safety of personnel, the field technician will immediately cease sampling and contact the field supervisor. Some instances are:

- Inclement weather
- Dust or particulate from plants or equipment
- Mowing in close proximity of monitoring well
- Spraying of chemicals
- Dramatic changes in water quality (muddy or dry well)

The field personnel will contact the project manager who will make a decision to continue sampling or terminate the event. If the field personnel terminates a sampling event, the re-sampling will be rescheduled and completed as soon as practicable.

2.7.2 Decontamination Procedures

Equipment used for static water level measurements, field measurements, and other activities associated with on-site work will be decontaminated between wells/sample locations and before it is taken from the site by rinsing thoroughly with a non-phosphate laboratory detergent and distilled/deionized water followed by a rinse with distilled/deionized water. Non-dedicated purging equipment will be thoroughly decontaminated between wells by disassembling and will be cleaned in the following manner:

- Rinse with deionized/distilled water.
- Wash with a non-phosphate laboratory detergent and tap water.
- Rinse with deionized/distilled water.

- Allow to air dry.

Electronic water level meters may be decontaminated between uses by wiping with an alcohol wipe and allowing to air dry or rinsing with deionized/distilled water.

2.7.3 Quality Control Sampling

Field quality control (QC) may involve the collection and analysis of two types of QC blanks, trip and field blanks, to verify that the sample collection and handling processes have not impaired the quality of the samples.

- **Trip Blank** – Trip blanks are prepared for volatile organic compound analysis via SW (Solid Waste)-846 Method and 8260. Laboratory personnel fill sample bottles with distilled/deionized water and transport them to the site. Trip blanks are prepared immediately prior to the sampling event and transported with the empty bottle kits. Field personnel handle the trip blanks like a sample; they remain un-opened, are transported in the sample cooler, and are returned to the laboratory for analysis. A trip blank is used to indicate potential contamination due to migration of volatile organic compounds from the air on-site or in the sample shipping containers through the septum or around the lid of the sampling vials and into the sample.
- **Field Blank** – The field blank is a sample of deionized/distilled water, which is taken to the field and used as rinse water for sampling equipment. The field blank is prepared like an actual sample and sent to the laboratory for identical analysis. A field blank is used to evaluate if certain field sampling or cleaning procedures result in cross-contamination of site samples or if atmospheric contamination has occurred.

3 LABORATORY ANALYSIS

Typically, sample analyses should be completed within 30 days after receipt by the contract laboratory. Once completed and reviewed, the project manager should be alerted to problems with the analysis results and the potential need for re-sampling. In accordance 25 Pa. Code 273.286 (b) (1), re-sampling will occur within 10 days of receipt of the laboratory analytical results in question.

The laboratory's Quality Assurance/Quality Control Manual will be used to maintain the integrity of the data. Analyses will be conducted in accordance with the methods presented in **Appendix A** or another comparable method.

Upon receipt by the laboratory, samples, including the blanks, will be assigned a unique laboratory identification number and inspected for integrity and consistency with information entered on the chain-of-custody document. The samples will also be tested for proper preservation or, in the case of volatile organic samples, inspected for lack of air bubbles in the sample vials. Deviations from applicable protocol will be noted on the chain-of-custody document. If possible, missing, broken, or improperly preserved samples will be replaced within 30 days from the date that the deviation is first noted.

While awaiting analysis, samples will be stored in a secure location under the appropriate method of preservation (i.e. refrigeration). If a method-prescribed holding time is exceeded, the sample will be discarded and replaced.

Analytical results will be reported relative to a reporting detection limit (RDL). The RDL values are parameter, analytical method, and matrix specific. Sub-RDL results will be reported as not detected. Results equal to or greater than the RDL value will be reported without estimation.

4 REPORTING

4.1 QUARTERLY REPORTING

In accordance with 25 Pa. Code 273.285, groundwater and surface water data analyses shall be submitted on PADEP Form 19: Municipal Waste Landfill Quarterly and Annual Water Quality Analyses. Leachate data analyses shall be submitted on PADEP Form 50: Municipal Waste Landfill Leachate Analyses. Forms 19 and 50 shall be submitted to PADEP within 60 days of sampling or 15 days of completion of analyses (whichever occurs first).

4.2 RECORD KEEPING REQUIREMENTS

As required by 25 Pa Code 273.288, records of analyses and evaluations of monitoring data and groundwater elevations performed in accordance with this Plan will be retained until release of the facility bond. The records will also be made available to PADEP upon request. The documents will be stored at:

Greater Lebanon Refuse Authority
1610 Russell Road
Lebanon, Pennsylvania 17046
Phone: (717) 867-5790

5 REFERENCES

Barcelona, Michael J. and Robert W. Puls. Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures. EPA Groundwater Issue. EPA/540/S-95/504. April 1996.

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Environmental Protection Agency. November 2001.

Form 19 Municipal Waste Landfill Quarterly and Annual Water Quality Analyses. 2540-PM-BWN0041. Commonwealth of Pennsylvania Department of Environmental Protection Bureau of Waste Management. June 2005.

Greater Lebanon Refuse Authority Schilling Farm Expansion Form 7. Carlyle Gray Associates. April 1992.

Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. EQASOP-GW 001. Quality Assurance Unit Environmental Protection Agency Region 1. Revised January 19, 2010.

Narrative for Leachate Collection System and Natural Aquatic Life Treatment System (NALTS) ponds for Greater Lebanon Refuse Authority's (GLRA) inactive landfills, including area within Permit No. 100825. Greater Lebanon Refuse Authority.

Natural Aquatic Life Treatment System Final Report. Greater Lebanon Refuse Authority. October 2016.

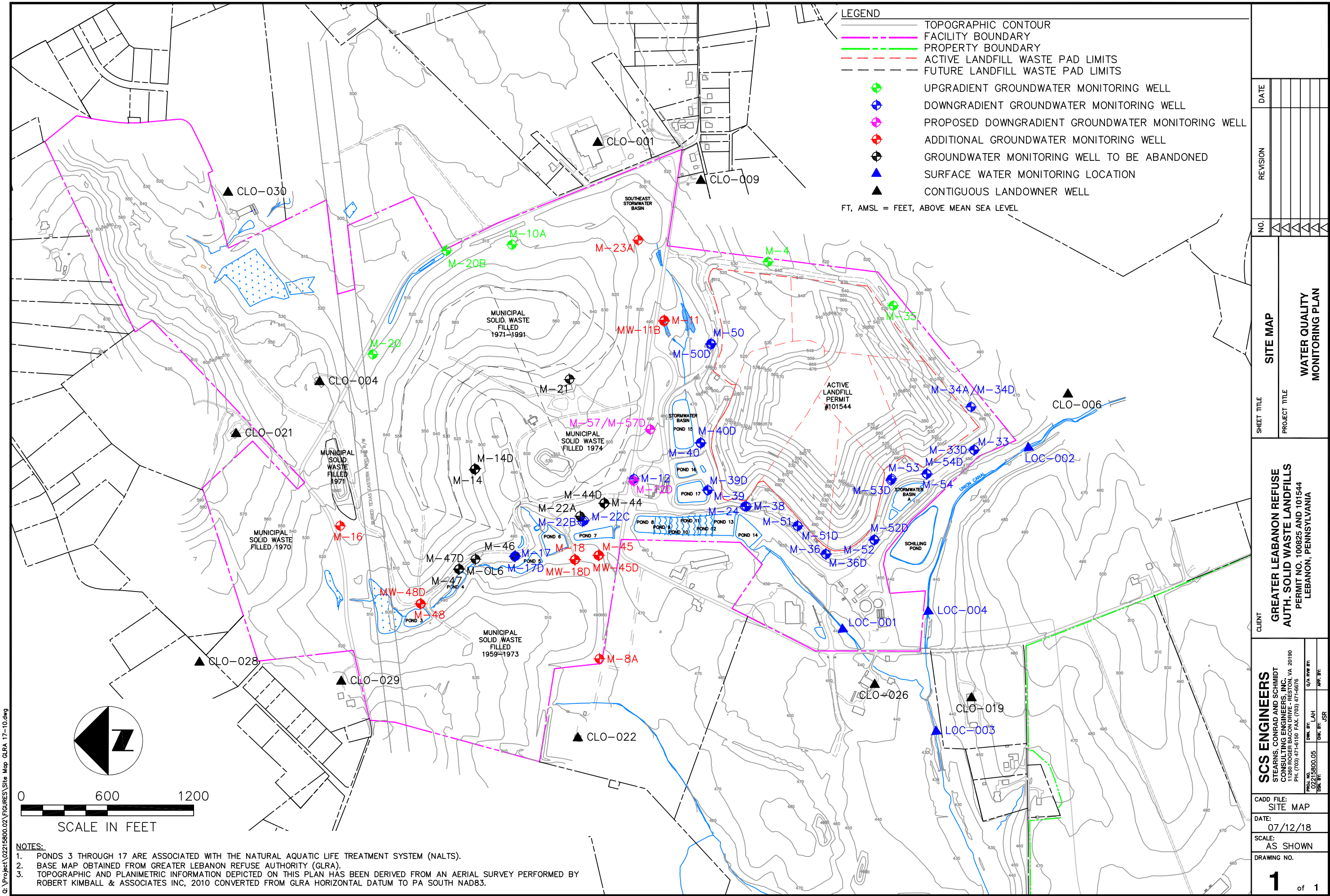
Groundwater Monitoring Sampling and Analysis Plan. Greater Lebanon Refuse Authority. December 1994.

The Pennsylvania Code, Chapter 288. Commonwealth of Pennsylvania. As updated.

Yeskis, Douglas and Bernard Zavala. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. EPA 542-S-02-001. Ground Water Forum Issue Paper. Office of Solid Waste and Emergency Response US Environmental Protection Agency Regions 5 and 10. May 2002.

FIGURES

- 1 Site Map



NO.	DATE	
	REVISION	

SHEET TITLE	PROJECT TITLE
SITE MAP	WATER QUALITY MONITORING PLAN

CLIENT	GREATER LEBANON REFUSE AUTH. SOLID WASTE LANDFILLS PERMIT NO. 100825 AND 101544 LEBANON, PENNSYLVANIA

SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS, INC. 11280 ROGER BACON DRIVE - RESTON, VA 20190 PH. (703) 471-6150 FAX. (703) 471-6676	DWN. BY: LAH CHK. BY: JSR O/A REV. BY: APP. BY:
CADD FILE: SITE MAP	DATE: 07/12/18
SCALE: AS SHOWN	DRAWING NO. 1 of 1

APPENDIX A

Analytical Parameters

GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
GROUNDWATER AND SURFACE WATER LABORATORY ANALYTICAL PARAMETERS

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
QUARTERLY					
Water Quality Indicators/Other	Alkalinity-Total	SM2320B-97	500 mL - plastic	14 days	None
	Ammonia-Nitrogen	D6919-09	500 mL - plastic	28 days	Sulfuric Acid
	Bicarbonate	SM2320B-97	500 mL - plastic	14 days	None
	Chemical Oxygen Demand	EPA 410.4	500 mL - plastic	28 days	Sulfuric Acid
	Chloride	EPA 300.0	1 L - plastic	28 days	None
	Fluoride	EPA 300.0	1 L - plastic	28 days	None
	Nitrate-Nitrogen	EPA 300.1	1 L - plastic	2 days	None
	Sulfate	EPA 300.0	1 L - plastic	28 days	None
	Total Dissolved Solids	SM2540C-11	1 L - plastic	7 days	None
	Total Organic Carbon	SW-846 9060A	40 mL (2) - Clear VOA	28 days	HCl
Metals (Total and Dissolved)	Phenols	EPA 420.4	500 mL - Glass Amber	28 days	4°C, H ₂ SO ₄
	Calcium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Iron	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Magnesium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Manganese	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Potassium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
Volatile Organic Compounds	Sodium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	1,1,1-Trichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCl; No head space
	1,1-Dichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCl; No head space
	1,1-Dichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCl; No head space
	1,2-Dibromoethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCl; No head space
	1,2-Dichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCl; No head space

GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
GROUNDWATER AND SURFACE WATER LABORATORY ANALYTICAL PARAMETERS

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Volatile Organic Compounds	cis-1,2-Dichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Benzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Ethyl Benzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Methylene Chloride	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Tetrachloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Trichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	trans-1,2-Dichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Toluene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Vinyl chloride	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Xylene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
Laboratory Measurement	pH	SM4500-4 B	125 mL - plastic	15 minutes	4°C
	Specific Conductance	SM 2510 B	125 mL - plastic	28 days	4°C

GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
GROUNDWATER AND SURFACE WATER LABORATORY ANALYTICAL PARAMETERS

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
ANNUALLY					
Metals (Total and Dissolved)	Arsenic	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Barium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Cadmium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Chromium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Copper	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Lead	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Mercury	SW-846 7470A	500 mL - plastic	90 days	Nitric Acid
	Selenium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Silver	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Zinc	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
Volatile Organic Compounds	1,1,1,2-Tetrachloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,1,2,2-Tetrachloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,1,2-Trichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2,3-Trichloropropane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2-Dichlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2-Dichloropropane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,3-Dichlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,4-Dichlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
GROUNDWATER AND SURFACE WATER LABORATORY ANALYTICAL PARAMETERS

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Volatile Organic Compounds	4-Methyl-2-pentanone	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Allyl chloride	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Bromoform	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Bromomethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Carbon tetrachloride	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Chlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Chloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Chloromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	cis-1,3-Dichloropropene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Dibromochloromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Dichlorodifluoromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Methyl ethyl ketone	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	trans-1,3-Dichloropropene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

**GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
GROUNDWATER AND SURFACE WATER LABORATORY ANALYTICAL PARAMETERS**

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Volatile Organic Compounds	Trichlorofluoromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

Notes:

1. Parameter lists are based on the requirements of 25 Pa. Code 273.284 and Form 19 Municipal Waste Landfill Quarterly and Annual Water Quality Analyses
2. Samples collected for dissolved metals will be filtered in the field.

**GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
LEACHATE LABORATORY ANALYTICAL PARAMETERS**

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
QUARTERLY					
Water Quality Indicators	Alkalinity-Total	SM2320B-97	500 mL - plastic	14 days	None
	Ammonia-Nitrogen	D6919-09	500 mL - plastic	28 days	Sulfuric Acid
	Bicarbonate	SM2320B-97	500 mL - plastic	14 days	None
	Chemical Oxygen Demand	EPA 410.4	500 mL - plastic	28 days	Sulfuric Acid
	Chloride	EPA 300.0	1 L - plastic	28 days	None
	Sulfate	EPA 300.0	1 L - plastic	28 days	None
	Total Organic Carbon	SW-846 9060A	40 mL (2) - Clear VOA	28 days	HCl
Metals (Total)	Calcium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Magnesium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Potassium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Sodium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
Laboratory Measurement	pH	SM4500-4 B	125 mL - plastic	15 minutes	4°C
	Specific Conductance	SM 2510 B	125 mL - plastic	28 days	4°C
ANNUALLY					
Water Quality Indicators/Other	Fluoride	EPA 300.0	1 L - plastic	28 days	None
	Nitrate-Nitrogen	EPA 300.1	1 L - plastic	2 days	None
	Total Dissolved Solids	SM2540C-11	1 L - plastic	7 days	None
	Total Phenols	EPA 420.4	500 mL - Glass Amber	28 days	4°C, H ₂ SO ₄
	Tritium	Scintillation Counter - Direct Count	50 mL - plastic	6 months	None

**GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
LEACHATE LABORATORY ANALYTICAL PARAMETERS**

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Metals (Total)	Antimony	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Arsenic	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Barium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Beryllium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Cadmium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Chromium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Cobalt	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Copper	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Iron	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Lead	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Manganese	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Mercury	SW-846 7470A	500 mL - plastic	90 days	Nitric Acid
	Nickel	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Selenium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Silver	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Thallium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Vanadium	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
	Zinc	SW-846 6010C	500 mL - plastic	90 days	Nitric Acid
Volatile Organic Compounds	1,1,1,2-Tetrachloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,1,1-Trichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,1,2,2-Tetrachloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,1,2-Trichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,1-Dichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

**GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
LEACHATE LABORATORY ANALYTICAL PARAMETERS**

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Volatile Organic Compounds	1,1-Dichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2,3-Trichloropropane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2-Dibromo-3-chloropropane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2-Dibromoethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2-Dichlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2-Dichloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,2-Dichloropropane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,3-Dichlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	1,4-Dichlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	2-Hexanone	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	3-Chloro-1-propene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	4-Methyl-2-pentanone	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Acetone	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

**GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
LEACHATE LABORATORY ANALYTICAL PARAMETERS**

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Volatile Organic Compounds	Acrylonitrile	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Benzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Bromochloromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Bromodichloromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Bromoform	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Bromomethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Carbon disulfide	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Carbon tetrachloride	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Chlorobenzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Chloroethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Chloroform	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Chloromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	cis-1,2-Dichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

**GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
LEACHATE LABORATORY ANALYTICAL PARAMETERS**

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Volatile Organic Compounds	cis-1,3-Dichloropropene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Dibromochloromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Dibromomethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Dichlorodifluoromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Ethyl Benzene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Iodomethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Methyl ethyl ketone	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Methylene Chloride	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Tetrachloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Toluene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	trans-1,2-Dichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	trans-1,3-Dichloropropene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	trans-1,4-Dichloro-2-butene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

**GREATER LEBANON REFUSE AUTHORITY
SOLID WASTE FACILITY #100825 & 101544
LEACHATE LABORATORY ANALYTICAL PARAMETERS**

Parameter Group	Parameter	Analytical Method	Sample Size - Container	Maximum Holding Time	Preservation
Volatile Organic Compounds	Trichloroethene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Trichlorofluoromethane	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Styrene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Vinyl acetate	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Vinyl chloride	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space
	Xylene	SW-846 8260B	40 mL (3) - Clear VOA	14 days	4°C; HCL; No head space

Notes:

1. Parameter lists are based on the requirements of Form 50 Municipal Waste Landfill Leachate Analyses.
2. Any fluid found in any detection zone monitoring point must be sampled during the initial four quarters to establish a baseline fluid composition. Quarterly sampling of the fluid in any detection zone monitoring point is required only when the quarterly flow at that monitoring point exceeds 10 gallons per acre per day (weekly average for the quarter) for the cell(s) served by that monitoring point.
3. If the indicator analyses confirm leachate contamination in the detection zone, the fluid will be analyzed initially within 30 days and thereafter annually.
4. Analysis must be performed during the 4th quarter.

Form 24
Liner System



Date Prepared/Revised
July 2018

DEP USE ONLY

Date Received

FORM 24 LINER SYSTEM - PHASE II

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 24, reference the item number and identify the date prepared. The "date prepared/revised" on any attached sheets needs to match the "date prepared/revised" on this page.

General References: 273.161 and 273.251 to 273.260/277.161 and 277.251 to 277.260/285.123

SECTION A. SITE IDENTIFIER

Applicant/permittee Greater Lebanon Refuse Authority

Site Name GLRA Municipal Waste Landfill

Facility ID (as issued by DEP) 101544

SECTION B. GENERAL ITEMS

Liner System is for:

- ☒ 1. Municipal Waste Landfill.
- ☐ 2. Construction/Demolition Waste Landfill.
- ☐ 3. Storage Impoundment.

SECTION C. LINER SYSTEM COMPONENTS

Liner System Components are:	Area (ft ²)	Is Equivalency Review Being Requested (Y/N)
☒ 1. Subbase.	2,034,252	
☒ 2. Secondary Liner.	2,034,252	
☒ 3. Leachate Detection Zone.	2,034,252	Y
☒ 4. Primary Liner.	2,034,252	
☒ 5. Protective Cover.	2,034,252	Y
☒ 6. Leachate Collection System (within Protective Cover).	2,034,252	
☒ 7. Cap	2,034,252	
☐ 8. Natural Attenuation		
☐ 9. Composite Liner Primary or Secondary (circle one)		

SECTION D. SUPPORTING DATA

Supporting Data:

The following information must be submitted along with this form. For information not appended to this form, indicate below where in the specifications or drawings the required information is located.

	(Drawing)	(Specification)
1. Design of Liner System. (Refer to Part II.)	See permit drawings.	See narrative.
2. Liner Installation Plan. (Refer to Part III.)	See permit drawings.	See narrative.
3. Compatibility of Liner to Leachate. (Refer to Part IV)	N/A	See narrative.
4. Physical, Chemical, Mechanical, and Thermal Properties of Liners. (Refer to Part V)	N/A	See narrative.
5. Quality Assurance Plan for Construction and Installation of Liners. (Refer to Part VI)	N/A	Form J
6. Quality Control Plan for construction and installation of liners.	N/A	Form J
7. Slope Stability Analysis	N/A	See narrative.
8. If applicable, seismic impact analysis	N/A	See narrative.

PART II. DESIGN OF LINER SYSTEM

SECTION A. PROJECT SPECIFICATIONS

Project Specifications	Subbase	Secondary Liner	Leachate Detection Zone	Primary Liner	Leachate Collection Zone	Protective Cover	Cap
Thickness (inches or mils)	See	narrative					
Maximum Particle Size (inches)							
Standard Proctor Density (percent) <u>FIELD</u> LAB							
Bearing Capacity (minimum) (lb/ft ²)							
Total Applied Load (lb/ft ²)							
Permeability (cm/s) <u>FIELD</u> LAB							
Slope (percent) <u>MINIMUM</u> MAXIMUM							

- Geosynthetics:** Where synthetic liners, geonets, geotextiles, or other geosynthetic materials are to be used, provided information as to the manufacturer, trade name, type, specifications and composition of each product.
- Non-Synthetic Liners:** Where clay or other soils will be used as the liner, provide information on the Atterberg Limits, soil density, moisture relationship moisture content, and sieve analysis to be maintained at the time of installation.
- Drainage System:** Where piping is installed as part of the leachate detection, leachate collection or gas disposal system submit plans and profile drawings of each level, cell or zone which clearly illustrates the: slope, spacing, diameter and schedule of all piping to be installed.

SECTION B. DESIGN BASIS

For each major element of the liner system outlined above, provide the following information which supports the basis for the design. Include copies of the results of all tests conducted at the site, assumptions, and calculations used in the design. The stability of the landfill site and design is to be determined at critical sections. This is to include any below grade excavations/embankments or berms that may be critical. Consideration must be given to long and short term stresses, equipment loadings, filling sequence, and the possibility of earthquakes. Where geosynthetics are used, a veneer stability analysis should be performed on the interfaces of the material and the soil or aggregates. A puncture analysis is to be included where a geosynthetic is used to protect a geomembrane. Include test results of all liner interfaces for friction angles. Following information is to be attached to this form and referenced to the appropriate section.

1. Subbase:

- i. Submit detailed information on how the subbase was sized and located, including the minimum and maximum depths to seasonal high water table and regional groundwater table. Be sure all elevations are tied to projects grid system and benchmarks. Explain this bases for the subbase size and materials selected.
- ii. Describe how the subbase will bear the weight of the liners, leachate detection and collection systems, wastes, cover material, and operations equipment without causing or allowing any failure of the liner system. Explain what evaluations were conducted at the site and of the subgrade materials to ensure adequacy for the projected loads.
- iii. Discuss the potential for subsidence and the liner systems ability to allow for settlement.

2. Secondary Liner:

- i. Describe the physical, chemical, and thermal properties taken into consideration in selecting the secondary liner.
- ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or leachate.

SECTION B. DESIGN BASIS (con't)

3. Leachate Detection Zone:

- i. Describe the physical, chemical, and thermal properties taken into consideration in selecting materials.
- ii. Submit and discuss the results of any testing conducted on the detection zone materials which ensures they will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or its leachate.
- iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage.
- iv. Describe how the leachate detection zone will support the primary liner without causing punctures in the event of subsidence.

4. Primary Liner:

- i. Describe the physical, chemical and thermal properties taken into consideration in selecting the primary liner.
- ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or its leachate.

5. Protective Cover:

- i. Provide a detailed description of the physical and structural aspects of the protective cover. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated stresses and loads from wastes and operating equipment. Describe how the cover material will protect the primary liner from physical damage from stresses and disturbances from overlying wastes, cover materials, and equipment operations.
- ii. Describe how the protective cover will allow the continuous and free flow of leachate. Describe the possibility and effects of subsidence should it occur.

6. Leachate Collection System within Protective Cover:

- i. Provide a detailed description of the physical and structural aspects of the proposed leachate detection system. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated bearing loads (wastes and equipment), and leachate detection capabilities. Indicate which drawings and sections of the specifications contain the information on layout and material requirements.
- ii. Provide a description of how the system will detect, collect, and transmit leachate. Briefly describe the leachate treatment facilities and approvals obtained.
- iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage.
- iv. Provide an evaluation of geotextiles used as filters for filtration and clogging.
- v. Provide an evaluation for the transmissivity of geonets.

7. Cap:

- i. Provide a detailed description of the chemical and structural characteristics of the materials to be used for the final cover. Be sure to indicate the minimum and maximum size of materials allowed, sieve sizes, USDA Texture Class, and any other significant distinguishing characteristics.
- ii. Provide a description of how the materials are to be placed and compacted, with details on maximum slopes, minimum depths, and acceptable bearing loads.

PART III. LINER INSTALLATION PLAN	
SECTION A. SUBBASE	
1.	Information on the maximum depth of earth moving activities and the site preparation procedures to be followed prior to the installation of any subbase materials.
2.	Information on the selection of subbase materials, their grading and tests to be conducted to ensure uniformity.
3.	Information on how the subbase materials are placed, graded, compacted, and tested for proper installation.
SECTION B. LINERS	
1.	For synthetic liners, provide all information supplied by the manufacturer as to required handling and installation procedures.
2.	For non-synthetic liners, information on the minimum acceptable characteristics (i.e. moisture content, etc.) are to be provided.
3.	For synthetic and non-synthetic liners, information as to the equipment required, pre and post installation testing is to be provided.
SECTION C. LEACHATE DETECTION AND COLLECTION ZONES	
1.	Provide details on how the detection and collection zones will be installed with specific information as to what materials and construction techniques will be used to construct each zone.
2.	Describe the sequence of construction and equipment used.
3.	Describe the sequence for installing the sump and all monitoring or gas venting facilities.
SECTION D. PROTECTIVE COVER	
1.	Describe where the cover materials will come from, and how they are transported and placed at the site.
2.	Provide details on how the cover materials will be routinely tested for conformance with design specifications.
SECTION E. FINAL COVER AND GRADING	
1.	Provide a detailed description of how the final cover material is to be placed, compacted, and graded.
2.	Describe the proposed final layout for the area with specific reference to any drainage facilities which will remain.
SECTION F. ATTENUATING SOIL BASE (C/D WASTE LANDFILLS)	
1.	Explain how this proposal meets the requirements of Section 277.122 of the municipal waste regulations.
2.	Describe the Class of soils to be used as classified by the United State Department of Agriculture.
3.	Describe the proposed sequence for placement of waste and attenuating soils.
SECTION G. HIGHWALLS	
1.	Describe how the liner or barrier materials will be installed to prevent the migration of leachate from the disposal area.
2.	Provide information on each type of barrier material to be used and its minimum thickness. Include appropriate information on the physical and chemical characteristics of the material, and proof the material is not adversely affected by solid waste, leachate, or its constituents.
3.	Provide detailed information on the different seams or outcrops at the proposed site and how they will be isolated from wastes.
4.	Explain how groundwater and surface water drainage will be controlled and eliminated.
5.	Submit a plan for controlling damage from subsidence or the collapse of highwalls.
SECTION H. LIMITATIONS	
1.	Provide appropriate information on any land use restrictions or limitations that should be followed during and after closure of the facility.

PART IV. COMPATIBILITY OF LINER TO LEACHATE

A sampling plan for each component of the liner system, including sample size, methods for determining sample locations, sampling frequency, acceptance and rejection criteria, and methods for ensuring that corrective measures are implemented is to be included with this form.

SECTION A.

Information must be submitted which demonstrates that leachate will not adversely affect the physical or chemical characteristics of the liner system, or inhibit the liner's ability to restrict the flow of solid waste, solid waste constituents, or leachate, based on EPA or ASTM guidelines approved by the Department.

SECTION B.

Attach a copy of the chemical analysis of the leachate used in determining the above results.

SECTION C.

Where appropriate, attach an analysis of the current leachate emanating from this landfill.

PART V. PROPERTIES OF SYNTHETIC LINERS

Supply the following physical, chemical, mechanical, and thermal properties for liners, based on ASTM methods where appropriate. Additional information may be submitted.

	Results with Units of Measurement	ASTM Method
1. Thickness	See narrative.	
2. Tensile Strength at Yield		
3. Elongation at Yield		
4. Elongation at Break		
5. Density		
6. Tear Resistance		
7. Carbon Black Content		
8. Puncture Resistance		
9. Seam Strength (% of Liner Strength)		
10. Ultraviolet Light Resistance		
11. Carbon Black Dispersion		
12. Permeability		
13. Liner Friction Angle in Degrees		
14. Stress Crack Resistance		
15. Oxidative Induction Time		
16. Chemical Compatibility		
17. Percent Recycled Materials		

PART VI. QUALITY ASSURANCE PLAN FOR CONSTRUCTION AND FOR INSTALLATION OF LINERS

The following information shall be submitted on separate pages and referenced to the appropriate section. For each Section, a summary table is to be provided which explains the procedures, the frequency for each test, and the pass/fail criteria which must be met.

SECTION A.

Qualifications of independent QA personnel (describe experience and training).

SECTION B. SUBBASE

1. Provide design summary of procedures used to assure objectives are met:
 - a. Outline tests and observations to ensure quality of compacted fill.
 - b. Explain observations to ensure removal of objects or undesirable materials.
 - c. Discuss observations and tests that ensure that the surface is compacted, smooth, uniform, and consistent with design grades.
 - d. Summarize surveying to ensure that facility dimensions, side slopes, and bottom slopes are as specified in design.
 - e. Summarize review of Quality Control information.

SECTION C. NON-SYNTHETIC LINERS

1. Discuss inspection procedures of liner materials and test fill compaction. Properties to be tested should include: permeability, soil density/moisture content relationships, maximum clod size, particle size distribution, natural water content, Atterberg limits.
2. Outline procedures and methods for observing and testing liner materials before and after placement to ensure:
 - a. Removal of roots, rocks, etc.
 - b. Identification of changes in soil characteristics causing a change in construction specifications.
 - c. Adequate spreading and incorporation of water to obtain full penetration through clods and uniform distribution of the specified water content.
 - d. Maintaining optimum water content throughout wet and dry periods and during construction.

SECTION D. SYNTHETIC AND GEOSYNTHETIC LINERS

Outline Procedures For:

1. Inspection of product quality, the review of manufacturers control procedures and any other observations related to transporting, storing, and handling.
2. Inspection of foundation preparation and equipment.
3. Observations of liner placement.
4. Need and availability of manufacturers representative.
5. Observations of weather conditions.
6. Observations and measurements of anchor trench to ensure that it is as specified in design drawings.
7. Observations and tests to confirm that all designed liner penetrations and liner connections are installed as specified.
8. Visual inspection for tears, punctures, or thin spots during placement.
9. Inspections during and after liner seaming.
10. Observations and tests to assure that seals around liner penetrations are of sufficient strength and are impermeable to leachate.

SECTION E. PROTECTIVE COVER

Outline Procedures For:

1. Tests to ensure that the cover material meets design specifications, including permeability and clogging potential.
2. Observations that the cover material is free from objects that could damage the liner.
3. Observation to ensure that equipment used to place cover does not damage liner.
4. Measurements to ensure that entire liner is covered with specified thickness of cover material.

SECTION F. LEACHATE DETECTION AND COLLECTION SYSTEM

Discuss how the following activities will be conducted.

1. Observations and measurements to ensure that materials are of specified size and strength, and that pipe perforations are sized and spaced as specified.
2. Observations and tests to ensure that soils to be used are of proper size and gradation.
3. Method of placing bedding and inspection to ensure the pipes are bedded correctly and not susceptible to movement.
4. Observations and measurements to ensure that pipes are placed at specified locations, at specified grades, and are joined together as specified.
5. Observations and tests to ensure that backfilling is completed as specified in design, in all areas, including areas where a liner connects to a structure.
6. Testing of pipe joints and testing of solid wall pipes to ensure that there is no leakage.
7. Observations and tests of the granular drainage layer to ensure that the material meets the specifications of design (including permeability and clogging potential of geosynthetics).
8. Synthetic drainage layers: Observations to ensure proper placement, correct seaming, and allowable weather conditions.
9. Geotextiles: Observations of placement to ensure that specifications are followed, adequate overlap or seaming, and that there is no damage.
10. Sumps: Observations to ensure that structures are of specified dimensions, material, and capacity.
11. Mechanical and electrical equipment installation: Observations to ensure that equipment is in accordance with design specifications and manufacturer's recommendations.

SECTION G. FINAL COVER SYSTEM

Discuss who and how following activities will be conducted:

1. Observations and tests to evaluate stability of cover system foundation.
2. Observations and testing as necessary to confirm that soil materials meet specified design.
3. Non-synthetic component: Monitor soil type, moisture content, density, compaction, lift thickness, clod size, uniformity of compaction, completeness of coverage, and permeability.
4. Tests for seals around penetrations such as gas vent pipes to ensure that they do not leak.
5. Inspections for perimeter of cover, where the soil component joins or overlies the liner system, to ensure that it is installed according to specifications.
6. Liners used in the capping system shall follow guidelines for synthetic liners.
7. Observations for a protective layer, such as a geotextile, which is placed above the liner as protection from drainage layer, to ensure proper placement to avoid damage to the liner.
8. Drainage and gas venting layer placement: The gas discharge layer is placed below the synthetic liner and the water drainage layer is placed above the synthetic liner. Guidelines for the leachate collection and detection zone will be followed. Inspections of the installation of the drainage layers around the perimeter of the cover system is important, for it is here that the system connects to the surface drainage facilities. Ensure that design specifications, particularly dimensions and slopes, are achieved. Controlled gas discharge or collection systems are checked for proper installation and function.
9. Filter layer used above or below drainage layer to stop migration or piping of fine materials should be tested for any clogging potential. During construction of filter layer, inspection will include monitoring of particle size (for soil materials) or geotextile type and certification, seaming or overlap for geotextiles, slope of surface, and coverage.
10. Topsoil layer placement: Monitor uniformity of application process, observations to ensure that soil is not overly compacted, and measurements of thickness and slope of topsoil layer.
11. Topsoil seeding: Inspection of seeding process, measurement of tilling depth, application rate of additives should be monitored for consistency with design specifications. Application equipment will be appropriate. Verify that all vents and standpipes or other penetrations through cover are not damaged by tilling and application process. Weather conditions are to be appropriate. Post-construction: Slopes will be surveyed and any unusual depressions noted and corrected.
12. Review of Quality Control information.

Form 24 – Liner System – Phase II
Form 2540-PM-BWM0150, Rev. 6/2005
Greater Lebanon Refuse Authority (Permit No. 101544)
Heilmandale Expansion

PART II. DESIGN OF LINER SYSTEM

The proposed bottom liner system will consist of the following, top to bottom:

- 18 inches of Protective Cover (AASHTO No. 8 aggregate)
- 16 ounce per square yard non-woven geotextile cushion layer
- 60 mil textured high-density polyethylene (HDPE) liner
- Geocomposite drainage net Leachate Detection Zone
- 60 mil textured high-density polyethylene (HDPE) liner
- Geosynthetic clay liner (GCL)
- 6-inch thick Prepared Subbase soil layer

The proposed Standard final cover system will consist of the following, top to bottom:

- Two-feet of Final Cover, consisting of 18 inches of Vegetative Subsoil covered by six inches of Vegetative Topsoil material.
- Drainage Layer, consisting of a geocomposite drainage net (GDN)*
- 40 mil textured linear-low density polyethylene (LLDPE) liner*
- 10 ounce per square yard non-woven geotextile cushion layer
- Intermediate cover

*50 mil LLDPE Super Gripnet® by Agru America, with an overlying non-woven geotextile, is a proposed equivalent alternative to these components. The “friction spike” side faces downward with the “drainage stud” side upward.

A Settlement Accommodation Plan has been prepared and is included in **Attachment 24-C**.

A. PROJECT SPECIFICATIONS

Refer to specifications included as **Attachment B** in the Quality Assurance/Quality Control Plan in Form J.

B. DESIGN BASIS

1. Subbase

- i. **Submit detailed information on how the subbase was sized and located, including the minimum and maximum depths to seasonal high water table and regional groundwater table. Be sure all elevations are tied to project grid system and benchmarks. Explain this bases for the subbase size and materials selected.**

A geosynthetic clay liner (GCL) will be used in lieu of a soil subbase layer. An equivalency request (Form Q) for the use of the GCL is included with this permit application. It was previously approved with the Shilling Farms permit application.

The minimum depth to the seasonal high water table is eight feet at the sump area. The bottom liner is graded up at a minimum two percent from the sump area. Elevations are coordinates are tied to a coordinate grid system, as indicated on the Permit Drawings.

- ii. **Describe how the subbase will bear the weight of the liners, leachate detection and collection systems, wastes, cover material, and operations equipment without causing or allowing any failure of the liner system. Explain what evaluations were conducted at the site and of the subgrade materials to ensure adequacy for the projected loads.**

A bearing capacity analysis was performed to calculate the factor of safety against a general shear failure of the foundation soils due to the proposed maximum waste loads. Although the bearing capacity is indirectly computed in the global slope stability analysis performed using PCSTABL5M and found to be acceptable, as discussed herein, we also used the classic Terzaghi (reference J.E. Bowles, Foundation Analysis and Design, 1982) method for this specific calculation.

For this analysis, the maximum waste loading was assumed to be 220 feet of waste at an average density of 75 pounds per cubic foot (pcf). This average density value is based on previous reports, existing conditions, and engineering judgement. Regardless of the waste density assumptions, the landfill was conservatively modeled following Terzaghi's bearing capacity method as a rectangular foundation measuring 1750 feet by 1850 feet that overlying soil with an assumed friction angle of 30 degrees and zero cohesion.

The calculations are provided in a spreadsheet in **Attachment 24-B** titled Soil Bearing Capacity Calculation. A factor of safety (also referred to as Design Ratio DR, in the calculations) of 45 was computed, which indicates the foundation is more than adequate to support of the weight of the landfill at the maximum waste height of 220 feet. In general, a factor of safety of least 3.0 is required for this type of analysis.

- iii. **Discuss the potential for subsidence and the liner systems ability to allow for settlement.**

Settlement Potential of the Subgrade

Settlement potential beneath the liner system (subgrade) was evaluated for three cross sections of the landfill. Alignment locations are provided in **Attachment 24-B**. Settlement calculations

were performed for the areas that will overlie native shale and greywacke, or where compacted fill may be needed.

Assuming a conservative 40 foot depth of potentially compressible materials below the base grade and consisting of weathered Hamburg sequence, it was calculated that primary settlement of the base due to unloading from excavation, new waste loading, bottom liner and final cover materials ranges from approximately 2.1 inches at Station 2+00 near the toe of slope to a conservative maximum of 5.52 inches at Station 12+00 in the middle of the landfill, which is relatively small and will not result in significant elongation or tensile stresses in the bottom liner. Also, no significant change in bottom liner slope will occur as a result of these settlement magnitudes. A calculation spreadsheet is included in **Attachment 24-B**.

Final Cover Settlement

Settlement of the waste column is discussed in the Settlement Accommodation Plan (SAP) included as **Attachment 24-C**. Under the SAP, expansion waste will be over top of existing solid waste, and to an elevation that is slightly above the permitted grades. That waste will be allowed to settle back down to the permit grades for up to 5 years before capping will commence. Areas that do not settle below permitted grades will be graded to comply.

Similar to the SAP discussion, settlement of the final cover will be largely dependent on the final waste thickness in any one area, as well as on waste types, age, compaction and density. Assuming that the waste types, daily cover, and density are generally similar throughout the life of the landfill, the magnitude of post closure settlement will be predominantly a function of waste thickness.

Based on the work of Sowers (1973) and others, and for purposes of the SAP, we estimated that settlement over a period of 5 years from the end of filling (but, before final cover construction), will average up to 7.9 percent of the expansion waste thickness. That rate will decline each year after the cap system is in place. For the long term, that is for decades after closure, post closure settlement of landfills ranges from 4 percent to about 15 percent of waste thickness, depending on waste types, compaction, amount of organic matter, and other factors. The lower bound magnitude would be presentative of heavily compacted, low organic content waste, while the upper bound value would represent more organic waste that received nominal compaction.

Using Sowers relationship for estimating waste settlement and assuming conditions favorable to decomposition, a waste void ratio, e_0 of 2.5, the compression factor $C_s = 0.08 \times e_0 = 0.20$, secondary compression for a period of time 30 years after capping ($t_1 = 1$ year and $t_2 = 31$ years), S/H would be approximately 8.5 percent.

$$S = H * (C_s / (1 + e_0)) * \log(t_2 / t_1) \dots \dots \dots \text{Sowers (1973)}$$

Thus, for a maximum waste thickness of about 220 feet (which includes underlying waste in the piggyback area), the minimum total long term (post closure) settlement (S) could be between about 8.8 feet to 33 feet, but probably closer to 9 to 10 feet. For either case, a 3:1 sideslope that is 160 feet high by 480 feet across will gradually flatten to approximately 4:1 or

flatten over time. This settlement will not produce tensile stresses in the final liner cover system or general elongation of the liners. Based on the landfill cross sections, it appears that the most areas on the landfill plateau will have relatively similar waste thicknesses and thus will tend to settle approximately the same magnitudes. Additional localized settlements are likely to occur due to waste property variation and other factors, but such localized settlement can be repaired as part of the landfill maintenance program and should have a significant impact on cover system integrity.

Based on this evaluation, the final cover cap options and design slopes are more than adequate to handle the anticipated long term settlement. It is concluded that long term settlement will generally result in liner compression, rather than tension, indicating the overall final cover geomembrane will not experience elongation that could damage the liner components.

2. Secondary Liner

i. Describe the physical, chemical, and thermal properties taken into consideration in selecting the secondary liner.

GLRA is proposing to use 60 mil textured high density polyethylene (HDPE) geomembrane for the secondary liner. HDPE have proven to be an excellent means to resist degradation associated with physical, chemical and thermal conditions present in a landfill environment, while maintaining an impermeable ($\leq 1 \times 10^{-12}$ cm/sec) barrier to leachate. Additional material properties can be found in the technical specifications included as **Attachment B** in the Quality Assurance/Quality Control Plan in Form J.

ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or leachate.

Please note that the geosynthetic properties proposed for developing the Heilmandale Expansion were previously approved for the Shilling Farm Expansion. Technical specifications requirements are included as **Attachment B** in the Quality Assurance/Quality Control Plan in Form J.

The HDPE geomembrane specified has a very low hydraulic conductivity, excellent resistance to chemical constituents found in typical municipal solid waste leachate, adequate puncture resistance tensile properties, and is used frequently in sanitary landfill liner applications.

HDPE has a very low permeability, which minimizes the penetration of chemicals into the polymer, due to its relatively linear polymer structure, close fitting polymer chains, and relatively dense semi-crystalline structure. Carbon black is added to the polymer at between two and three percent to improve ultraviolet (UV) light resistance. However, project requirements will limit the period of potential UV exposure to less than 30 days to further limit potential degradation. Antioxidants are added in small quantities (less than 0.5 percent) to HDPE to reduce oxidation potential. However, conditions that may cause significant oxidation of stabilized HDPE are generally not expected in sanitary landfills. This is primarily since excessive temperatures required for oxidation are not present in landfills. Plasticizers are

not added to HDPE, in contrast to other geomembrane products, and thus migration of plasticizers is not a concern.

HDPE geomembrane is one of the most chemically resistant liners available, and is used frequently in sanitary landfill applications. HDPE properties and chemical resistance are well documented. Although none are expected, high concentrations of inorganic substances do not appear to degrade HDPE.

3. Leachate Detection Zone

i. Describe the physical, chemical, and thermal properties taken into consideration in selecting the secondary liner.

GLRA is proposing to use a geocomposite drainage net (GDN) within the leachate detection zone to convey liquid in the leachate detection zone. The geonet component of the drainage composite is comprised of an extruded HDPE polymer that is capable of resisting chemical degradation, while maintaining the required transmissivity under the anticipated loadings. In addition to the geonet component, the composite has a layer of polyester or polypropylene non-woven geotextile that is heat-bonded to each side of the geonet. The geotextile layers helps filter sediment from the liquid in the leachate detection zone. Polypropylene and polyester geosynthetics are capable of being used for a variety of applications within a landfill liner and cap system without concern over a loss in their performance due to chemical impact. A design analysis associated with the hydraulic characteristics (transmissivity) of the GDN is enclosed in **Form 25 - Attachment B**.

ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or leachate.

See response to 3.i above.

iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage.

N/A, since a geocomposite drainage net material will be used, there are no pipes to clean and/or maintain.

iv. Describe how the leachate detection zone will support the primary liner without causing punctures in the event of subsidence.

GDN liners are widely used for leachate detection systems. The materials are selected due to their ability to withstand the resulting loads while not puncturing the liner system. Testing of proposed materials will be as required by the technical specifications included as **Attachment B** in the Quality Assurance/Quality Control Plan in Form J. Part of the transmissivity testing considerations used in the selection of GDNs is the predicted bearing loads.

4. Primary Liner

- i. **Describe the physical, chemical, and thermal properties taken into consideration in selecting the secondary liner.**

See response to 2.i above.

- ii. **Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or leachate.**

See response to 2.ii above.

5. Protective Cover

- i. **Provide a detailed description of the physical and structural aspects of the protective cover. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated stresses and loads from wastes and operating equipment. Describe how the cover material will protect the primary liner from physical damage from stresses and disturbances from overlying wastes, cover materials, and equipment operations.**

The protective cover layer is comprised of an 18-inch thick layer of non-carbonate AASHTO No. 8 aggregate with a minimum permeability of 0.3 cm/sec. The protective cover will contain a network of perforated drainage pipes that outlet to the sump. The slope of the protective cover layer will range between 2 percent and 33 percent and cover the base and sideslopes of the disposal area.

An analysis on the required unit weight of the non-woven geotextile cushion layer needed to protect the primary geomembrane from the protective cover aggregate is enclosed under **Attachment B**. Based on the analysis, a minimum 16-ounce per square yard geotextile is necessary.

A veneer stability analysis (**Attachment 24-A**) was completed on the liner system. The analysis evaluated the forces that may develop in the geosynthetic components due to construction equipment during installation of the protective cover. The results of the analysis indicate that the forces that may develop in the geomembrane layers would be acceptable (i.e., below their yield strength).

- ii. **Describe how the protective cover will allow the continuous and free flow of leachate. Describe the possibility and effects of subsidence should it occur.**

The HELP Model results in Form 25 demonstrate that there will be no more than one foot of head on the liner. During construction of the bottom liner system samples of protective cover layer materials will be tested by an independent laboratory to verify that the minimum permeability requirements are achieved. Subsidence events are not anticipated to impact the bottom liner system.

6. Leachate Collection System within Protective Cover

- i. Provide a detailed description of the physical and structural aspects of the proposed leachate collection system. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated bearing loads from (wastes and equipment), and leachate detection capabilities. Indicate which drawings and sections of the specifications contain the information on layout and material requirements.**

The leachate collection system will be comprised of a network of perforated HDPE pipes located within the protective cover system. The perforated pipes will be embedded within a layer of AASHTO No. 57 (or approved equivalent) aggregate that will be encased by a 16 ounce per square yard non-woven geotextile. Refer to the Permit Drawings for a layout and details of the leachate collection system.

Pipe strength calculations for the leachate collection pipe can be found in **Form 25 - Attachment B**. Based on the results of the analysis, SDR 11 HDPE pipe will be capable of withstanding the design overburden stress.

The HELP Model demonstrates that hydraulic head will not exceed one foot over the liner system when leachate collection pipes are spaced no more than 200 feet (**Form 25 - Attachment A**). The pipe capacity analysis (**Form 25 - Attachment B**) demonstrates that the smallest diameter pipe within the leachate collection system (six inches) is capable of accommodating peak design flows predicted by the HELP Model.

Leachate transmission pipes located outside the lined disposal area will either be air, vacuum or water pressure tested per manufacturer's recommendations. Also, leachate transmission pipes outside of the lined disposal areas will be dual-contained, allowing leaks to be detected through visual inspections at the pipe outlets.

- ii. Provide a description of how the system will detect, collect, and transmit leachate. Briefly describe the leachate treatment facilities and approvals obtained.**

Leachate generated from the lined landfill area will be directed to the existing on-site leachate storage tank using gravity drains and lift stations. The leachate will be discharged to the municipal sanitary sewer for treatment. GLRA has an agreement in place to discharge leachate to the City of Lebanon Authority sanitary sewer system.

- iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage.**

GLRA will periodically inspect pipe mains for the presence of blockages. Inspections will also be completed when abnormally low flows are observed. In the event a blockage is identified, GLRA will attempt to remove the blockage by flushing the pipe system with a high pressure water cleaning system. Access to the leachate collection pipe mains will be achieved through the clean-out risers.

iv. Provide an evaluation of geotextiles used as filters for filtration and clogging.

A 16-ounce per square yard non-woven geotextile filter will be wrapped around the collection zone piping to minimize the impacts from sediment (See Permit Drawing 23).

v. Provide an evaluation for the transmissivity of geonets.

N/A, since geonets will not be used in the leachate collection system within the protective cover.

7. Cap

i. Provide a detailed description of the chemical and structural characteristics of the materials to be used for the final cover. Be sure to indicate the minimum and maximum size of materials allowed, sieve size, USDA Texture Class, and any other significant distinguishing characteristics.

The proposed Standard final cover system will consist of the following, top to bottom:

- Two-feet of Final Cover, consisting of 18 inches of Vegetative Subsoil covered by six inches of Vegetative Topsoil material.
- Drainage Layer, consisting of a geocomposite drainage net (GDN)*
- 40 mil textured linear-low density polyethylene (LLDPE) liner*
- 10 ounce per square yard non-woven geotextile cushion layer
- Intermediate cover

*50 mil LLDPE Super Gripnet® by Agru America, with an overlying non-woven geotextile, is a proposed equivalent alternative to these components. The “friction spike” side faces downward with the “drainage stud” side upward.

The cap geomembrane will be installed atop of a cushion geotextile placed on the minimum 12-inch thick intermediate cover soil material that will be graded to conform to the required contours.

Final cover must be at least two feet thick and capable of supporting the germination and propagation of vegetative cover as required by 25 PA 273.235 and 273.236 (relating to revegetation; and standards for successful revegetation). A six-inch thick Vegetative Support Layer is included in the final cover system to establish vegetation on the landfill. The final cover soil shall meet the following design requirements:

- (1) The cover soil shall fall within the United States Department of Agriculture textural classes of sandy loam, loam, sandy clay loam, silty clay loam, loamy sand and silt loam as defined in the Soil Survey Manual published by the United States Department of Agriculture, Soil Conservation Service.

(2) At least 40 percent by weight of the cover soil shall be capable of passing through a 2 millimeter, No. 10 mesh sieve.

(3) The cover may not include rocks that are greater than 6 inches in diameter.

Final cover benches (terraces) will be vegetated and sloped to manage stormwater. The final cover layer will be tested as needed to evaluate the ability to support vegetation. Nutrients and fertilizers needed for growth will be added as required. A detailed description of the vegetation plan is provide in the Form H, Revegetation.

A slope stability analysis, included in **Attachment 24-A**, demonstrates that slope stability Factors of Safety (FS) under seismic and static loading conditions for the proposed expansion grades meet regulatory requirements and good engineering practice for global and veneer stability.

ii. Provide a description of how the materials are to be placed and compacted, with details on maximum slopes, minimum depths, and acceptable bearing loads.

The proposed final grade of the landfill will incorporate slopes that range from 3 to 33 percent. The geosynthetic materials will be placed over the final lift of waste and cushion geotextile in accordance with the Technical Specifications included as Attachment B in the Quality Assurance/Quality Control Plan in Form J. Details are presented on the Permit Drawings.

A minimum 24-inch Final Cover Soil layer consists of 18-inches of Vegetative Support material and 6-inches of Vegetative Topsoil. The final cover layer will be placed in accordance with Technical Specification Section 02225 – Earthwork.

Final cover will be permanently stabilized with vegetation or aggregate (roads, channels) to limit erosion of the soil cover. For more information, refer to the Form H for Revegetation and Form I for Soil Erosion and Sedimentation Controls.

PART III. LINER INSTALLATION PLAN

Refer to Quality Assurance/Quality Control Plan in Form J, Attachment B.

PART IV. COMPATABILITY OF LINER TO LEACHATE

Please note that the liner proposed for developing the Heilmandale Expansion was previously approved for the Shilling Farm Expansion.

PART V. PROPERTIES OF SYNTHETIC LINERS

Refer to Quality Assurance/Quality Control Plan in Form J, Attachment B.

PART VI. QUALITY ASSURANCE PLAN FOR CONSTRUCTION AND INSTALLATION OF LINERS

Refer to Quality Assurance/Quality Control Plan in Form J, Attachment B.

FORM 24 – ATTACHMENT A

Slope Stability Analysis

**Form 24 – Attachment A – Slope Stability Analysis
Greater Lebanon Refuse Authority (Permit No. 101544)
Heilmandale Expansion**

INTRODUCTION

This slope stability analysis was performed as part of the Greater Lebanon Refuse Authority proposed Heilmandale landfill expansion project. This analysis addresses both global and veneer stability for selected loading conditions and was based on the base and final grading plans prepared by SCS Engineers dated July 2018.

The global slope stability was evaluated using the computer program PCSTABL5M, which uses two-dimensional limit equilibrium methods to calculate a factor of safety (FS) against shear failure for slope sections analyzed. This program uses an automatic search routine to generate multiple shear failure surfaces for both circular failures and block or wedge-type failure modes until the surface with the lowest FS-value is found. The ten most critical failure surfaces and their FS are reported on a graphical printout. The analytical methods used for the circular and sliding block failure modes in the slope stability analysis are the Modified Bishop and Modified Janbu methods, respectively. Final slope static and seismic stability analyses, minimum acceptable factors of safety are 1.5 and 1.0 by industry standards, respectively.

The final cover (veneer) slope stability was evaluated using an analytical model developed by Koerner and Soong, “Analysis and Design of Veneer Cover Systems,” 1998, and presented at the 6th International Conference on Geosynthetics. The model is presented in a spreadsheet and considers static conditions, seismic forces and seepage forces.

The soil, waste and geosynthetic interface shear strength and density parameters used in the analysis were taken from the existing site conditions, and based upon engineering judgment. The minimum factor of safety that corresponds to a specified interface friction angle was calculated for either the static or the seismic loading conditions.

The veneer stability was also evaluated for both the static and seismic loading conditions using a set of interface shear strength parameters that would be specified in the project specifications.

The assumptions used in the analysis and the conclusion and recommendations are presented in this memorandum.

SLOPE GEOMETRY AND SECTIONS EVALUATED

The proposed landfill final grading plan for the expansion is shown on **Figure 1**. The proposed final slopes at the proposed Heilmandale Expansion are to have minimum sideslopes of 3(H):1(V) between benches and a relatively small plateau area at the top of the landfill. The piggy-back filling area (over the existing unlined landfill area) has an existing average slope of 13 percent. The total waste height when the expansion is completed will be 220 ft, and includes the waste underlying the piggyback area.

Three critical cross sections were selected for the analysis as shown in **Figure 1**. These sections were taken at the steepest sections, as well as over the existing waste.

Based on the slope length, slope height and its base grades, these sections were considered to be most critical and therefore were used to evaluate the global static and seismic slope stability for the final slope. Both circular and block type failure modes were assumed and analyzed for each section.

LINER SYSTEMS

The bottom liner system consists of the following (top to bottom):

- 18-inches protective cover layer
- Geotextile (non-woven)
- 60 mil geomembrane (HDPE) – double-sided textured
- Geocomposite drainage net
- 60 mil geomembrane (HDPE) – double-sided textured
- Geosynthetic Clay Liner (GCL)
- 6-inches of prepared subbase

The final cover system consists of the following (top to bottom):

- Permanent vegetation
- 6-inches topsoil/vegetative support layer
- 18-inches final cover layer
- 300-mil Geocomposite drainage net*
- 40 mil geomembrane (LLDPE) – double-sided textured*
- 12-inches of intermediate/daily cover over waste

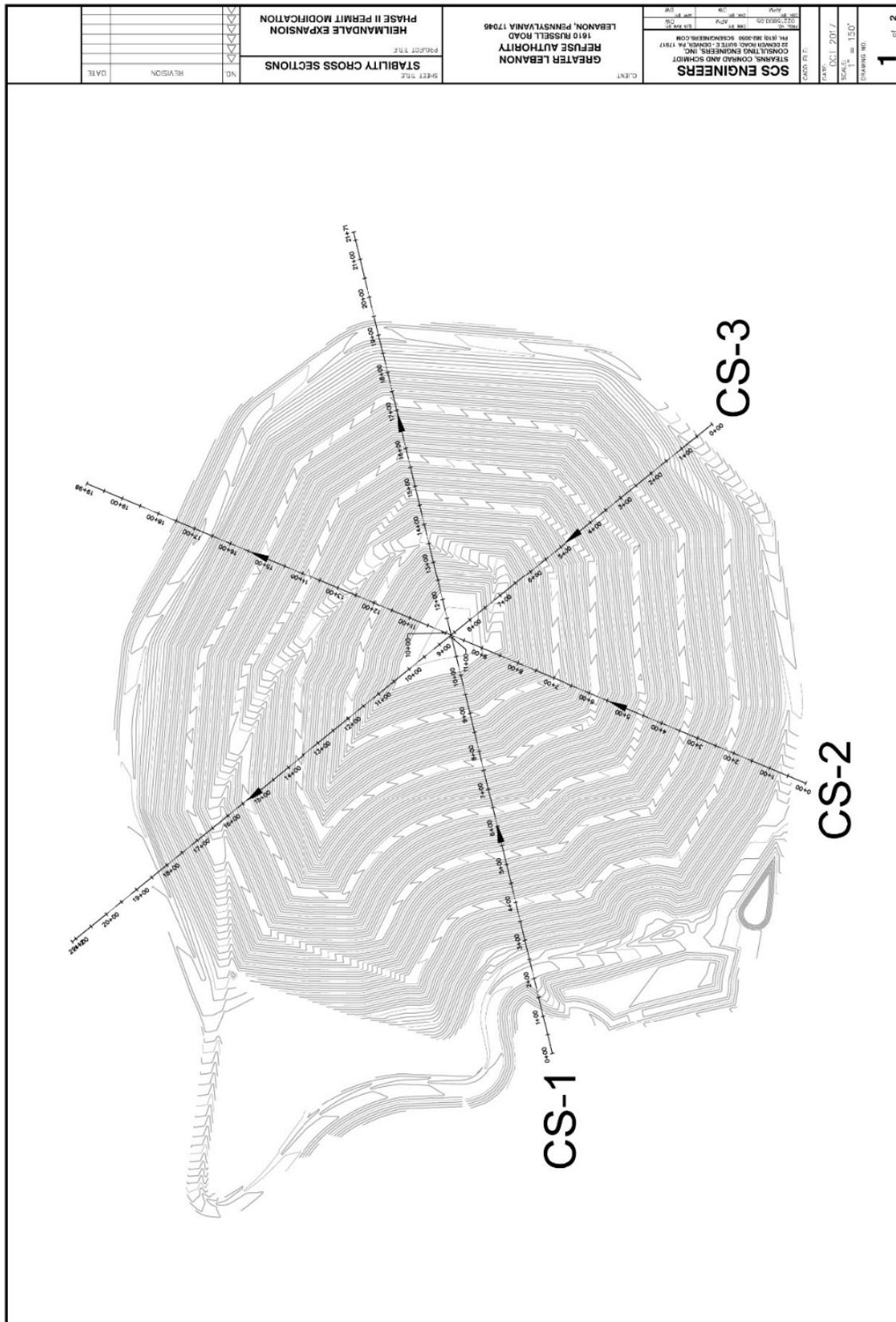
*50 mil LLDPE Super Gripnet® by Agru America, with an overlying non-woven geotextile, is a proposed equivalent alternative to these components. The “friction spike” side faces downward with the “drainage stud” side upward.

ASSUMPTIONS

The global slope stability analysis was performed on the final slopes based on these assumptions:

- The internal friction angle of waste material is assumed to be 25 degrees, with adhesion (cohesion) equal to 125 pounds per square foot (psf). These waste properties were taken from the Landfill Stability Analysis¹, and are realitively conservative for compacted MSW. The unit weight of the waste is assumed to be 60 pounds per cubic foot (pcf) for the anticipated compacted waste, which is also very conservative and considers the weight of daily soil cover material.

¹ Landfill Stability Analysis – Figure 11 – Gordon P. Boutwell (2004)

Figure 1. Final Slope Cross-Section Locations

- The maximum waste heights range from approximately 175 to 220 feet from the base of the unlined landfill to the top of the landfill final cover.
- The lowest (controlling) interface friction angle for the bottom liner system was assumed to be between the textured HDPE geomembrane and the non-woven geotextile, but the lowest interface will control. We have assumed the interface to have a 17-degree friction angle, with zero adhesion, or equivalent shear strength. Other interfaces such as between a textured geomembrane and Geosynthetic Clay Liner (GCL) interface will have similar or higher equivalent shear strength values when adhesion value is considered.
- The foundation soil for the landfill is assumed to have a density of 120 pcf with a friction angle of 30 degrees, based on engineering judgement.
- The analysis includes a block-type failure surface along the weakest interface of geosynthetic/geosynthetic or soil/geosynthetic components of the liner system as well as a circular failure surface within the waste mass.
- The maximum horizontal ground acceleration used in the analysis is 0.08g, based on the seismic map provided by the USGS Seismic Hazard Map (2014)².
- According to industry standards, acceptable factors of safety (FS) for global static and seismic slope stability analyses are equal to or greater than 1.5 and 1.0, respectively.
- The ground water level is assumed to be below the excavation grades.
- For the final cover (veneer) slope stability analysis, the following are assumed:
 - Lowest interface friction angle assumed in the analysis is 19 degrees and 0 psf adhesion. This value applies to the 40 mil double-textured LLDPE or the 50 mil Super Gripnet alternative.
 - Average cover soil (internal) friction angle was assumed to be 30 degrees and 0 psf cohesion.
 - Maximum final cover slope was assumed to be at a 3(H):1(V) slope, or 18.4 degrees between benches.
 - Maximum length of the slope was assumed to be 160 feet. (Note: Benches are spaced every 40 vertical ft along the slope)
 - The seepage analysis assumed a 24-hour, 25-year storm event to be 6 inches (6.70 mm per hour) and considered a permeability of the drainage layer to be equivalent to 4 cm/sec.

² USGS 2014 Seismic Hazards Map – 2014 Long-Term Model – PGA 2% in 50 years

RESULTS OF ANALYSIS

The results of the global slope stability analysis for the above mentioned section profiles and loading conditions are summarized in **Table 1**. Based on the locations of Sections CS-1, CS-2, and CS-3, the assumptions and values taken from the reports, the computed safety factors meet the requirements for long-term global slope stability. The locations of the critical failure surfaces for each circular and block-type failure surfaces are shown on the graphs presented in **Attachment 24-A-1**. Detailed PCSTABL5M output files are also included in **Attachment 24-A-1**.

For the final cover stability analysis, the results are shown in **Table 2**. Both static and seismic slope stability analysis meet the minimum factors of safety requirements. When considering the seepage forces in the final cover system during a 25-year 24-hour storm event, the calculation shows that the cap system is not saturated and the factor of safety is greater than 1.0. Detailed spreadsheet printouts for each evaluation are included in **Attachment 24-A-2**.

Static factors of safety calculated were above 1.5 and thus meet the minimum factor of safety required by industry standards. In addition, since seismic factors of safety calculated were above 1.0, a permanent displacement or deformation analysis was not necessary for the landfill expansion areas.

CONCLUSION AND RECOMMENDATION

As shown in **Table 1**, Section CS-1 represents the worst case scenario for circular failure mode within the waste mass and for block-type failure mode within the liner system. The static factor of safety calculated is equal to 1.78 for circular failure surface and 1.55 for block-type failure surface within the bottom liner system. Under seismic loading conditions of 0.08g, these factors of safety are reduced to 1.36 (static) for the circular failure surface and 1.16 (seismic) for the block-type failure surface within the liner system. The minimum interface friction angle of the bottom liner system should be specified as 17 degrees with no adhesion. However, if adhesion is considered in the analysis, then this minimum friction angle can be lowered to achieve the same effective shear strength.

From the results presented in **Table 1**, a block-type failure surface located along the weakest liner interface generally would have a lower FS than a circular failure surface located within waste mass. Therefore, it is concluded that a block-type failure surface along the weakest liner interface is more critical than that of a circular failure surface located within the waste mass.

From the results presented in **Table 2**, a minimum FS of 1.92 for static veneer slope stability analysis and 1.48 for the seismic slope stability analysis may be obtained for the 3:1 final sideslopes with a maximum slope length of 120 feet, assuming a block-type failure surface and using a critical interface friction angle of 19 degrees and 0 psf adhesion. When evaluating the final cover soil saturation issue, the specified drainage layer of 4 cm/sec is capable of draining infiltration from a 25-year 24-hour storm event and thus the final cover system should not be saturated. The FS values however would depend on the critical shear strength parameters of the weakest liner interfaces and the slope length of the 3:1 final side slopes.

Based on the analysis, it is concluded that the final cover system will be stable under both static and seismic loadings appropriate for the region and will have adequate drainage capacity to remain unsaturated.

Due to the sensitivity of the shear strength values used in the analysis, a project-specific interface friction angle testing using ASTM D 5321 (Direct Shear Testing) of the critical geosynthetic/soil or geosynthetic/geosynthetic interface or ASTM D 6243 (GCL/soil or GCL/geosynthetic interface) should be included as a part of the material selection and acceptance process. Normal stresses used in the test should be site-specific and reflect loading conditions above the approximate location of the failure zone.

Table 1. Summary of Final Global Slope Stability Modeling

Section	Description	Failure Mode	Friction (deg)/Adhesion (psf)	Factor of Safety (FS)	Status
CS-1	Runs West to East	<u>Circular</u> Static Seismic (0.08g)	17/0	1.78 1.36	OK OK
		<u>Block-type in liner system</u> Static Seismic (0.08g)	17/0	1.55 1.16	OK OK
CS-2	Runs Southwest to Northeast	<u>Circular</u> Static Seismic (0.08g)	17/0	2.13 1.62	OK OK
		<u>Block-type in liner system</u> Static Seismic (0.08g)	17/0	1.66 1.21	OK OK
CS-3	Runs Southeast to Northwest	<u>Circular</u> Static Seismic (0.08g)	17/0	1.87 1.44	OK OK
		<u>Block-type in liner system</u> Static Seismic (0.08g)	17/0	1.90 1.36	OK OK

Table 2. Veneer Slope Stability Analysis

Veneer Model	Factor of Safety	Comment
Static	1.77	Final cover soil system with interface friction angle = 19 degrees and 0 psf adhesion
Seismic	1.39	PGA = 0.08g
Seepage	1.09	Max. permeability of final cover soil = 1×10^{-6} cm/sec.; drainage layer = 4 cm/sec.

Attachments:

24-A-1 PCSTABL5M Graphical Data Printouts
24-A-2 Vener Stability Calculations

ATTACHMENT 24-A-1

PCSTABL5M Graphical and Data Printouts

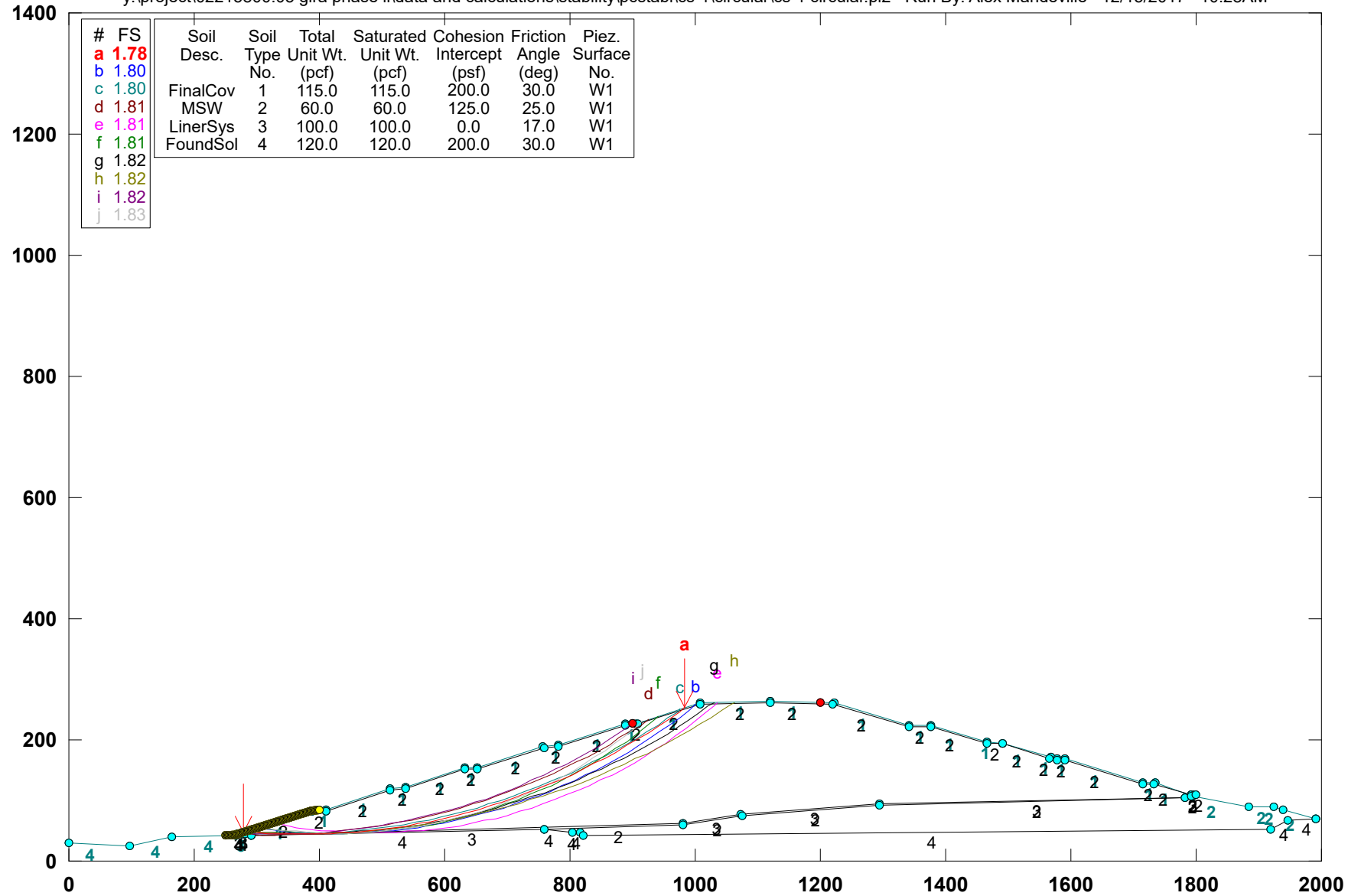
Section CS-1

Final Slope Stability Analysis

Circular Failure Surface, Static

GLRA - CS-1 Circular Failure

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-1\circular\cs-1 circular.pl2 Run By: Alex Mandeville 12/15/2017 10:28AM



PCSTABL5M3 FSmin=1.78

Safety Factors Are Calculated By The Modified Bishop Method

** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:28AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-1 circular.

Output Filename: Y:cs-1 circular.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-1 circular.PLT

PROBLEM DESCRIPTION GLRA - CS-1
Circular Failure

BOUNDARY COORDINATES

31 Top Boundaries
79 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	30.00	97.96	23.77	4
2	97.96	23.77	164.38	38.97	4
3	164.38	38.97	265.33	43.23	4

4	265.33	43.23	269.77	44.69	3
5	269.77	44.69	387.60	83.23	1
6	387.60	83.23	410.33	85.22	1
7	410.33	85.22	513.06	119.23	1
8	513.06	119.23	536.40	121.23	1
9	536.40	121.23	632.53	153.23	1
10	632.53	153.23	651.25	153.72	1
11	651.25	153.72	757.79	189.23	1
12	757.79	189.23	780.44	191.00	1
13	780.44	191.00	889.35	227.23	1
14	889.35	227.23	906.87	227.33	1
15	906.87	227.33	1008.77	261.23	1
16	1008.77	261.23	1120.91	263.23	1
17	1120.91	263.23	1221.01	261.23	1
18	1221.01	261.23	1342.42	224.20	1
19	1342.42	224.20	1376.58	224.20	1
20	1376.58	224.20	1465.91	197.23	1
21	1465.91	197.23	1490.18	195.23	1
22	1490.18	195.23	1566.93	170.81	1
23	1566.93	170.81	1577.87	169.27	1
24	1577.87	169.27	1589.91	169.23	1
25	1589.91	169.23	1715.34	129.33	1
26	1715.34	129.33	1733.68	129.23	1
27	1733.68	129.23	1794.33	107.23	1
28	1794.33	107.23	1884.06	89.23	2
29	1884.06	89.23	1924.99	89.60	2
30	1924.99	89.60	1938.67	85.23	2
31	1938.67	85.23	1991.05	70.57	2
32	275.54	46.58	281.47	46.47	3
33	281.47	46.47	388.00	81.26	2
34	388.00	81.26	410.78	83.25	2
35	410.78	83.25	513.46	117.26	2
36	513.46	117.26	536.81	119.26	2
37	536.81	119.26	632.88	151.24	2
38	632.88	151.24	651.60	151.73	2
39	651.60	151.73	758.19	187.26	2
40	758.19	187.26	780.84	189.02	2
41	780.84	189.02	889.68	225.23	2
42	889.68	225.23	907.20	225.33	2
43	907.20	225.33	1009.11	259.24	2
44	1009.11	259.24	1120.91	261.23	2
45	1120.91	261.23	1220.69	259.24	2
46	1220.69	259.24	1342.12	222.20	2
47	1342.12	222.20	1376.28	222.20	2
48	1376.28	222.20	1465.53	195.26	2
49	1465.53	195.26	1489.79	193.26	2
50	1489.79	193.26	1566.48	168.85	2
51	1566.48	168.85	1577.73	167.27	2
52	1577.73	167.27	1589.60	167.23	2

53	1589.60	167.23	1715.02	127.33	2
54	1715.02	127.33	1733.37	127.23	2
55	1733.37	127.23	1792.55	108.76	2
56	1792.55	108.76	1795.87	109.82	2
57	281.47	46.47	290.58	43.50	3
58	290.58	43.50	980.14	61.35	3
59	980.14	61.35	1073.77	76.19	3
60	1073.77	76.19	1293.66	94.09	3
61	1293.66	94.09	1782.45	105.55	3
62	1782.45	105.55	1792.55	108.76	3
63	1792.55	108.76	1795.87	109.82	3
64	269.77	44.69	275.84	44.57	4
65	275.84	44.57	281.13	44.47	4
66	281.13	44.47	290.29	41.49	4
67	290.29	41.49	759.00	53.31	4
68	759.00	53.31	980.32	59.36	2
69	980.32	59.36	1074.01	74.20	2
70	1074.01	74.20	1293.77	92.09	2
71	1293.77	92.09	1782.78	103.56	2
72	1782.78	103.56	1791.20	106.24	2
73	1791.20	106.24	1799.41	108.85	2
74	759.00	53.31	804.88	47.23	4
75	804.88	47.23	815.76	47.23	4
76	815.76	47.23	821.85	43.23	4
77	821.85	43.23	1919.91	53.23	4
78	1919.91	53.23	1945.29	67.23	4
79	1945.29	67.23	1991.05	70.57	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 100 Points Equally Spaced
Along The Ground Surface Between X = 250.00 ft.
and X = 400.00 ft.

Each Surface Terminates Between X = 900.00 ft.
and X = 1200.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

20.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	278.79	47.64
2	298.73	46.11
3	318.70	44.97
4	338.68	44.22
5	358.68	43.87
6	378.68	43.91
7	398.67	44.35
8	418.66	45.18
9	438.62	46.40
10	458.55	48.02
11	478.45	50.03

12	498.31	52.43
13	518.11	55.22
14	537.86	58.41
15	557.54	61.98
16	577.14	65.94
17	596.66	70.28
18	616.10	75.01
19	635.43	80.12
20	654.66	85.61
21	673.78	91.48
22	692.78	97.73
23	711.66	104.35
24	730.39	111.34
25	748.99	118.69
26	767.44	126.42
27	785.73	134.50
28	803.86	142.95
29	821.82	151.75
30	839.61	160.90
31	857.21	170.40
32	874.62	180.24
33	891.83	190.43
34	908.83	200.96
35	925.63	211.81
36	942.21	223.00
37	958.56	234.51
38	974.69	246.34
39	982.90	252.62

Circle Center At X = 366.5 ; Y = 1058.3 and Radius, 1014.4

*** 1.780 ***

Individual data on the 62 slices

Slice No.	Width (ft)	Weight (lbs)	Water	Water	Tie	Tie	Earthquake		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Force Hor (lbs)	Force Ver (lbs)	
1	5.1	597.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	14.9	6186.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	20.0	16509.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	11.7	13832.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5	8.3	11757.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	20.0	34800.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	20.0	43390.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	8.9	21915.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.4	1015.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	10.7	27303.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	11.7	30212.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.5	1175.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	7.9	21144.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	20.0	57838.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	16.8	53112.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	3.1	10129.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	19.9	68518.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	19.9	73575.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	14.8	57747.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.4	1598.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	4.7	18536.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	18.3	71963.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.4	1598.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	1.0	4094.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	19.7	78785.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	19.6	81750.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	19.5	84173.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	19.4	86058.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	16.4	74193.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.3	1589.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	2.6	11530.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	15.8	69250.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.3	1490.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	3.1	13066.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	19.1	81936.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	19.0	81760.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	18.9	81078.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	18.7	79899.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	18.6	78233.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	8.8	36506.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.4	1647.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	9.3	37176.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	13.0	49171.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.4	1456.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	4.9	17754.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	18.1	64169.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	18.0	60745.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	17.8	56912.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	17.6	52689.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	17.4	48096.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	14.7	37228.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	0.3	793.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	2.1	5057.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

54	15.0	30722.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	0.3	582.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	1.6	2860.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	16.8	26530.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	16.6	20743.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	16.4	14701.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	16.1	8428.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	3.3	953.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	4.9	590.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	298.48	54.08
2	318.32	51.55
3	338.22	49.47
4	358.15	47.83
5	378.11	46.64
6	398.10	45.89
7	418.10	45.59
8	438.10	45.74
9	458.09	46.33
10	478.06	47.37
11	498.00	48.86
12	517.91	50.79
13	537.77	53.17
14	557.57	55.98
15	577.30	59.25
16	596.96	62.95
17	616.52	67.09
18	635.99	71.66
19	655.36	76.67
20	674.60	82.11
21	693.72	87.99
22	712.70	94.28
23	731.54	101.00
24	750.22	108.14
25	768.74	115.69
26	787.09	123.66
27	805.25	132.03
28	823.22	140.81
29	840.99	149.99
30	858.55	159.56
31	875.89	169.52
32	893.01	179.87
33	909.89	190.59

34	926.53	201.69
35	942.91	213.17
36	959.03	225.00
37	974.89	237.19
38	990.47	249.73
39	1001.07	258.67

Circle Center At X = 421.5 ; Y = 940.4 and Radius, 894.9

*** 1.799 ***

1

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.76	46.65
2	295.72	45.46
3	315.71	44.64
4	335.70	44.20
5	355.70	44.14
6	375.70	44.46
7	395.69	45.16
8	415.66	46.23
9	435.60	47.69
10	455.52	49.52
11	475.40	51.72
12	495.23	54.30
13	515.01	57.26
14	534.73	60.58
15	554.39	64.28
16	573.97	68.36
17	593.47	72.80
18	612.88	77.61
19	632.20	82.78
20	651.42	88.32
21	670.53	94.22
22	689.52	100.48
23	708.40	107.10
24	727.14	114.08
25	745.75	121.41
26	764.22	129.09
27	782.53	137.11

28	800.70	145.49
29	818.70	154.20
30	836.53	163.25
31	854.19	172.64
32	871.67	182.36
33	888.96	192.41
34	906.06	202.78
35	922.96	213.48
36	939.66	224.49
37	956.14	235.82
38	972.41	247.46
39	976.49	250.49

Circle Center At X = 348.8 ; Y = 1102.0 and Radius, 1057.8

*** 1.802 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	269.70	44.67
2	289.68	43.85
3	309.68	43.41
4	329.68	43.36
5	349.67	43.69
6	369.66	44.39
7	389.63	45.48
8	409.58	46.95
9	429.49	48.80
10	449.37	51.03
11	469.20	53.63
12	488.97	56.62
13	508.69	59.98
14	528.34	63.71
15	547.91	67.82
16	567.40	72.30
17	586.81	77.15
18	606.11	82.37
19	625.32	87.96
20	644.41	93.91
21	663.39	100.22
22	682.24	106.90

23	700.96	113.93
24	719.55	121.32
25	737.99	129.06
26	756.28	137.15
27	774.41	145.58
28	792.38	154.37
29	810.18	163.49
30	827.80	172.95
31	845.24	182.74
32	862.49	192.87
33	879.54	203.32
34	896.39	214.09
35	913.03	225.19
36	924.62	233.24

Circle Center At X = 322.6 ; Y = 1092.6 and Radius, 1049.3

*** 1.805 ***

1

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	324.24	62.51
2	343.90	58.82
3	363.64	55.61
4	383.45	52.89
5	403.33	50.65
6	423.25	48.91
7	443.21	47.65
8	463.20	46.89
9	483.20	46.62
10	503.20	46.84
11	523.18	47.55
12	543.15	48.75
13	563.07	50.45
14	582.96	52.63
15	602.78	55.30
16	622.53	58.45
17	642.19	62.09
18	661.76	66.22
19	681.23	70.82

20	700.57	75.90
21	719.78	81.45
22	738.85	87.47
23	757.77	93.97
24	776.52	100.92
25	795.10	108.33
26	813.49	116.20
27	831.68	124.51
28	849.66	133.27
29	867.41	142.47
30	884.94	152.11
31	902.23	162.17
32	919.26	172.65
33	936.03	183.55
34	952.53	194.86
35	968.74	206.57
36	984.66	218.67
37	1000.28	231.16
38	1015.59	244.04
39	1030.57	257.28
40	1035.34	261.70

Circle Center At X = 484.3 ; Y = 860.1 and Radius, 813.5

*** 1.810 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	303.03	55.57
2	322.81	52.62
3	342.66	50.19
4	362.57	48.27
5	382.52	46.85
6	402.50	45.95
7	422.50	45.57
8	442.50	45.69
9	462.49	46.33
10	482.45	47.49
11	502.38	49.15
12	522.26	51.33
13	542.08	54.02

14	561.83	57.21
15	581.48	60.91
16	601.03	65.12
17	620.47	69.82
18	639.78	75.03
19	658.96	80.72
20	677.97	86.91
21	696.83	93.58
22	715.50	100.74
23	733.99	108.37
24	752.27	116.48
25	770.34	125.05
26	788.19	134.08
27	805.79	143.57
28	823.15	153.51
29	840.25	163.89
30	857.07	174.70
31	873.61	185.95
32	889.86	197.61
33	905.80	209.69
34	921.42	222.17
35	936.72	235.05
36	940.71	238.59

Circle Center At X = 427.6 ; Y = 824.1 and Radius, 778.5

*** 1.811 ***

1

Failure Surface Specified By 41 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	286.36	50.12
2	306.30	48.46
3	326.25	47.18
4	346.23	46.26
5	366.23	45.73
6	386.23	45.56
7	406.22	45.77
8	426.22	46.36
9	446.19	47.31
10	466.15	48.64

11	486.08	50.35
12	505.97	52.42
13	525.82	54.87
14	545.62	57.69
15	565.36	60.87
16	585.04	64.43
17	604.66	68.35
18	624.19	72.64
19	643.64	77.29
20	663.00	82.30
21	682.27	87.68
22	701.43	93.41
23	720.48	99.51
24	739.41	105.95
25	758.22	112.75
26	776.90	119.90
27	795.44	127.40
28	813.84	135.24
29	832.08	143.43
30	850.18	151.95
31	868.11	160.81
32	885.87	170.01
33	903.45	179.54
34	920.86	189.39
35	938.08	199.56
36	955.10	210.06
37	971.93	220.87
38	988.55	232.00
39	1004.96	243.43
40	1021.15	255.17
41	1029.69	261.60

Circle Center At X = 385.0 ; Y = 1115.7 and Radius, 1070.2

*** 1.817 ***

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	283.33	49.13
2	303.28	47.68
3	323.25	46.58

4	343.24	45.81
5	363.23	45.38
6	383.23	45.29
7	403.23	45.53
8	423.22	46.11
9	443.20	47.03
10	463.16	48.29
11	483.10	49.88
12	503.00	51.81
13	522.88	54.07
14	542.71	56.67
15	562.49	59.61
16	582.22	62.88
17	601.89	66.48
18	621.50	70.41
19	641.04	74.67
20	660.51	79.26
21	679.89	84.18
22	699.19	89.43
23	718.40	95.00
24	737.51	100.89
25	756.52	107.11
26	775.43	113.65
27	794.21	120.50
28	812.88	127.67
29	831.43	135.16
30	849.85	142.95
31	868.13	151.06
32	886.28	159.48
33	904.28	168.19
34	922.12	177.22
35	939.82	186.54
36	957.35	196.16
37	974.72	206.07
38	991.92	216.28
39	1008.95	226.77
40	1025.80	237.55
41	1042.46	248.61
42	1058.93	259.96
43	1062.04	262.18

Circle Center At X = 378.8 ; Y = 1230.1 and Radius, 1184.8

*** 1.819 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	272.73	45.66
2	292.71	44.71
3	312.70	44.16
4	332.70	44.03
5	352.70	44.29
6	372.68	44.96
7	392.66	46.04
8	412.60	47.52
9	432.51	49.41
10	452.38	51.70
11	472.20	54.39
12	491.96	57.49
13	511.65	60.98
14	531.27	64.87
15	550.80	69.16
16	570.25	73.84
17	589.59	78.92
18	608.83	84.39
19	627.95	90.25
20	646.95	96.49
21	665.82	103.12
22	684.55	110.13
23	703.14	117.51
24	721.57	125.28
25	739.84	133.41
26	757.94	141.91
27	775.87	150.78
28	793.61	160.01
29	811.17	169.60
30	828.52	179.54
31	845.67	189.83
32	862.60	200.47
33	879.32	211.45
34	895.81	222.77
35	902.15	227.30

Circle Center At X = 329.5 ; Y = 1030.4 and Radius, 986.4

*** 1.820 ***

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	304.55	56.06
2	324.31	53.02
3	344.15	50.51
4	364.06	48.54
5	384.00	47.10
6	403.98	46.20
7	423.98	45.85
8	443.98	46.03
9	463.97	46.75
10	483.93	48.01
11	503.85	49.81
12	523.71	52.15
13	543.50	55.02
14	563.21	58.42
15	582.82	62.36
16	602.32	66.82
17	621.68	71.81
18	640.91	77.32
19	659.98	83.35
20	678.88	89.88
21	697.60	96.93
22	716.12	104.48
23	734.43	112.53
24	752.52	121.06
25	770.37	130.08
26	787.96	139.59
27	805.30	149.56
28	822.36	159.99
29	839.14	170.89
30	855.61	182.23
31	871.77	194.01
32	887.61	206.23
33	903.11	218.86
34	916.76	230.62

Circle Center At X = 427.2 ; Y = 786.7 and Radius, 740.8

*** 1.826 ***

	Y	A	X	I	S	F	T
	0.00	248.88	497.76	746.64	995.53	1244.41	
X	0.00	+*-----+-----+-----+-----+-----+					
	-						
	-*						
	-						
	- *						
	-						
	248.88	+.*					
	-.*						
	-.15						
	..1*						
	..1*.						
	..1..						
A	497.76	..1..*					
	..13.*						
	..21..						
	..514.*						
	...11.*						
	...514..						
X	746.64	..*.114.*					
	..*.511.*						
	..*.5139						
	-.....213*						
	- 21*						
	- 5511						
I	995.53	+ *......5*.					
	- 55						
	- * 88						
	-**						
	-*						
	-*						
S	1244.41	+ *					
	- *						
	- *						
	- *						
	- *						
	1493.29	+ *					
	- *						
	- *						
	- *						

		-	*
F	1742.17	+	*
		-	*
		-	
		-	*
		-	*
		-	*
T	1991.05	+	*

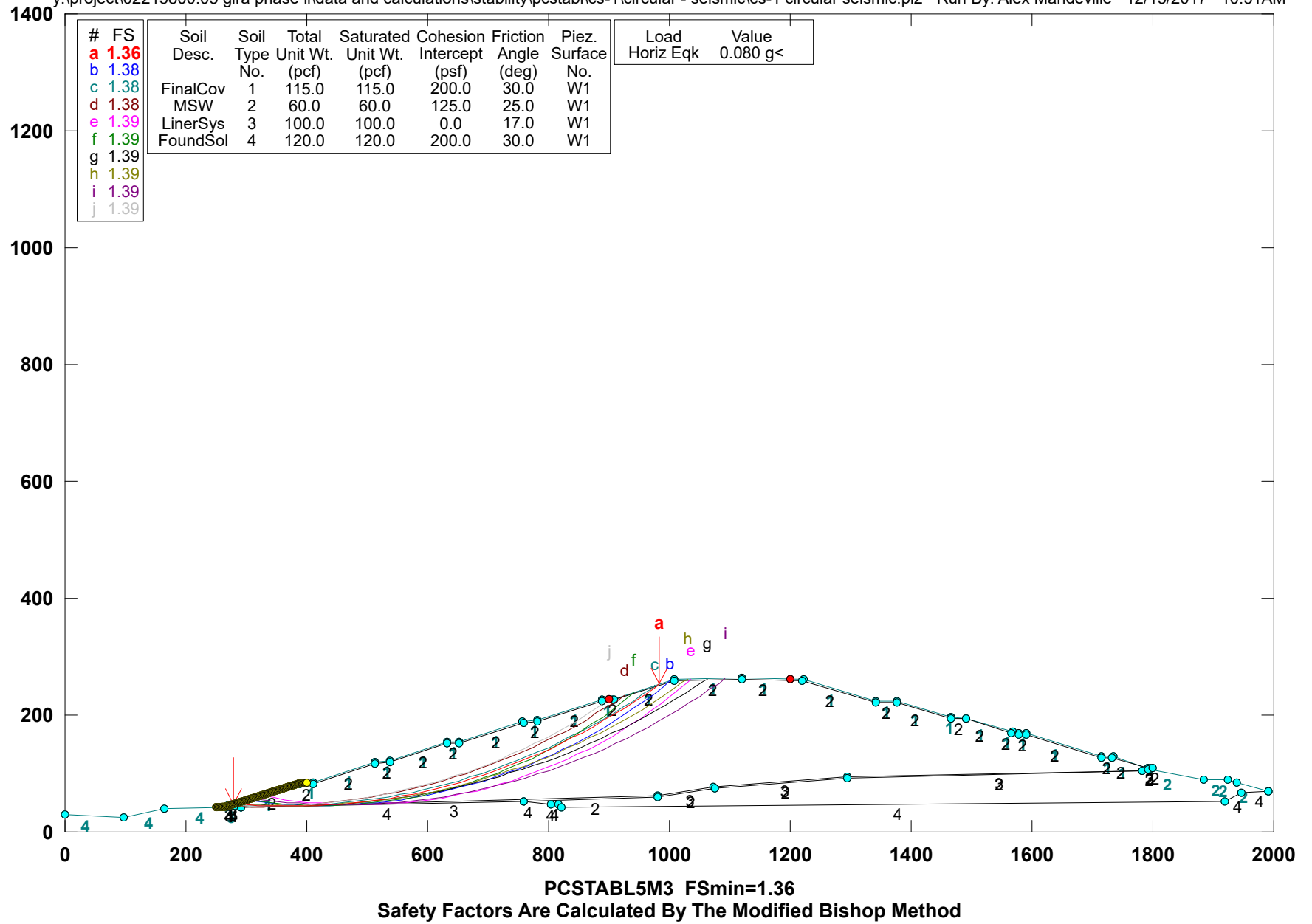
Section CS-1

Final Slope Stability Analysis

Circular Failure Surface, Seismic = 0.08g

GLRA - CS-1 Circular Failure - Seismic

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-1\circular - seismic\cs-1 circular seismic.pl2 Run By: Alex Mandeville 12/15/2017 10:31AM



** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:31AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-1 circular seismic.

Output Filename: Y:cs-1 circular seismic.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-1 circular seismic.PLT

PROBLEM DESCRIPTION GLRA - CS-1
Circular Failure - Seismic

BOUNDARY COORDINATES

31 Top Boundaries
79 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	30.00	97.96	23.77	4
2	97.96	23.77	164.38	38.97	4
3	164.38	38.97	265.33	43.23	4

4	265.33	43.23	269.77	44.69	3
5	269.77	44.69	387.60	83.23	1
6	387.60	83.23	410.33	85.22	1
7	410.33	85.22	513.06	119.23	1
8	513.06	119.23	536.40	121.23	1
9	536.40	121.23	632.53	153.23	1
10	632.53	153.23	651.25	153.72	1
11	651.25	153.72	757.79	189.23	1
12	757.79	189.23	780.44	191.00	1
13	780.44	191.00	889.35	227.23	1
14	889.35	227.23	906.87	227.33	1
15	906.87	227.33	1008.77	261.23	1
16	1008.77	261.23	1120.91	263.23	1
17	1120.91	263.23	1221.01	261.23	1
18	1221.01	261.23	1342.42	224.20	1
19	1342.42	224.20	1376.58	224.20	1
20	1376.58	224.20	1465.91	197.23	1
21	1465.91	197.23	1490.18	195.23	1
22	1490.18	195.23	1566.93	170.81	1
23	1566.93	170.81	1577.87	169.27	1
24	1577.87	169.27	1589.91	169.23	1
25	1589.91	169.23	1715.34	129.33	1
26	1715.34	129.33	1733.68	129.23	1
27	1733.68	129.23	1794.33	107.23	1
28	1794.33	107.23	1884.06	89.23	2
29	1884.06	89.23	1924.99	89.60	2
30	1924.99	89.60	1938.67	85.23	2
31	1938.67	85.23	1991.05	70.57	2
32	275.54	46.58	281.47	46.47	3
33	281.47	46.47	388.00	81.26	2
34	388.00	81.26	410.78	83.25	2
35	410.78	83.25	513.46	117.26	2
36	513.46	117.26	536.81	119.26	2
37	536.81	119.26	632.88	151.24	2
38	632.88	151.24	651.60	151.73	2
39	651.60	151.73	758.19	187.26	2
40	758.19	187.26	780.84	189.02	2
41	780.84	189.02	889.68	225.23	2
42	889.68	225.23	907.20	225.33	2
43	907.20	225.33	1009.11	259.24	2
44	1009.11	259.24	1120.91	261.23	2
45	1120.91	261.23	1220.69	259.24	2
46	1220.69	259.24	1342.12	222.20	2
47	1342.12	222.20	1376.28	222.20	2
48	1376.28	222.20	1465.53	195.26	2
49	1465.53	195.26	1489.79	193.26	2
50	1489.79	193.26	1566.48	168.85	2
51	1566.48	168.85	1577.73	167.27	2
52	1577.73	167.27	1589.60	167.23	2

53	1589.60	167.23	1715.02	127.33	2
54	1715.02	127.33	1733.37	127.23	2
55	1733.37	127.23	1792.55	108.76	2
56	1792.55	108.76	1795.87	109.82	2
57	281.47	46.47	290.58	43.50	3
58	290.58	43.50	980.14	61.35	3
59	980.14	61.35	1073.77	76.19	3
60	1073.77	76.19	1293.66	94.09	3
61	1293.66	94.09	1782.45	105.55	3
62	1782.45	105.55	1792.55	108.76	3
63	1792.55	108.76	1795.87	109.82	3
64	269.77	44.69	275.84	44.57	4
65	275.84	44.57	281.13	44.47	4
66	281.13	44.47	290.29	41.49	4
67	290.29	41.49	759.00	53.31	4
68	759.00	53.31	980.32	59.36	2
69	980.32	59.36	1074.01	74.20	2
70	1074.01	74.20	1293.77	92.09	2
71	1293.77	92.09	1782.78	103.56	2
72	1782.78	103.56	1791.20	106.24	2
73	1791.20	106.24	1799.41	108.85	2
74	759.00	53.31	804.88	47.23	4
75	804.88	47.23	815.76	47.23	4
76	815.76	47.23	821.85	43.23	4
77	821.85	43.23	1919.91	53.23	4
78	1919.91	53.23	1945.29	67.23	4
79	1945.29	67.23	1991.05	70.57	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

A Horizontal Earthquake Loading Coefficient
Of 0.080 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of 0.000 Has Been Assigned

Cavitation Pressure = 0.0 (psf)

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 100 Points Equally Spaced
Along The Ground Surface Between X = 250.00 ft.
and X = 400.00 ft.

Each Surface Terminates Between X = 900.00 ft.
and X = 1200.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

20.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	278.79	47.64

2	298.73	46.11
3	318.70	44.97
4	338.68	44.22
5	358.68	43.87
6	378.68	43.91
7	398.67	44.35
8	418.66	45.18
9	438.62	46.40
10	458.55	48.02
11	478.45	50.03
12	498.31	52.43
13	518.11	55.22
14	537.86	58.41
15	557.54	61.98
16	577.14	65.94
17	596.66	70.28
18	616.10	75.01
19	635.43	80.12
20	654.66	85.61
21	673.78	91.48
22	692.78	97.73
23	711.66	104.35
24	730.39	111.34
25	748.99	118.69
26	767.44	126.42
27	785.73	134.50
28	803.86	142.95
29	821.82	151.75
30	839.61	160.90
31	857.21	170.40
32	874.62	180.24
33	891.83	190.43
34	908.83	200.96
35	925.63	211.81
36	942.21	223.00
37	958.56	234.51
38	974.69	246.34
39	982.90	252.62

Circle Center At X = 366.5 ; Y = 1058.3 and Radius, 1014.4

*** 1.361 ***

Individual data on the 62 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	5.1	597.0	0.0	0.0	0.0	0.0	47.8	0.0	0.0
2	14.9	6186.1	0.0	0.0	0.0	0.0	494.9	0.0	0.0
3	20.0	16509.7	0.0	0.0	0.0	0.0	1320.8	0.0	0.0
4	11.7	13832.6	0.0	0.0	0.0	0.0	1106.6	0.0	0.0
5	8.3	11757.5	0.0	0.0	0.0	0.0	940.6	0.0	0.0
6	20.0	34800.2	0.0	0.0	0.0	0.0	2784.0	0.0	0.0
7	20.0	43390.2	0.0	0.0	0.0	0.0	3471.2	0.0	0.0
8	8.9	21915.7	0.0	0.0	0.0	0.0	1753.3	0.0	0.0
9	0.4	1015.0	0.0	0.0	0.0	0.0	81.2	0.0	0.0
10	10.7	27303.3	0.0	0.0	0.0	0.0	2184.3	0.0	0.0
11	11.7	30212.0	0.0	0.0	0.0	0.0	2417.0	0.0	0.0
12	0.5	1175.2	0.0	0.0	0.0	0.0	94.0	0.0	0.0
13	7.9	21144.7	0.0	0.0	0.0	0.0	1691.6	0.0	0.0
14	20.0	57838.1	0.0	0.0	0.0	0.0	4627.0	0.0	0.0
15	16.8	53112.2	0.0	0.0	0.0	0.0	4249.0	0.0	0.0
16	3.1	10129.7	0.0	0.0	0.0	0.0	810.4	0.0	0.0
17	19.9	68518.2	0.0	0.0	0.0	0.0	5481.5	0.0	0.0
18	19.9	73575.9	0.0	0.0	0.0	0.0	5886.1	0.0	0.0
19	14.8	57747.4	0.0	0.0	0.0	0.0	4619.8	0.0	0.0
20	0.4	1598.2	0.0	0.0	0.0	0.0	127.9	0.0	0.0
21	4.7	18536.6	0.0	0.0	0.0	0.0	1482.9	0.0	0.0
22	18.3	71963.8	0.0	0.0	0.0	0.0	5757.1	0.0	0.0
23	0.4	1598.3	0.0	0.0	0.0	0.0	127.9	0.0	0.0
24	1.0	4094.8	0.0	0.0	0.0	0.0	327.6	0.0	0.0
25	19.7	78785.9	0.0	0.0	0.0	0.0	6302.9	0.0	0.0
26	19.6	81750.3	0.0	0.0	0.0	0.0	6540.0	0.0	0.0
27	19.5	84173.5	0.0	0.0	0.0	0.0	6733.9	0.0	0.0
28	19.4	86058.1	0.0	0.0	0.0	0.0	6884.6	0.0	0.0
29	16.4	74193.1	0.0	0.0	0.0	0.0	5935.4	0.0	0.0
30	0.3	1589.9	0.0	0.0	0.0	0.0	127.2	0.0	0.0
31	2.6	11530.4	0.0	0.0	0.0	0.0	922.4	0.0	0.0
32	15.8	69250.8	0.0	0.0	0.0	0.0	5540.1	0.0	0.0
33	0.3	1490.3	0.0	0.0	0.0	0.0	119.2	0.0	0.0
34	3.1	13066.3	0.0	0.0	0.0	0.0	1045.3	0.0	0.0
35	19.1	81936.4	0.0	0.0	0.0	0.0	6554.9	0.0	0.0
36	19.0	81760.6	0.0	0.0	0.0	0.0	6540.9	0.0	0.0
37	18.9	81078.3	0.0	0.0	0.0	0.0	6486.3	0.0	0.0
38	18.7	79899.0	0.0	0.0	0.0	0.0	6391.9	0.0	0.0
39	18.6	78233.9	0.0	0.0	0.0	0.0	6258.7	0.0	0.0
40	8.8	36506.9	0.0	0.0	0.0	0.0	2920.6	0.0	0.0
41	0.4	1647.8	0.0	0.0	0.0	0.0	131.8	0.0	0.0
42	9.3	37176.2	0.0	0.0	0.0	0.0	2974.1	0.0	0.0
43	13.0	49171.0	0.0	0.0	0.0	0.0	3933.7	0.0	0.0

44	0.4	1456.8	0.0	0.0	0.0	0.0	116.5	0.0	0.0
45	4.9	17754.3	0.0	0.0	0.0	0.0	1420.3	0.0	0.0
46	18.1	64169.5	0.0	0.0	0.0	0.0	5133.6	0.0	0.0
47	18.0	60745.2	0.0	0.0	0.0	0.0	4859.6	0.0	0.0
48	17.8	56912.4	0.0	0.0	0.0	0.0	4553.0	0.0	0.0
49	17.6	52689.5	0.0	0.0	0.0	0.0	4215.2	0.0	0.0
50	17.4	48096.0	0.0	0.0	0.0	0.0	3847.7	0.0	0.0
51	14.7	37228.0	0.0	0.0	0.0	0.0	2978.2	0.0	0.0
52	0.3	793.1	0.0	0.0	0.0	0.0	63.4	0.0	0.0
53	2.1	5057.6	0.0	0.0	0.0	0.0	404.6	0.0	0.0
54	15.0	30722.1	0.0	0.0	0.0	0.0	2457.8	0.0	0.0
55	0.3	582.7	0.0	0.0	0.0	0.0	46.6	0.0	0.0
56	1.6	2860.4	0.0	0.0	0.0	0.0	228.8	0.0	0.0
57	16.8	26530.0	0.0	0.0	0.0	0.0	2122.4	0.0	0.0
58	16.6	20743.8	0.0	0.0	0.0	0.0	1659.5	0.0	0.0
59	16.4	14701.7	0.0	0.0	0.0	0.0	1176.1	0.0	0.0
60	16.1	8428.7	0.0	0.0	0.0	0.0	674.3	0.0	0.0
61	3.3	953.4	0.0	0.0	0.0	0.0	76.3	0.0	0.0
62	4.9	590.0	0.0	0.0	0.0	0.0	47.2	0.0	0.0

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	298.48	54.08
2	318.32	51.55
3	338.22	49.47
4	358.15	47.83
5	378.11	46.64
6	398.10	45.89
7	418.10	45.59
8	438.10	45.74
9	458.09	46.33
10	478.06	47.37
11	498.00	48.86
12	517.91	50.79
13	537.77	53.17
14	557.57	55.98
15	577.30	59.25
16	596.96	62.95
17	616.52	67.09
18	635.99	71.66
19	655.36	76.67
20	674.60	82.11
21	693.72	87.99
22	712.70	94.28
23	731.54	101.00

24	750.22	108.14
25	768.74	115.69
26	787.09	123.66
27	805.25	132.03
28	823.22	140.81
29	840.99	149.99
30	858.55	159.56
31	875.89	169.52
32	893.01	179.87
33	909.89	190.59
34	926.53	201.69
35	942.91	213.17
36	959.03	225.00
37	974.89	237.19
38	990.47	249.73
39	1001.07	258.67

Circle Center At X = 421.5 ; Y = 940.4 and Radius, 894.9

*** 1.377 ***

1

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.76	46.65
2	295.72	45.46
3	315.71	44.64
4	335.70	44.20
5	355.70	44.14
6	375.70	44.46
7	395.69	45.16
8	415.66	46.23
9	435.60	47.69
10	455.52	49.52
11	475.40	51.72
12	495.23	54.30
13	515.01	57.26
14	534.73	60.58
15	554.39	64.28
16	573.97	68.36
17	593.47	72.80

18	612.88	77.61
19	632.20	82.78
20	651.42	88.32
21	670.53	94.22
22	689.52	100.48
23	708.40	107.10
24	727.14	114.08
25	745.75	121.41
26	764.22	129.09
27	782.53	137.11
28	800.70	145.49
29	818.70	154.20
30	836.53	163.25
31	854.19	172.64
32	871.67	182.36
33	888.96	192.41
34	906.06	202.78
35	922.96	213.48
36	939.66	224.49
37	956.14	235.82
38	972.41	247.46
39	976.49	250.49

Circle Center At X = 348.8 ; Y = 1102.0 and Radius, 1057.8

*** 1.379 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	269.70	44.67
2	289.68	43.85
3	309.68	43.41
4	329.68	43.36
5	349.67	43.69
6	369.66	44.39
7	389.63	45.48
8	409.58	46.95
9	429.49	48.80
10	449.37	51.03
11	469.20	53.63
12	488.97	56.62

13	508.69	59.98
14	528.34	63.71
15	547.91	67.82
16	567.40	72.30
17	586.81	77.15
18	606.11	82.37
19	625.32	87.96
20	644.41	93.91
21	663.39	100.22
22	682.24	106.90
23	700.96	113.93
24	719.55	121.32
25	737.99	129.06
26	756.28	137.15
27	774.41	145.58
28	792.38	154.37
29	810.18	163.49
30	827.80	172.95
31	845.24	182.74
32	862.49	192.87
33	879.54	203.32
34	896.39	214.09
35	913.03	225.19
36	924.62	233.24

Circle Center At X = 322.6 ; Y = 1092.6 and Radius, 1049.3

*** 1.381 ***

1

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	324.24	62.51
2	343.90	58.82
3	363.64	55.61
4	383.45	52.89
5	403.33	50.65
6	423.25	48.91
7	443.21	47.65
8	463.20	46.89
9	483.20	46.62

10	503.20	46.84
11	523.18	47.55
12	543.15	48.75
13	563.07	50.45
14	582.96	52.63
15	602.78	55.30
16	622.53	58.45
17	642.19	62.09
18	661.76	66.22
19	681.23	70.82
20	700.57	75.90
21	719.78	81.45
22	738.85	87.47
23	757.77	93.97
24	776.52	100.92
25	795.10	108.33
26	813.49	116.20
27	831.68	124.51
28	849.66	133.27
29	867.41	142.47
30	884.94	152.11
31	902.23	162.17
32	919.26	172.65
33	936.03	183.55
34	952.53	194.86
35	968.74	206.57
36	984.66	218.67
37	1000.28	231.16
38	1015.59	244.04
39	1030.57	257.28
40	1035.34	261.70

Circle Center At X = 484.3 ; Y = 860.1 and Radius, 813.5

*** 1.385 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	303.03	55.57
2	322.81	52.62
3	342.66	50.19

4	362.57	48.27
5	382.52	46.85
6	402.50	45.95
7	422.50	45.57
8	442.50	45.69
9	462.49	46.33
10	482.45	47.49
11	502.38	49.15
12	522.26	51.33
13	542.08	54.02
14	561.83	57.21
15	581.48	60.91
16	601.03	65.12
17	620.47	69.82
18	639.78	75.03
19	658.96	80.72
20	677.97	86.91
21	696.83	93.58
22	715.50	100.74
23	733.99	108.37
24	752.27	116.48
25	770.34	125.05
26	788.19	134.08
27	805.79	143.57
28	823.15	153.51
29	840.25	163.89
30	857.07	174.70
31	873.61	185.95
32	889.86	197.61
33	905.80	209.69
34	921.42	222.17
35	936.72	235.05
36	940.71	238.59

Circle Center At X = 427.6 ; Y = 824.1 and Radius, 778.5

*** 1.385 ***

1

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	283.33	49.13
2	303.28	47.68
3	323.25	46.58
4	343.24	45.81
5	363.23	45.38
6	383.23	45.29
7	403.23	45.53
8	423.22	46.11
9	443.20	47.03
10	463.16	48.29
11	483.10	49.88
12	503.00	51.81
13	522.88	54.07
14	542.71	56.67
15	562.49	59.61
16	582.22	62.88
17	601.89	66.48
18	621.50	70.41
19	641.04	74.67
20	660.51	79.26
21	679.89	84.18
22	699.19	89.43
23	718.40	95.00
24	737.51	100.89
25	756.52	107.11
26	775.43	113.65
27	794.21	120.50
28	812.88	127.67
29	831.43	135.16
30	849.85	142.95
31	868.13	151.06
32	886.28	159.48
33	904.28	168.19
34	922.12	177.22
35	939.82	186.54
36	957.35	196.16
37	974.72	206.07
38	991.92	216.28
39	1008.95	226.77
40	1025.80	237.55
41	1042.46	248.61
42	1058.93	259.96
43	1062.04	262.18

Circle Center At X = 378.8 ; Y = 1230.1 and Radius, 1184.8

*** 1.389 ***

Failure Surface Specified By 41 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	286.36	50.12
2	306.30	48.46
3	326.25	47.18
4	346.23	46.26
5	366.23	45.73
6	386.23	45.56
7	406.22	45.77
8	426.22	46.36
9	446.19	47.31
10	466.15	48.64
11	486.08	50.35
12	505.97	52.42
13	525.82	54.87
14	545.62	57.69
15	565.36	60.87
16	585.04	64.43
17	604.66	68.35
18	624.19	72.64
19	643.64	77.29
20	663.00	82.30
21	682.27	87.68
22	701.43	93.41
23	720.48	99.51
24	739.41	105.95
25	758.22	112.75
26	776.90	119.90
27	795.44	127.40
28	813.84	135.24
29	832.08	143.43
30	850.18	151.95
31	868.11	160.81
32	885.87	170.01
33	903.45	179.54
34	920.86	189.39
35	938.08	199.56
36	955.10	210.06
37	971.93	220.87
38	988.55	232.00
39	1004.96	243.43
40	1021.15	255.17

41 1029.69 261.60

Circle Center At X = 385.0 ; Y = 1115.7 and Radius, 1070.2

*** 1.392 ***

1

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	307.58	57.06
2	327.40	54.39
3	347.27	52.11
4	367.18	50.21
5	387.12	48.69
6	407.09	47.56
7	427.07	46.81
8	447.07	46.44
9	467.07	46.45
10	487.07	46.85
11	507.05	47.64
12	527.02	48.80
13	546.96	50.35
14	566.86	52.28
15	586.73	54.59
16	606.55	57.29
17	626.31	60.36
18	646.01	63.81
19	665.64	67.64
20	685.19	71.84
21	704.66	76.42
22	724.04	81.38
23	743.32	86.70
24	762.49	92.39
25	781.55	98.45
26	800.49	104.87
27	819.30	111.65
28	837.98	118.80
29	856.52	126.30
30	874.92	134.16
31	893.16	142.36
32	911.23	150.92

33	929.14	159.82
34	946.88	169.06
35	964.44	178.65
36	981.80	188.56
37	998.98	198.81
38	1015.95	209.38
39	1032.72	220.28
40	1049.28	231.50
41	1065.62	243.04
42	1081.73	254.88
43	1091.97	262.71

Circle Center At X = 456.3 ; Y = 1088.9 and Radius, 1042.5

*** 1.394 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	272.73	45.66
2	292.71	44.71
3	312.70	44.16
4	332.70	44.03
5	352.70	44.29
6	372.68	44.96
7	392.66	46.04
8	412.60	47.52
9	432.51	49.41
10	452.38	51.70
11	472.20	54.39
12	491.96	57.49
13	511.65	60.98
14	531.27	64.87
15	550.80	69.16
16	570.25	73.84
17	589.59	78.92
18	608.83	84.39
19	627.95	90.25
20	646.95	96.49
21	665.82	103.12
22	684.55	110.13
23	703.14	117.51

24	721.57	125.28
25	739.84	133.41
26	757.94	141.91
27	775.87	150.78
28	793.61	160.01
29	811.17	169.60
30	828.52	179.54
31	845.67	189.83
32	862.60	200.47
33	879.32	211.45
34	895.81	222.77
35	902.15	227.30

Circle Center At X = 329.5 ; Y = 1030.4 and Radius, 986.4

*** 1.394 ***

1

	Y	A	X	I	S	F	T
	0.00	248.88	497.76	746.64	995.53	1244.41	
X	0.00	+*-----+-----+-----+-----+-----+					
	-						
	-*						
	-						
	- *						
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	248.88	+.*					
		-.*					
		-.15					
		..1*					
		..1*.					
		..1..					
A	497.76	..1..*					
		..13.*					
		..21..					
		..514.*					
		...11.*					
		...514..					
X	746.64	..*9114.*					
		..*.511.*					
		-.*.95130					
		-....9213*					

		-	921*
		-	5511
I	995.53	+	*.....95*.
		-	955
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		-	
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		-	*.
S	1244.41	+	
		-	*
		-	*
		-	*
		-	*
		-	*
	1493.29	+	*
		-	*
		-	*
		-	*
		-	*
F	1742.17	+	*
		-	*
		-	*
		-	*
		-	* *
		-	*
T	1991.05	+	*

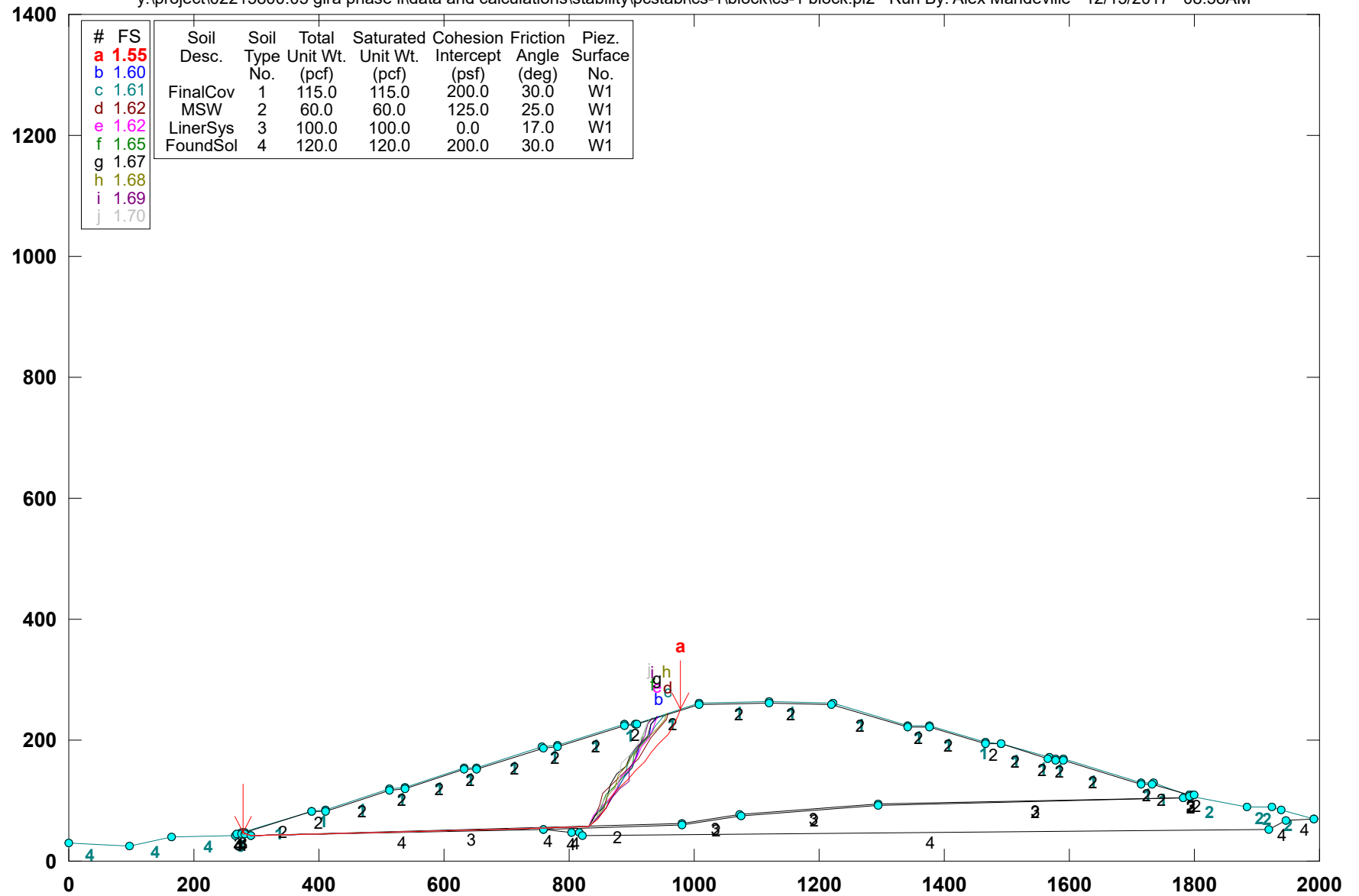
Section CS-1

Final Slope Stability Analysis

Block-Type Failure Surface within Liner System, Static

GLRA - CS-1 Block Failure

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-1\block\cs-1 block.pl2 Run By: Alex Mandeville 12/15/2017 08:58AM



PCSTABL5M3 FSmin=1.55
Safety Factors Are Calculated By The Modified Janbu Method

** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 08:58AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-1 block.

Output Filename: Y:cs-1 block.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-1 block.PLT

PROBLEM DESCRIPTION GLRA - CS-1
Block Failure

BOUNDARY COORDINATES

31 Top Boundaries
79 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	30.00	97.96	23.77	4
2	97.96	23.77	164.38	38.97	4
3	164.38	38.97	265.33	43.23	4

4	265.33	43.23	269.77	44.69	3
5	269.77	44.69	387.60	83.23	1
6	387.60	83.23	410.33	85.22	1
7	410.33	85.22	513.06	119.23	1
8	513.06	119.23	536.40	121.23	1
9	536.40	121.23	632.53	153.23	1
10	632.53	153.23	651.25	153.72	1
11	651.25	153.72	757.79	189.23	1
12	757.79	189.23	780.44	191.00	1
13	780.44	191.00	889.35	227.23	1
14	889.35	227.23	906.87	227.33	1
15	906.87	227.33	1008.77	261.23	1
16	1008.77	261.23	1120.91	263.23	1
17	1120.91	263.23	1221.01	261.23	1
18	1221.01	261.23	1342.42	224.20	1
19	1342.42	224.20	1376.58	224.20	1
20	1376.58	224.20	1465.91	197.23	1
21	1465.91	197.23	1490.18	195.23	1
22	1490.18	195.23	1566.93	170.81	1
23	1566.93	170.81	1577.87	169.27	1
24	1577.87	169.27	1589.91	169.23	1
25	1589.91	169.23	1715.34	129.33	1
26	1715.34	129.33	1733.68	129.23	1
27	1733.68	129.23	1794.33	107.23	1
28	1794.33	107.23	1884.06	89.23	2
29	1884.06	89.23	1924.99	89.60	2
30	1924.99	89.60	1938.67	85.23	2
31	1938.67	85.23	1991.05	70.57	2
32	275.54	46.58	281.47	46.47	3
33	281.47	46.47	388.00	81.26	2
34	388.00	81.26	410.78	83.25	2
35	410.78	83.25	513.46	117.26	2
36	513.46	117.26	536.81	119.26	2
37	536.81	119.26	632.88	151.24	2
38	632.88	151.24	651.60	151.73	2
39	651.60	151.73	758.19	187.26	2
40	758.19	187.26	780.84	189.02	2
41	780.84	189.02	889.68	225.23	2
42	889.68	225.23	907.20	225.33	2
43	907.20	225.33	1009.11	259.24	2
44	1009.11	259.24	1120.91	261.23	2
45	1120.91	261.23	1220.69	259.24	2
46	1220.69	259.24	1342.12	222.20	2
47	1342.12	222.20	1376.28	222.20	2
48	1376.28	222.20	1465.53	195.26	2
49	1465.53	195.26	1489.79	193.26	2
50	1489.79	193.26	1566.48	168.85	2
51	1566.48	168.85	1577.73	167.27	2
52	1577.73	167.27	1589.60	167.23	2

53	1589.60	167.23	1715.02	127.33	2
54	1715.02	127.33	1733.37	127.23	2
55	1733.37	127.23	1792.55	108.76	2
56	1792.55	108.76	1795.87	109.82	2
57	281.47	46.47	290.58	43.50	3
58	290.58	43.50	980.14	61.35	3
59	980.14	61.35	1073.77	76.19	3
60	1073.77	76.19	1293.66	94.09	3
61	1293.66	94.09	1782.45	105.55	3
62	1782.45	105.55	1792.55	108.76	3
63	1792.55	108.76	1795.87	109.82	3
64	269.77	44.69	275.84	44.57	4
65	275.84	44.57	281.13	44.47	4
66	281.13	44.47	290.29	41.49	4
67	290.29	41.49	759.00	53.31	4
68	759.00	53.31	980.32	59.36	2
69	980.32	59.36	1074.01	74.20	2
70	1074.01	74.20	1293.77	92.09	2
71	1293.77	92.09	1782.78	103.56	2
72	1782.78	103.56	1791.20	106.24	2
73	1791.20	106.24	1799.41	108.85	2
74	759.00	53.31	804.88	47.23	4
75	804.88	47.23	815.76	47.23	4
76	815.76	47.23	821.85	43.23	4
77	821.85	43.23	1919.91	53.23	4
78	1919.91	53.23	1945.29	67.23	4
79	1945.29	67.23	1991.05	70.57	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been

Specified.

20 Trial Surfaces Have Been Generated.

5 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of
Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	279.33	45.87	279.33	45.87	1.00
2	290.68	42.66	290.68	42.66	1.00
3	398.52	45.26	398.52	45.26	1.00
4	683.32	52.45	683.32	52.45	1.00
5	831.61	56.71	831.61	56.71	1.00

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.97	47.37
2	279.33	46.04
3	290.68	42.75
4	398.52	45.00
5	683.32	52.04
6	831.61	56.56
7	845.75	70.70
8	858.60	86.03
9	865.10	104.95
10	878.28	119.98
11	892.33	134.22

12	906.40	148.44
13	920.01	163.09
14	930.26	180.26
15	944.28	194.52
16	957.27	209.73
17	968.76	226.10
18	976.70	244.46
19	978.81	251.26

*** 1.548 ***

Individual data on the 43 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	0.9	57.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.5	79.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.1	574.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	9.1	4576.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.1	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	96.9	152268.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.4	988.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	10.5	26207.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	11.8	29949.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.5	1154.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	102.3	359501.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.4	1782.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	22.9	103125.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.4	1863.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	95.7	520560.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.3	2212.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	18.4	116115.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.3	2214.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	31.7	210271.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	74.5	565439.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.4	3303.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	22.2	184403.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.4	3329.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	50.8	446067.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	1.0	8912.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	13.2	117260.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

27	12.9	106740.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	6.5	48514.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	13.2	87695.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	11.1	67546.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.3	1935.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	2.7	15301.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	14.1	74092.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.5	2286.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.3	1587.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	12.8	57863.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	10.3	39160.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	14.0	43737.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	13.0	32527.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	11.5	20695.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	7.9	7573.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	1.4	500.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.7	88.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.87	47.34
2	279.33	46.00
3	290.68	42.46
4	398.52	45.54
5	683.32	52.26
6	831.61	57.07
7	845.56	71.40
8	857.82	87.20
9	867.42	104.74
10	878.23	121.57
11	889.44	138.13
12	901.12	154.37
13	907.43	173.35
14	913.32	192.46
15	927.20	206.86
16	931.09	226.47
17	944.08	239.71

*** 1.601 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.77	47.31
2	279.33	45.75
3	290.68	43.09
4	398.52	44.91
5	683.32	52.61
6	831.61	57.00
7	840.77	74.78
8	854.27	89.53
9	868.40	103.69
10	877.88	121.29
11	887.84	138.64
12	892.55	158.08
13	901.70	175.86
14	914.10	191.55
15	927.43	206.46
16	938.82	222.91
17	951.63	238.26
18	957.47	244.16

*** 1.606 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	276.95	47.04
2	279.33	46.23
3	290.68	42.53
4	398.52	45.12
5	683.32	52.25
6	831.61	56.62
7	840.26	74.65
8	848.27	92.98
9	854.86	111.86
10	868.86	126.15
11	882.62	140.65
12	896.59	154.97

13	910.48	169.36
14	920.55	186.64
15	929.66	204.44
16	943.78	218.61
17	956.57	233.98
18	958.27	244.43

*** 1.618 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.75	46.65
2	279.33	45.93
3	290.68	42.72
4	398.52	45.21
5	683.32	52.54
6	831.61	56.29
7	838.55	75.04
8	852.29	89.58
9	866.06	104.09
10	877.25	120.66
11	884.05	139.47
12	897.50	154.27
13	908.25	171.13
14	916.68	189.27
15	929.28	204.80
16	936.53	223.44
17	939.74	238.27

*** 1.618 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	276.91	47.02
2	279.33	45.47
3	290.68	42.88
4	398.52	44.83
5	683.32	52.92
6	831.61	56.23
7	841.79	73.44
8	851.86	90.72
9	859.57	109.18
10	873.41	123.62
11	886.68	138.58
12	899.98	153.52
13	903.64	173.18
14	913.17	190.77
15	917.62	210.26
16	926.54	228.16
17	933.69	236.25

*** 1.652 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.07	46.42
2	279.33	45.83
3	290.68	42.36
4	398.52	45.66
5	683.32	52.70
6	831.61	56.96
7	841.23	74.49
8	855.30	88.71
9	861.45	107.74
10	865.91	127.24
11	877.09	143.82
12	891.22	157.98
13	898.51	176.60
14	911.85	191.50
15	925.61	206.02
16	929.65	225.61
17	940.30	238.45

*** 1.674 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.53	46.57
2	279.33	46.36
3	290.68	42.71
4	398.52	45.14
5	683.32	52.13
6	831.61	56.64
7	844.28	72.12
8	857.38	87.23
9	859.96	107.06
10	873.14	122.12
11	878.04	141.50
12	891.31	156.47
13	901.50	173.68
14	914.19	189.13
15	926.95	204.54
16	939.56	220.06
17	953.49	234.41
18	954.85	243.29

*** 1.683 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.53	47.23
2	279.33	46.29
3	290.68	42.61
4	398.52	45.67

5	683.32	52.20
6	831.61	56.40
7	845.26	71.02
8	857.92	86.50
9	868.74	103.32
10	882.04	118.26
11	896.08	132.50
12	897.16	152.48
13	905.94	170.45
14	912.02	189.50
15	920.73	207.51
16	926.12	226.76
17	934.34	236.47

*** 1.686 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.56	47.24
2	279.33	45.57
3	290.68	42.98
4	398.52	45.10
5	683.32	52.06
6	831.61	56.43
7	842.64	73.11
8	851.54	91.02
9	861.59	108.31
10	875.68	122.51
11	882.12	141.44
12	883.65	161.38
13	897.48	175.83
14	908.64	192.43
15	917.78	210.22
16	925.99	228.46
17	928.16	234.41

*** 1.696 ***

	Y	A	X	I	S	F	T
	0.00	248.88	497.76	746.64	995.53	1244.41	
X	0.00	+*-----+-----+-----+-----+-----+					
	-						
	-*						
	-						
	- *						
	-						
	248.88	+ *					
	- *						
	-						
	- *						
	- 1*						
	-						
A	497.76	+ *					
	- *						
	-						
	- *						
	- 1 *						
	-						
X	746.64	+ *	*				
	- *		*				
	-						
	- *14.						
	- 1112..*						
	- 1112*						
	- 112						
I	995.53	+ *	*				
	-						
	- *						
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S	1244.41	+ *					
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	1493.29	+ *					
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F	1742.17	+	*
		-	*
		-	
		-	*
		-	* *
		-	*
T	1991.05	+	*

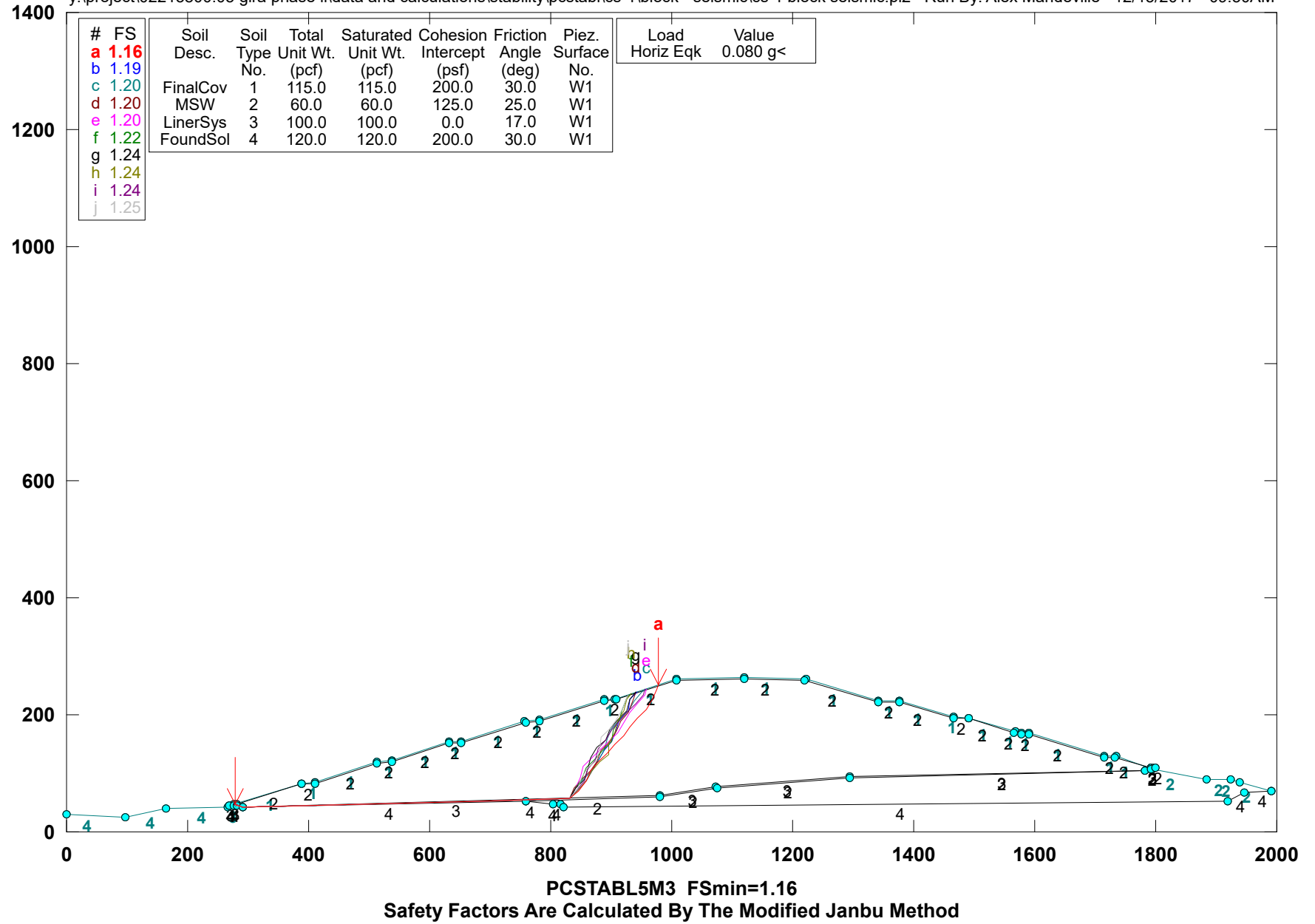
Section CS-1

Final Slope Stability Analysis

Block-Type Failure Surface within Liner System, Seismic =
0.08g

GLRA - CS-1 Block Failure - Seismic

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-1\block - seismic\cs-1 block seismic.pl2 Run By: Alex Mandeville 12/15/2017 09:50AM



** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 09:50AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-1 block seismic.

Output Filename: Y:cs-1 block seismic.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-1 block seismic.PLT

PROBLEM DESCRIPTION GLRA - CS-1
Block Failure - Seismic

BOUNDARY COORDINATES

31 Top Boundaries
79 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	30.00	97.96	23.77	4
2	97.96	23.77	164.38	38.97	4
3	164.38	38.97	265.33	43.23	4

4	265.33	43.23	269.77	44.69	3
5	269.77	44.69	387.60	83.23	1
6	387.60	83.23	410.33	85.22	1
7	410.33	85.22	513.06	119.23	1
8	513.06	119.23	536.40	121.23	1
9	536.40	121.23	632.53	153.23	1
10	632.53	153.23	651.25	153.72	1
11	651.25	153.72	757.79	189.23	1
12	757.79	189.23	780.44	191.00	1
13	780.44	191.00	889.35	227.23	1
14	889.35	227.23	906.87	227.33	1
15	906.87	227.33	1008.77	261.23	1
16	1008.77	261.23	1120.91	263.23	1
17	1120.91	263.23	1221.01	261.23	1
18	1221.01	261.23	1342.42	224.20	1
19	1342.42	224.20	1376.58	224.20	1
20	1376.58	224.20	1465.91	197.23	1
21	1465.91	197.23	1490.18	195.23	1
22	1490.18	195.23	1566.93	170.81	1
23	1566.93	170.81	1577.87	169.27	1
24	1577.87	169.27	1589.91	169.23	1
25	1589.91	169.23	1715.34	129.33	1
26	1715.34	129.33	1733.68	129.23	1
27	1733.68	129.23	1794.33	107.23	1
28	1794.33	107.23	1884.06	89.23	2
29	1884.06	89.23	1924.99	89.60	2
30	1924.99	89.60	1938.67	85.23	2
31	1938.67	85.23	1991.05	70.57	2
32	275.54	46.58	281.47	46.47	3
33	281.47	46.47	388.00	81.26	2
34	388.00	81.26	410.78	83.25	2
35	410.78	83.25	513.46	117.26	2
36	513.46	117.26	536.81	119.26	2
37	536.81	119.26	632.88	151.24	2
38	632.88	151.24	651.60	151.73	2
39	651.60	151.73	758.19	187.26	2
40	758.19	187.26	780.84	189.02	2
41	780.84	189.02	889.68	225.23	2
42	889.68	225.23	907.20	225.33	2
43	907.20	225.33	1009.11	259.24	2
44	1009.11	259.24	1120.91	261.23	2
45	1120.91	261.23	1220.69	259.24	2
46	1220.69	259.24	1342.12	222.20	2
47	1342.12	222.20	1376.28	222.20	2
48	1376.28	222.20	1465.53	195.26	2
49	1465.53	195.26	1489.79	193.26	2
50	1489.79	193.26	1566.48	168.85	2
51	1566.48	168.85	1577.73	167.27	2
52	1577.73	167.27	1589.60	167.23	2

53	1589.60	167.23	1715.02	127.33	2
54	1715.02	127.33	1733.37	127.23	2
55	1733.37	127.23	1792.55	108.76	2
56	1792.55	108.76	1795.87	109.82	2
57	281.47	46.47	290.58	43.50	3
58	290.58	43.50	980.14	61.35	3
59	980.14	61.35	1073.77	76.19	3
60	1073.77	76.19	1293.66	94.09	3
61	1293.66	94.09	1782.45	105.55	3
62	1782.45	105.55	1792.55	108.76	3
63	1792.55	108.76	1795.87	109.82	3
64	269.77	44.69	275.84	44.57	4
65	275.84	44.57	281.13	44.47	4
66	281.13	44.47	290.29	41.49	4
67	290.29	41.49	759.00	53.31	4
68	759.00	53.31	980.32	59.36	2
69	980.32	59.36	1074.01	74.20	2
70	1074.01	74.20	1293.77	92.09	2
71	1293.77	92.09	1782.78	103.56	2
72	1782.78	103.56	1791.20	106.24	2
73	1791.20	106.24	1799.41	108.85	2
74	759.00	53.31	804.88	47.23	4
75	804.88	47.23	815.76	47.23	4
76	815.76	47.23	821.85	43.23	4
77	821.85	43.23	1919.91	53.23	4
78	1919.91	53.23	1945.29	67.23	4
79	1945.29	67.23	1991.05	70.57	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

A Horizontal Earthquake Loading Coefficient
Of 0.080 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of 0.000 Has Been Assigned

Cavitation Pressure = 0.0 (psf)

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Sliding Block Surfaces, Has Been
Specified.

20 Trial Surfaces Have Been Generated.

5 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of
Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	279.33	45.87	279.33	45.87	1.00
2	290.68	42.66	290.68	42.66	1.00
3	398.52	45.26	398.52	45.26	1.00
4	683.32	52.45	683.32	52.45	1.00
5	831.61	56.71	831.61	56.71	1.00

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.97	47.37

2	279.33	46.04
3	290.68	42.75
4	398.52	45.00
5	683.32	52.04
6	831.61	56.56
7	845.75	70.70
8	858.60	86.03
9	865.10	104.95
10	878.28	119.98
11	892.33	134.22
12	906.40	148.44
13	920.01	163.09
14	930.26	180.26
15	944.28	194.52
16	957.27	209.73
17	968.76	226.10
18	976.70	244.46
19	978.81	251.26

*** 1.159 ***

Individual data on the 43 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	0.9	57.3	0.0	0.0	0.0	0.0	4.6	0.0	0.0
2	0.5	79.8	0.0	0.0	0.0	0.0	6.4	0.0	0.0
3	2.1	574.6	0.0	0.0	0.0	0.0	46.0	0.0	0.0
4	9.1	4576.1	0.0	0.0	0.0	0.0	366.1	0.0	0.0
5	0.1	66.7	0.0	0.0	0.0	0.0	5.3	0.0	0.0
6	96.9	152268.8	0.0	0.0	0.0	0.0	12181.5	0.0	0.0
7	0.4	988.3	0.0	0.0	0.0	0.0	79.1	0.0	0.0
8	10.5	26207.4	0.0	0.0	0.0	0.0	2096.6	0.0	0.0
9	11.8	29949.9	0.0	0.0	0.0	0.0	2396.0	0.0	0.0
10	0.5	1154.6	0.0	0.0	0.0	0.0	92.4	0.0	0.0
11	102.3	359501.1	0.0	0.0	0.0	0.0	28760.1	0.0	0.0
12	0.4	1782.1	0.0	0.0	0.0	0.0	142.6	0.0	0.0
13	22.9	103125.6	0.0	0.0	0.0	0.0	8250.1	0.0	0.0
14	0.4	1863.2	0.0	0.0	0.0	0.0	149.1	0.0	0.0
15	95.7	520560.0	0.0	0.0	0.0	0.0	41644.8	0.0	0.0
16	0.3	2212.8	0.0	0.0	0.0	0.0	177.0	0.0	0.0

17	18.4	116115.8	0.0	0.0	0.0	0.0	9289.3	0.0	0.0
18	0.3	2214.8	0.0	0.0	0.0	0.0	177.2	0.0	0.0
19	31.7	210271.2	0.0	0.0	0.0	0.0	16821.7	0.0	0.0
20	74.5	565439.5	0.0	0.0	0.0	0.0	45235.2	0.0	0.0
21	0.4	3303.7	0.0	0.0	0.0	0.0	264.3	0.0	0.0
22	22.2	184403.6	0.0	0.0	0.0	0.0	14752.3	0.0	0.0
23	0.4	3329.4	0.0	0.0	0.0	0.0	266.3	0.0	0.0
24	50.8	446067.6	0.0	0.0	0.0	0.0	35685.4	0.0	0.0
25	1.0	8912.8	0.0	0.0	0.0	0.0	713.0	0.0	0.0
26	13.2	117260.5	0.0	0.0	0.0	0.0	9380.8	0.0	0.0
27	12.9	106740.0	0.0	0.0	0.0	0.0	8539.2	0.0	0.0
28	6.5	48514.9	0.0	0.0	0.0	0.0	3881.2	0.0	0.0
29	13.2	87695.0	0.0	0.0	0.0	0.0	7015.6	0.0	0.0
30	11.1	67546.7	0.0	0.0	0.0	0.0	5403.7	0.0	0.0
31	0.3	1935.6	0.0	0.0	0.0	0.0	154.8	0.0	0.0
32	2.7	15301.5	0.0	0.0	0.0	0.0	1224.1	0.0	0.0
33	14.1	74092.7	0.0	0.0	0.0	0.0	5927.4	0.0	0.0
34	0.5	2286.3	0.0	0.0	0.0	0.0	182.9	0.0	0.0
35	0.3	1587.0	0.0	0.0	0.0	0.0	127.0	0.0	0.0
36	12.8	57863.4	0.0	0.0	0.0	0.0	4629.1	0.0	0.0
37	10.3	39160.8	0.0	0.0	0.0	0.0	3132.9	0.0	0.0
38	14.0	43737.4	0.0	0.0	0.0	0.0	3499.0	0.0	0.0
39	13.0	32527.1	0.0	0.0	0.0	0.0	2602.2	0.0	0.0
40	11.5	20695.7	0.0	0.0	0.0	0.0	1655.7	0.0	0.0
41	7.9	7573.0	0.0	0.0	0.0	0.0	605.8	0.0	0.0
42	1.4	500.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0
43	0.7	88.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.87	47.34
2	279.33	46.00
3	290.68	42.46
4	398.52	45.54
5	683.32	52.26
6	831.61	57.07
7	845.56	71.40
8	857.82	87.20
9	867.42	104.74
10	878.23	121.57
11	889.44	138.13
12	901.12	154.37
13	907.43	173.35
14	913.32	192.46
15	927.20	206.86

16	931.09	226.47
17	944.08	239.71

*** 1.192 ***

1

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.77	47.31
2	279.33	45.75
3	290.68	43.09
4	398.52	44.91
5	683.32	52.61
6	831.61	57.00
7	840.77	74.78
8	854.27	89.53
9	868.40	103.69
10	877.88	121.29
11	887.84	138.64
12	892.55	158.08
13	901.70	175.86
14	914.10	191.55
15	927.43	206.46
16	938.82	222.91
17	951.63	238.26
18	957.47	244.16

*** 1.197 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.75	46.65
2	279.33	45.93

3	290.68	42.72
4	398.52	45.21
5	683.32	52.54
6	831.61	56.29
7	838.55	75.04
8	852.29	89.58
9	866.06	104.09
10	877.25	120.66
11	884.05	139.47
12	897.50	154.27
13	908.25	171.13
14	916.68	189.27
15	929.28	204.80
16	936.53	223.44
17	939.74	238.27

*** 1.204 ***

1

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	276.95	47.04
2	279.33	46.23
3	290.68	42.53
4	398.52	45.12
5	683.32	52.25
6	831.61	56.62
7	840.26	74.65
8	848.27	92.98
9	854.86	111.86
10	868.86	126.15
11	882.62	140.65
12	896.59	154.97
13	910.48	169.36
14	920.55	186.64
15	929.66	204.44
16	943.78	218.61
17	956.57	233.98
18	958.27	244.43

*** 1.204 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	276.91	47.02
2	279.33	45.47
3	290.68	42.88
4	398.52	44.83
5	683.32	52.92
6	831.61	56.23
7	841.79	73.44
8	851.86	90.72
9	859.57	109.18
10	873.41	123.62
11	886.68	138.58
12	899.98	153.52
13	903.64	173.18
14	913.17	190.77
15	917.62	210.26
16	926.54	228.16
17	933.69	236.25

*** 1.224 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.07	46.42
2	279.33	45.83
3	290.68	42.36
4	398.52	45.66
5	683.32	52.70
6	831.61	56.96
7	841.23	74.49

8	855.30	88.71
9	861.45	107.74
10	865.91	127.24
11	877.09	143.82
12	891.22	157.98
13	898.51	176.60
14	911.85	191.50
15	925.61	206.02
16	929.65	225.61
17	940.30	238.45

*** 1.238 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.53	47.23
2	279.33	46.29
3	290.68	42.61
4	398.52	45.67
5	683.32	52.20
6	831.61	56.40
7	845.26	71.02
8	857.92	86.50
9	868.74	103.32
10	882.04	118.26
11	896.08	132.50
12	897.16	152.48
13	905.94	170.45
14	912.02	189.50
15	920.73	207.51
16	926.12	226.76
17	934.34	236.47

*** 1.238 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	275.53	46.57
2	279.33	46.36
3	290.68	42.71
4	398.52	45.14
5	683.32	52.13
6	831.61	56.64
7	844.28	72.12
8	857.38	87.23
9	859.96	107.06
10	873.14	122.12
11	878.04	141.50
12	891.31	156.47
13	901.50	173.68
14	914.19	189.13
15	926.95	204.54
16	939.56	220.06
17	953.49	234.41
18	954.85	243.29

*** 1.239 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	277.56	47.24
2	279.33	45.57
3	290.68	42.98
4	398.52	45.10
5	683.32	52.06
6	831.61	56.43
7	842.64	73.11
8	851.54	91.02
9	861.59	108.31
10	875.68	122.51
11	882.12	141.44
12	883.65	161.38
13	897.48	175.83

*** 1.248 ***

	Y	A	X	I	S	F	T
	0.00	248.88	497.76	746.64	995.53	1244.41	
X	0.00	+*	-----+	-----+	-----+	-----+	-----+
		-					
		-*					
		-					
		- *					
		-					
	248.88	+ *					
		- *					
		-					
		- *					
		- 1*					
		-					
A	497.76	+ *					
		- *					
		-					
		- *					
		- 1 *					
		-					
X	746.64	+ *	*				
		- *	*				
		- *15.					
		- 1112..*					
		- 1112*					
		- 112					
I	995.53	+ *	*				
		-					
		- *					
		-	**				
		-					
		- *					
S	1244.41	+ *					
		- *					

		-	*
		-	*
		-	
		-	*
	1493.29	+	*
		-	
		-	*
		-	
		-	
		-	*
F	1742.17	+	*
		-	*
		-	
		-	*
		-	*
		-	*
		-	*
T	1991.05	+	*

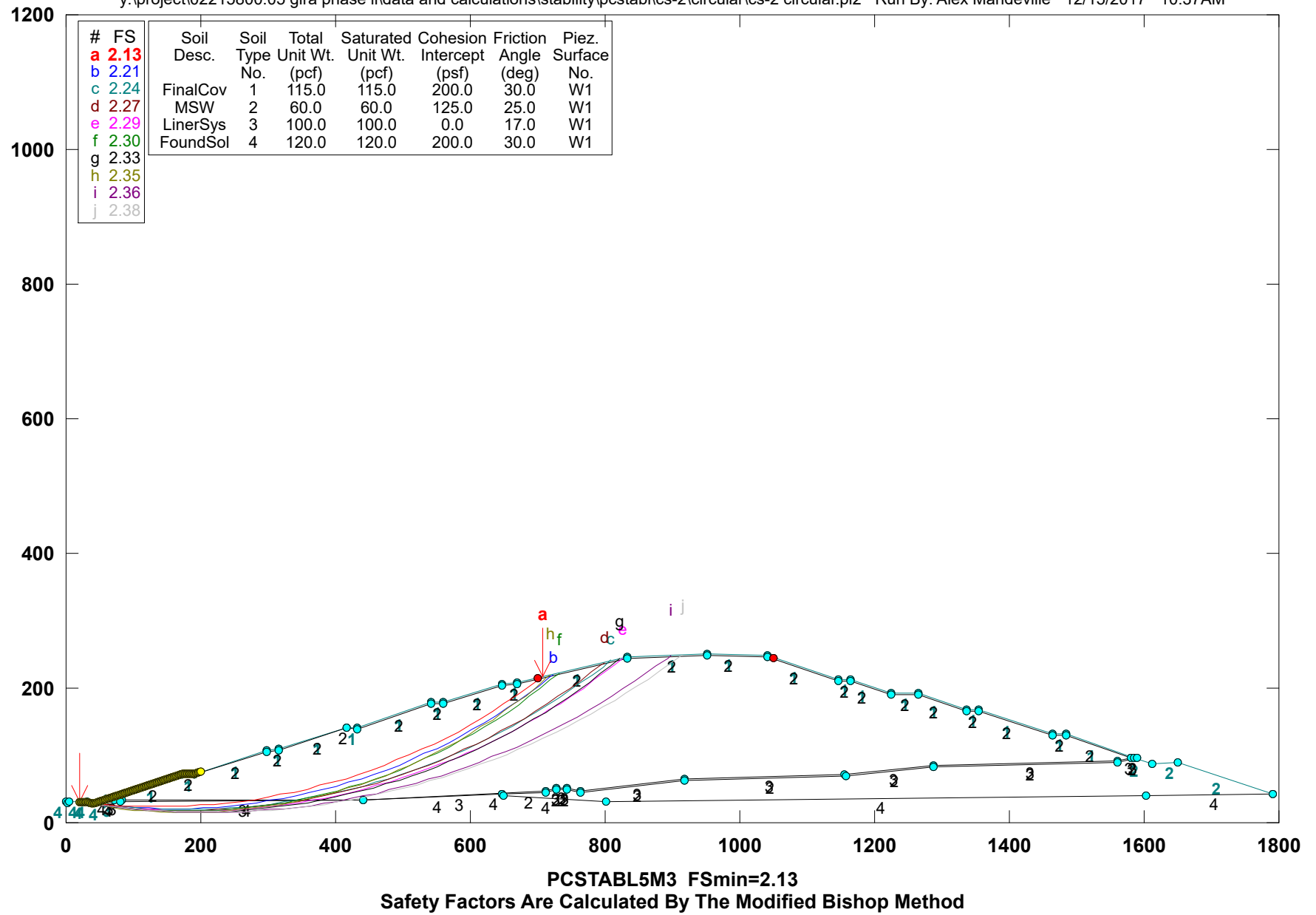
Section CS-2

Final Slope Stability Analysis

Circular Failure Surface, Static

GLRA - CS-2 Circular Failure

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-2\circular\cs-2 circular.pl2 Run By: Alex Mandeville 12/15/2017 10:37AM



** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:37AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-2 circular.

Output Filename: Y:cs-2 circular.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-2 circular.PLT

PROBLEM DESCRIPTION GLRA - CS-2
Circular Failure

BOUNDARY COORDINATES

31 Top Boundaries
83 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.90	30.39	3.31	30.01	4
2	3.31	30.01	4.70	30.47	4
3	4.70	30.47	31.67	30.61	4

4	31.67	30.61	37.54	28.83	4
5	37.54	28.83	42.39	29.02	4
6	42.39	29.02	65.68	36.80	3
7	65.68	36.80	172.94	72.65	1
8	172.94	72.65	190.09	72.65	1
9	190.09	72.65	297.45	107.87	1
10	297.45	107.87	315.27	108.65	1
11	315.27	108.65	415.36	142.00	1
12	415.36	142.00	431.14	141.66	1
13	431.14	141.66	541.53	178.46	1
14	541.53	178.46	559.45	178.91	1
15	559.45	178.91	647.60	206.65	1
16	647.60	206.65	669.44	207.27	1
17	669.44	207.27	833.00	246.65	1
18	833.00	246.65	950.98	250.65	1
19	950.98	250.65	1040.41	247.82	1
20	1040.41	247.82	1146.90	212.65	1
21	1146.90	212.65	1163.56	212.65	1
22	1163.56	212.65	1224.09	192.65	1
23	1224.09	192.65	1264.14	192.63	1
24	1264.14	192.63	1337.37	168.65	1
25	1337.37	168.65	1354.60	168.65	1
26	1354.60	168.65	1464.40	132.52	1
27	1464.40	132.52	1483.66	131.37	1
28	1483.66	131.37	1584.52	96.62	1
29	1584.52	96.62	1612.71	86.91	2
30	1612.71	86.91	1650.92	88.65	2
31	1650.92	88.65	1790.88	42.13	2
32	71.63	36.64	173.27	70.65	2
33	173.27	70.65	190.41	70.65	2
34	190.41	70.65	297.81	105.88	2
35	297.81	105.88	315.64	106.66	2
36	315.64	106.66	415.66	139.99	2
37	415.66	139.99	431.45	139.65	2
38	431.45	139.65	541.88	176.47	2
39	541.88	176.47	559.78	176.92	2
40	559.78	176.92	647.93	204.66	2
41	647.93	204.66	669.70	205.27	2
42	669.70	205.27	833.27	244.66	2
43	833.27	244.66	950.98	248.65	2
44	950.98	248.65	1040.05	245.83	2
45	1040.05	245.83	1146.57	210.65	2
46	1146.57	210.65	1163.23	210.65	2
47	1163.23	210.65	1223.77	190.65	2
48	1223.77	190.65	1263.82	190.93	2
49	1263.82	190.93	1337.05	166.65	2
50	1337.05	166.65	1354.28	166.65	2
51	1354.28	166.65	1464.02	130.53	2
52	1464.02	130.53	1483.27	129.39	2

53	1483.27	129.39	1580.42	95.92	2
54	65.68	36.80	71.63	36.64	3
55	71.63	36.64	81.84	33.32	3
56	81.84	33.32	439.97	34.65	3
57	439.97	34.65	711.88	46.64	3
58	711.88	46.64	727.23	50.51	3
59	727.23	50.51	743.99	50.51	3
60	743.99	50.51	763.56	46.67	3
61	763.56	46.67	918.62	65.43	3
62	918.62	65.43	1156.14	70.93	3
63	1156.14	70.93	1286.37	84.65	3
64	1286.37	84.65	1561.21	92.65	3
65	1561.21	92.65	1580.42	95.92	3
66	1580.42	95.92	1584.52	96.62	3
67	59.82	34.96	71.29	34.65	4
68	71.29	34.65	81.52	31.32	4
69	81.52	31.32	440.01	32.65	4
70	440.01	32.65	647.23	41.54	4
71	647.23	41.54	712.17	44.65	2
72	712.17	44.65	727.48	48.51	2
73	727.48	48.51	743.79	48.51	2
74	743.79	48.51	763.48	44.65	2
75	763.48	44.65	918.76	63.43	2
76	918.76	63.43	1156.27	68.94	2
77	1156.27	68.94	1286.51	82.65	2
78	1286.51	82.65	1561.41	90.65	2
79	1561.41	90.65	1588.46	95.26	2
80	647.23	41.54	648.95	40.65	4
81	648.95	40.65	802.15	32.18	4
82	802.15	32.18	1603.66	40.05	4
83	1603.66	40.05	1790.88	42.13	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 100 Points Equally Spaced
Along The Ground Surface Between X = 20.00 ft.
and X = 200.00 ft.

Each Surface Terminates Between X = 700.00 ft.
and X = 1050.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

20.00 ft. Line Segments Define Each Trial Failure Surface.

**** ERROR - RC11 ****

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.00	30.55
2	39.88	28.33
3	59.80	26.54
4	79.75	25.16

5	99.73	24.21
6	119.72	23.68
7	139.72	23.57
8	159.72	23.88
9	179.70	24.61
10	199.67	25.77
11	219.61	27.34
12	239.51	29.34
13	259.36	31.76
14	279.16	34.60
15	298.89	37.85
16	318.55	41.52
17	338.13	45.60
18	357.62	50.10
19	377.01	55.00
20	396.29	60.32
21	415.45	66.04
22	434.49	72.16
23	453.40	78.68
24	472.16	85.60
25	490.78	92.92
26	509.23	100.63
27	527.52	108.72
28	545.64	117.20
29	563.57	126.06
30	581.31	135.30
31	598.85	144.90
32	616.18	154.88
33	633.30	165.22
34	650.20	175.92
35	666.87	186.97
36	683.30	198.38
37	699.48	210.12
38	707.94	216.54

Circle Center At X = 135.0 ; Y = 970.6 and Radius, 947.1

*** 2.131 ***

Individual data on the 69 slices

Slice	Width	Weight	Water Force Top	Water Force Bot	Tie Force Norm	Tie Force Tan	Earthquake Force Hor	Surcharge Ver	Load

No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	11.7	953.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	5.9	562.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.3	115.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.5	226.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	17.4	8017.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	19.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	5.9	6561.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	5.6	7690.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.3	512.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	8.1	12593.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	1.8	2819.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.3	512.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	17.9	32808.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	20.0	46006.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	20.0	54892.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	20.0	62745.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	13.2	45306.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.3	1164.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	6.4	22580.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	10.4	35956.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.3	1098.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	9.3	32378.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	19.9	72982.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	19.9	76467.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	19.9	78884.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	1.6	6351.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	14.3	58321.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	3.9	16070.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	18.3	77590.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.4	1557.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	1.1	4674.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	16.4	69526.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.4	1546.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	2.9	12225.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	19.6	83855.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	19.5	86062.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	19.4	87690.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	19.3	88743.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	19.1	88784.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.1	442.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.2	958.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	15.5	69727.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.3	1347.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	3.0	13250.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	18.9	82180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	18.8	81062.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	18.6	79420.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0

48	18.5	77267.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	18.3	74618.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	14.0	55516.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.3	1364.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	3.8	14430.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	13.8	49692.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	0.3	1123.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	3.8	12816.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	17.7	57730.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	17.5	53008.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	17.3	47906.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	17.1	42447.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	14.3	31376.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	0.3	676.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	2.3	4535.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	16.7	27351.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	2.6	3274.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	0.3	316.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	13.6	14033.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	16.2	9900.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	4.5	1372.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	4.0	471.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.64	30.57
2	43.45	27.84
3	63.32	25.55
4	83.23	23.70
5	103.18	22.29
6	123.16	21.32
7	143.15	20.79
8	163.15	20.71
9	183.15	21.07
10	203.13	21.87
11	223.09	23.11
12	243.02	24.79
13	262.91	26.91
14	282.75	29.48
15	302.52	32.48
16	322.22	35.92
17	341.84	39.79
18	361.37	44.09
19	380.81	48.83
20	400.13	53.99

21	419.33	59.58
22	438.40	65.60
23	457.34	72.03
24	476.13	78.88
25	494.76	86.15
26	513.23	93.83
27	531.53	101.91
28	549.64	110.39
29	567.56	119.28
30	585.27	128.55
31	602.78	138.22
32	620.07	148.27
33	637.14	158.70
34	653.97	169.51
35	670.55	180.69
36	686.89	192.23
37	702.96	204.13
38	718.77	216.38
39	723.63	220.32

Circle Center At X = 157.0 ; Y = 925.0 and Radius, 904.3

*** 2.213 ***

1

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.64	30.57
2	43.45	27.83
3	63.31	25.47
4	83.21	23.51
5	103.15	21.93
6	123.11	20.75
7	143.10	19.95
8	163.10	19.55
9	183.10	19.54
10	203.09	19.92
11	223.08	20.69
12	243.04	21.86
13	262.98	23.41
14	282.89	25.35

15	302.75	27.69
16	322.57	30.41
17	342.32	33.52
18	362.01	37.01
19	381.63	40.89
20	401.17	45.15
21	420.63	49.80
22	439.99	54.82
23	459.24	60.23
24	478.39	66.00
25	497.42	72.16
26	516.33	78.68
27	535.10	85.57
28	553.74	92.83
29	572.23	100.45
30	590.57	108.43
31	608.75	116.77
32	626.76	125.47
33	644.59	134.51
34	662.25	143.90
35	679.72	153.64
36	697.00	163.72
37	714.07	174.13
38	730.94	184.87
39	747.60	195.95
40	764.03	207.34
41	780.24	219.06
42	796.22	231.09
43	808.56	240.77

Circle Center At X = 173.6 ; Y = 1041.2 and Radius, 1021.7

*** 2.237 ***

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.46	30.58
2	45.23	27.60
3	65.07	25.03
4	84.95	22.86
5	104.87	21.10

6	124.83	19.75
7	144.80	18.81
8	164.80	18.28
9	184.80	18.16
10	204.79	18.45
11	224.78	19.15
12	244.75	20.25
13	264.69	21.77
14	284.60	23.69
15	304.46	26.02
16	324.28	28.76
17	344.03	31.90
18	363.71	35.45
19	383.32	39.40
20	402.84	43.75
21	422.27	48.49
22	441.59	53.64
23	460.81	59.18
24	479.91	65.11
25	498.89	71.43
26	517.73	78.14
27	536.43	85.24
28	554.98	92.71
29	573.37	100.56
30	591.60	108.79
31	609.66	117.39
32	627.53	126.36
33	645.22	135.69
34	662.72	145.39
35	680.01	155.44
36	697.09	165.84
37	713.96	176.59
38	730.60	187.68
39	747.01	199.11
40	763.18	210.87
41	779.11	222.97
42	794.79	235.38
43	798.33	238.30

Circle Center At X = 180.7 ; Y = 994.7 and Radius, 976.5

*** 2.272 ***

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.46	30.58
2	45.22	27.54
3	65.05	24.90
4	84.92	22.65
5	104.83	20.79
6	124.78	19.33
7	144.75	18.27
8	164.74	17.60
9	184.74	17.33
10	204.74	17.46
11	224.73	17.98
12	244.71	18.90
13	264.67	20.22
14	284.59	21.93
15	304.48	24.04
16	324.33	26.54
17	344.12	29.43
18	363.84	32.72
19	383.50	36.40
20	403.09	40.46
21	422.58	44.92
22	441.99	49.76
23	461.29	54.98
24	480.49	60.59
25	499.58	66.57
26	518.54	72.94
27	537.37	79.68
28	556.06	86.79
29	574.61	94.27
30	593.01	102.11
31	611.24	110.32
32	629.31	118.89
33	647.21	127.82
34	664.93	137.10
35	682.46	146.73
36	699.79	156.71
37	716.92	167.02
38	733.85	177.68
39	750.56	188.67
40	767.05	199.99
41	783.31	211.63
42	799.34	223.60
43	815.12	235.88
44	826.48	245.08

Circle Center At X = 188.4 ; Y = 1025.1 and Radius, 1007.8

*** 2.289 ***

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.46	30.58
2	45.18	27.28
3	64.98	24.45
4	84.84	22.08
5	104.75	20.18
6	124.70	18.74
7	144.67	17.77
8	164.67	17.27
9	184.67	17.23
10	204.66	17.66
11	224.64	18.56
12	244.60	19.92
13	264.51	21.76
14	284.38	24.05
15	304.19	26.81
16	323.93	30.03
17	343.59	33.72
18	363.15	37.86
19	382.62	42.45
20	401.97	47.50
21	421.20	53.01
22	440.29	58.95
23	459.24	65.35
24	478.04	72.18
25	496.67	79.46
26	515.12	87.16
27	533.39	95.30
28	551.47	103.86
29	569.34	112.84
30	587.00	122.24
31	604.43	132.04
32	621.62	142.25
33	638.58	152.86
34	655.28	163.86

35	671.72	175.25
36	687.89	187.03
37	703.78	199.17
38	719.38	211.69
39	732.05	222.34

Circle Center At X = 176.2 ; Y = 872.8 and Radius, 855.6

*** 2.303 ***

1

Failure Surface Specified By 44 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.00	30.55
2	39.73	27.25
3	59.52	24.35
4	79.36	21.86
5	99.25	19.77
6	119.18	18.09
7	139.14	16.82
8	159.12	15.95
9	179.11	15.49
10	199.11	15.43
11	219.11	15.79
12	239.10	16.55
13	259.06	17.72
14	279.00	19.29
15	298.90	21.28
16	318.76	23.66
17	338.56	26.45
18	358.31	29.65
19	377.98	33.24
20	397.58	37.24
21	417.09	41.63
22	436.51	46.42
23	455.82	51.61
24	475.03	57.19
25	494.12	63.15
26	513.08	69.51
27	531.91	76.25
28	550.60	83.38

29	569.14	90.88
30	587.52	98.76
31	605.74	107.01
32	623.79	115.63
33	641.65	124.62
34	659.33	133.97
35	676.82	143.68
36	694.10	153.74
37	711.18	164.15
38	728.04	174.91
39	744.67	186.01
40	761.08	197.45
41	777.25	209.22
42	793.18	221.31
43	808.86	233.73
44	821.01	243.76

Circle Center At X = 191.7 ; Y = 996.6 and Radius, 981.2

*** 2.331 ***

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.82	30.56
2	41.49	26.93
3	61.24	23.79
4	81.06	21.13
5	100.94	18.96
6	120.87	17.28
7	140.84	16.09
8	160.82	15.39
9	180.82	15.18
10	200.82	15.46
11	220.81	16.23
12	240.77	17.49
13	260.69	19.24
14	280.56	21.48
15	300.38	24.21
16	320.12	27.42
17	339.77	31.11
18	359.33	35.29

19	378.78	39.95
20	398.11	45.08
21	417.31	50.68
22	436.37	56.76
23	455.27	63.30
24	474.00	70.30
25	492.56	77.76
26	510.93	85.67
27	529.09	94.04
28	547.05	102.84
29	564.79	112.08
30	582.29	121.76
31	599.55	131.86
32	616.56	142.39
33	633.30	153.32
34	649.77	164.67
35	665.96	176.41
36	681.86	188.55
37	697.45	201.08
38	712.73	213.99
39	718.46	219.07

Circle Center At X = 179.4 ; Y = 829.9 and Radius, 814.8

*** 2.354 ***

1

Failure Surface Specified By 48 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.64	30.57
2	43.39	27.46
3	63.20	24.71
4	83.06	22.30
5	102.95	20.25
6	122.88	18.55
7	142.83	17.20
8	162.81	16.20
9	182.80	15.56
10	202.80	15.27
11	222.80	15.34
12	242.79	15.75

13	262.78	16.53
14	282.75	17.65
15	302.69	19.13
16	322.61	20.96
17	342.49	23.14
18	362.33	25.68
19	382.12	28.56
20	401.85	31.80
21	421.53	35.38
22	441.14	39.31
23	460.68	43.58
24	480.14	48.21
25	499.51	53.17
26	518.80	58.48
27	537.98	64.12
28	557.07	70.11
29	576.04	76.43
30	594.90	83.08
31	613.64	90.07
32	632.25	97.39
33	650.73	105.04
34	669.08	113.01
35	687.27	121.30
36	705.32	129.92
37	723.22	138.85
38	740.95	148.10
39	758.52	157.66
40	775.91	167.53
41	793.13	177.71
42	810.16	188.19
43	827.01	198.97
44	843.67	210.04
45	860.12	221.41
46	876.37	233.06
47	892.42	245.01
48	897.37	248.83

Circle Center At X = 209.1 ; Y = 1146.0 and Radius, 1130.7

*** 2.358 ***

Failure Surface Specified By 49 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	25.46	30.58
2	45.22	27.52
3	65.03	24.80
4	84.89	22.43
5	104.79	20.39
6	124.72	18.69
7	144.67	17.34
8	164.65	16.33
9	184.63	15.66
10	204.63	15.33
11	224.63	15.34
12	244.63	15.70
13	264.62	16.40
14	284.59	17.44
15	304.54	18.82
16	324.47	20.55
17	344.36	22.61
18	364.21	25.02
19	384.03	27.76
20	403.79	30.85
21	423.49	34.27
22	443.13	38.03
23	462.71	42.12
24	482.21	46.55
25	501.64	51.31
26	520.98	56.41
27	540.23	61.83
28	559.38	67.58
29	578.44	73.67
30	597.38	80.07
31	616.22	86.80
32	634.93	93.85
33	653.53	101.22
34	671.99	108.91
35	690.32	116.91
36	708.51	125.23
37	726.55	133.85
38	744.45	142.79
39	762.18	152.03
40	779.76	161.57
41	797.17	171.41
42	814.41	181.54
43	831.48	191.98
44	848.36	202.70
45	865.06	213.71
46	881.57	225.00
47	897.88	236.57

48	913.99	248.42
49	915.32	249.44

Circle Center At X = 213.8 ; Y = 1183.3 and Radius, 1168.0

*** 2.375 ***

1

	Y	A	X	I	S	F	T
	0.00	223.86	447.72	671.58	895.44	1119.30	
X	0.00	+	*	-	-	-	-
		-	*				
		.	**				
		.	1				
		.	1				
		.	1	*			
	223.86	.	1				
		.	11				
		.	21	*			
		.	31				
		.	51				
		.	921	*			
A	447.72	.	**11	*			
		-	.931				
		-	..411				
		-	..9311	*			
		-	..0731				
		-	*.95311*				
X	671.58	+	...9331*				
		-	*..093311				
		-	*...09336				
		-	*...99534				
		-	...997*				
		-	99.				
I	895.44	+	09				
		-	*....*				
		-					
		-	...				
		-	.*				
		-					
S	1119.30	+					
		-	*	*			

		-		
		-		*
		-	*	*
		-		
	1343.16	+		**
		-		
		-		
		-		*
		-		*
		-		
F	1567.02	+	*	
		-	*	*
		-		*
		-		
		-		
		-		
T	1790.88	+	*	

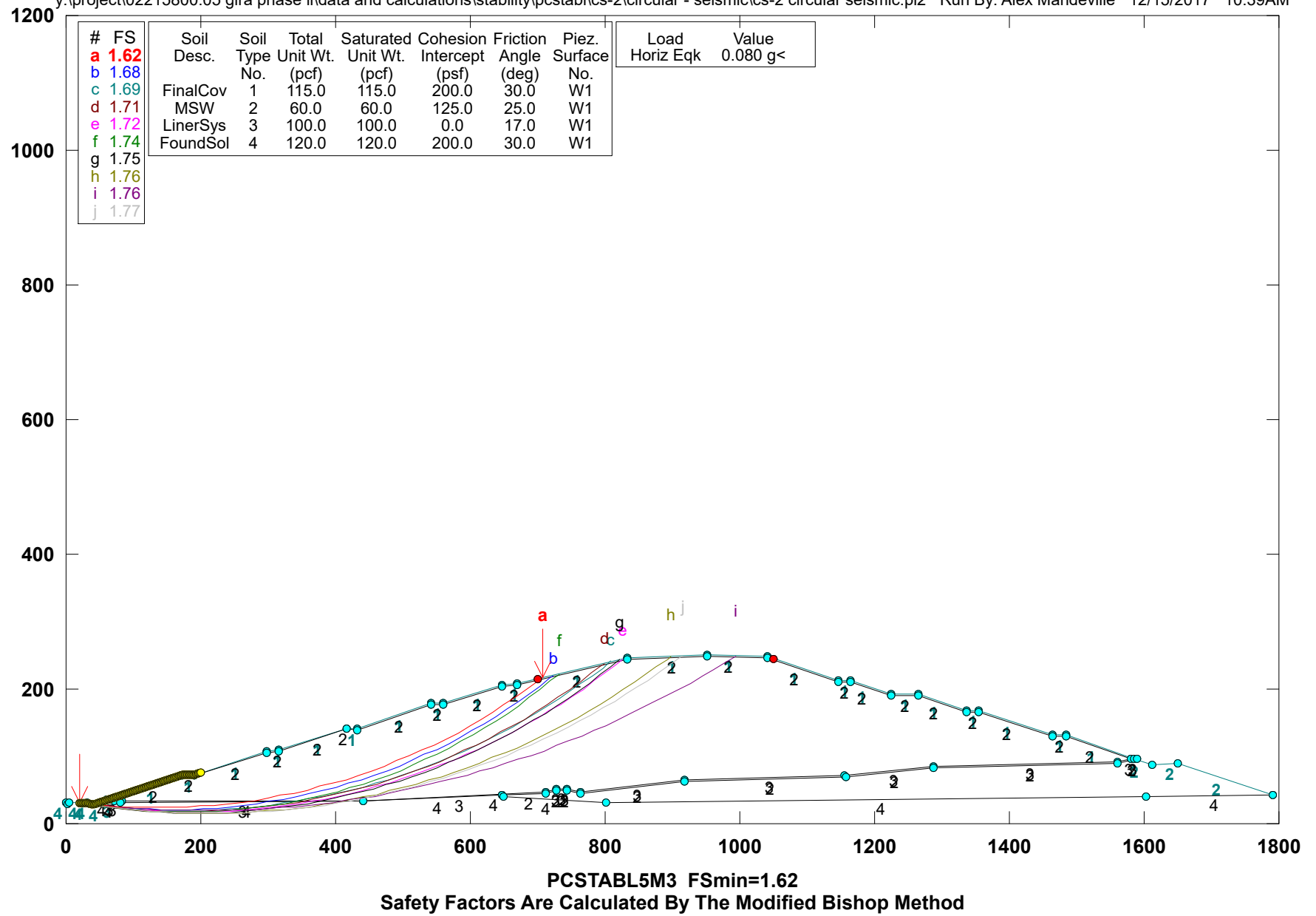
Section CS-2

Final Slope Stability Analysis

Circular Failure Surface, Seismic = 0.08g

GLRA - CS-2 Circular Failure - Seismic

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-2\circular - seismic\cs-2 circular seismic.pl2 Run By: Alex Mandeville 12/15/2017 10:39AM



** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:39AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-2 circular seismic.

Output Filename: Y:cs-2 circular seismic.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-2 circular seismic.PLT

PROBLEM DESCRIPTION GLRA - CS-2
Circular Failure - Seismic

BOUNDARY COORDINATES

31 Top Boundaries
83 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.90	30.39	3.31	30.01	4
2	3.31	30.01	4.70	30.47	4
3	4.70	30.47	31.67	30.61	4

4	31.67	30.61	37.54	28.83	4
5	37.54	28.83	42.39	29.02	4
6	42.39	29.02	65.68	36.80	3
7	65.68	36.80	172.94	72.65	1
8	172.94	72.65	190.09	72.65	1
9	190.09	72.65	297.45	107.87	1
10	297.45	107.87	315.27	108.65	1
11	315.27	108.65	415.36	142.00	1
12	415.36	142.00	431.14	141.66	1
13	431.14	141.66	541.53	178.46	1
14	541.53	178.46	559.45	178.91	1
15	559.45	178.91	647.60	206.65	1
16	647.60	206.65	669.44	207.27	1
17	669.44	207.27	833.00	246.65	1
18	833.00	246.65	950.98	250.65	1
19	950.98	250.65	1040.41	247.82	1
20	1040.41	247.82	1146.90	212.65	1
21	1146.90	212.65	1163.56	212.65	1
22	1163.56	212.65	1224.09	192.65	1
23	1224.09	192.65	1264.14	192.63	1
24	1264.14	192.63	1337.37	168.65	1
25	1337.37	168.65	1354.60	168.65	1
26	1354.60	168.65	1464.40	132.52	1
27	1464.40	132.52	1483.66	131.37	1
28	1483.66	131.37	1584.52	96.62	1
29	1584.52	96.62	1612.71	86.91	2
30	1612.71	86.91	1650.92	88.65	2
31	1650.92	88.65	1790.88	42.13	2
32	71.63	36.64	173.27	70.65	2
33	173.27	70.65	190.41	70.65	2
34	190.41	70.65	297.81	105.88	2
35	297.81	105.88	315.64	106.66	2
36	315.64	106.66	415.66	139.99	2
37	415.66	139.99	431.45	139.65	2
38	431.45	139.65	541.88	176.47	2
39	541.88	176.47	559.78	176.92	2
40	559.78	176.92	647.93	204.66	2
41	647.93	204.66	669.70	205.27	2
42	669.70	205.27	833.27	244.66	2
43	833.27	244.66	950.98	248.65	2
44	950.98	248.65	1040.05	245.83	2
45	1040.05	245.83	1146.57	210.65	2
46	1146.57	210.65	1163.23	210.65	2
47	1163.23	210.65	1223.77	190.65	2
48	1223.77	190.65	1263.82	190.93	2
49	1263.82	190.93	1337.05	166.65	2
50	1337.05	166.65	1354.28	166.65	2
51	1354.28	166.65	1464.02	130.53	2
52	1464.02	130.53	1483.27	129.39	2

53	1483.27	129.39	1580.42	95.92	2
54	65.68	36.80	71.63	36.64	3
55	71.63	36.64	81.84	33.32	3
56	81.84	33.32	439.97	34.65	3
57	439.97	34.65	711.88	46.64	3
58	711.88	46.64	727.23	50.51	3
59	727.23	50.51	743.99	50.51	3
60	743.99	50.51	763.56	46.67	3
61	763.56	46.67	918.62	65.43	3
62	918.62	65.43	1156.14	70.93	3
63	1156.14	70.93	1286.37	84.65	3
64	1286.37	84.65	1561.21	92.65	3
65	1561.21	92.65	1580.42	95.92	3
66	1580.42	95.92	1584.52	96.62	3
67	59.82	34.96	71.29	34.65	4
68	71.29	34.65	81.52	31.32	4
69	81.52	31.32	440.01	32.65	4
70	440.01	32.65	647.23	41.54	4
71	647.23	41.54	712.17	44.65	2
72	712.17	44.65	727.48	48.51	2
73	727.48	48.51	743.79	48.51	2
74	743.79	48.51	763.48	44.65	2
75	763.48	44.65	918.76	63.43	2
76	918.76	63.43	1156.27	68.94	2
77	1156.27	68.94	1286.51	82.65	2
78	1286.51	82.65	1561.41	90.65	2
79	1561.41	90.65	1588.46	95.26	2
80	647.23	41.54	648.95	40.65	4
81	648.95	40.65	802.15	32.18	4
82	802.15	32.18	1603.66	40.05	4
83	1603.66	40.05	1790.88	42.13	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

A Horizontal Earthquake Loading Coefficient
Of 0.080 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of 0.000 Has Been Assigned

Cavitation Pressure = 0.0 (psf)

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 100 Points Equally Spaced
Along The Ground Surface Between X = 20.00 ft.
and X = 200.00 ft.

Each Surface Terminates Between X = 700.00 ft.
and X = 1050.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

20.00 ft. Line Segments Define Each Trial Failure Surface.

**** ERROR - RC11 ****

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.00	30.55
2	39.88	28.33
3	59.80	26.54
4	79.75	25.16
5	99.73	24.21
6	119.72	23.68
7	139.72	23.57
8	159.72	23.88
9	179.70	24.61
10	199.67	25.77
11	219.61	27.34
12	239.51	29.34
13	259.36	31.76
14	279.16	34.60
15	298.89	37.85
16	318.55	41.52
17	338.13	45.60
18	357.62	50.10
19	377.01	55.00
20	396.29	60.32
21	415.45	66.04
22	434.49	72.16
23	453.40	78.68
24	472.16	85.60
25	490.78	92.92
26	509.23	100.63
27	527.52	108.72
28	545.64	117.20
29	563.57	126.06
30	581.31	135.30
31	598.85	144.90
32	616.18	154.88
33	633.30	165.22
34	650.20	175.92
35	666.87	186.97
36	683.30	198.38
37	699.48	210.12
38	707.94	216.54

Circle Center At X = 135.0 ; Y = 970.6 and Radius, 947.1

*** 1.620 ***

Individual data on the 69 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	11.7	953.5	0.0	0.0	0.0	0.0	76.3	0.0	0.0
2	5.9	562.9	0.0	0.0	0.0	0.0	45.0	0.0	0.0
3	2.3	115.7	0.0	0.0	0.0	0.0	9.3	0.0	0.0
4	2.5	226.5	0.0	0.0	0.0	0.0	18.1	0.0	0.0
5	17.4	8017.0	0.0	0.0	0.0	0.0	641.4	0.0	0.0
6	0.0	19.5	0.0	0.0	0.0	0.0	1.6	0.0	0.0
7	5.9	6561.8	0.0	0.0	0.0	0.0	524.9	0.0	0.0
8	5.6	7690.9	0.0	0.0	0.0	0.0	615.3	0.0	0.0
9	0.3	512.9	0.0	0.0	0.0	0.0	41.0	0.0	0.0
10	8.1	12593.2	0.0	0.0	0.0	0.0	1007.5	0.0	0.0
11	1.8	2819.7	0.0	0.0	0.0	0.0	225.6	0.0	0.0
12	0.3	512.0	0.0	0.0	0.0	0.0	41.0	0.0	0.0
13	17.9	32808.9	0.0	0.0	0.0	0.0	2624.7	0.0	0.0
14	20.0	46006.0	0.0	0.0	0.0	0.0	3680.5	0.0	0.0
15	20.0	54892.9	0.0	0.0	0.0	0.0	4391.4	0.0	0.0
16	20.0	62745.2	0.0	0.0	0.0	0.0	5019.6	0.0	0.0
17	13.2	45306.5	0.0	0.0	0.0	0.0	3624.5	0.0	0.0
18	0.3	1164.1	0.0	0.0	0.0	0.0	93.1	0.0	0.0
19	6.4	22580.5	0.0	0.0	0.0	0.0	1806.4	0.0	0.0
20	10.4	35956.5	0.0	0.0	0.0	0.0	2876.5	0.0	0.0
21	0.3	1098.1	0.0	0.0	0.0	0.0	87.9	0.0	0.0
22	9.3	32378.1	0.0	0.0	0.0	0.0	2590.2	0.0	0.0
23	19.9	72982.5	0.0	0.0	0.0	0.0	5838.6	0.0	0.0
24	19.9	76467.1	0.0	0.0	0.0	0.0	6117.4	0.0	0.0
25	19.9	78884.9	0.0	0.0	0.0	0.0	6310.8	0.0	0.0
26	1.6	6351.6	0.0	0.0	0.0	0.0	508.1	0.0	0.0
27	14.3	58321.9	0.0	0.0	0.0	0.0	4665.8	0.0	0.0
28	3.9	16070.5	0.0	0.0	0.0	0.0	1285.6	0.0	0.0
29	18.3	77590.4	0.0	0.0	0.0	0.0	6207.2	0.0	0.0
30	0.4	1557.9	0.0	0.0	0.0	0.0	124.6	0.0	0.0
31	1.1	4674.8	0.0	0.0	0.0	0.0	374.0	0.0	0.0
32	16.4	69526.9	0.0	0.0	0.0	0.0	5562.2	0.0	0.0
33	0.4	1546.4	0.0	0.0	0.0	0.0	123.7	0.0	0.0
34	2.9	12225.4	0.0	0.0	0.0	0.0	978.0	0.0	0.0
35	19.6	83855.9	0.0	0.0	0.0	0.0	6708.5	0.0	0.0
36	19.5	86062.4	0.0	0.0	0.0	0.0	6885.0	0.0	0.0
37	19.4	87690.0	0.0	0.0	0.0	0.0	7015.2	0.0	0.0

38	19.3	88743.1	0.0	0.0	0.0	0.0	7099.4	0.0	0.0
39	19.1	88784.8	0.0	0.0	0.0	0.0	7102.8	0.0	0.0
40	0.1	442.6	0.0	0.0	0.0	0.0	35.4	0.0	0.0
41	0.2	958.4	0.0	0.0	0.0	0.0	76.7	0.0	0.0
42	15.5	69727.3	0.0	0.0	0.0	0.0	5578.2	0.0	0.0
43	0.3	1347.8	0.0	0.0	0.0	0.0	107.8	0.0	0.0
44	3.0	13250.0	0.0	0.0	0.0	0.0	1060.0	0.0	0.0
45	18.9	82180.0	0.0	0.0	0.0	0.0	6574.4	0.0	0.0
46	18.8	81062.7	0.0	0.0	0.0	0.0	6485.0	0.0	0.0
47	18.6	79420.4	0.0	0.0	0.0	0.0	6353.6	0.0	0.0
48	18.5	77267.1	0.0	0.0	0.0	0.0	6181.4	0.0	0.0
49	18.3	74618.5	0.0	0.0	0.0	0.0	5969.5	0.0	0.0
50	14.0	55516.8	0.0	0.0	0.0	0.0	4441.3	0.0	0.0
51	0.3	1364.6	0.0	0.0	0.0	0.0	109.2	0.0	0.0
52	3.8	14430.7	0.0	0.0	0.0	0.0	1154.5	0.0	0.0
53	13.8	49692.2	0.0	0.0	0.0	0.0	3975.4	0.0	0.0
54	0.3	1123.3	0.0	0.0	0.0	0.0	89.9	0.0	0.0
55	3.8	12816.5	0.0	0.0	0.0	0.0	1025.3	0.0	0.0
56	17.7	57730.1	0.0	0.0	0.0	0.0	4618.4	0.0	0.0
57	17.5	53008.7	0.0	0.0	0.0	0.0	4240.7	0.0	0.0
58	17.3	47906.5	0.0	0.0	0.0	0.0	3832.5	0.0	0.0
59	17.1	42447.9	0.0	0.0	0.0	0.0	3395.8	0.0	0.0
60	14.3	31376.1	0.0	0.0	0.0	0.0	2510.1	0.0	0.0
61	0.3	676.4	0.0	0.0	0.0	0.0	54.1	0.0	0.0
62	2.3	4535.3	0.0	0.0	0.0	0.0	362.8	0.0	0.0
63	16.7	27351.4	0.0	0.0	0.0	0.0	2188.1	0.0	0.0
64	2.6	3274.7	0.0	0.0	0.0	0.0	262.0	0.0	0.0
65	0.3	316.9	0.0	0.0	0.0	0.0	25.4	0.0	0.0
66	13.6	14033.1	0.0	0.0	0.0	0.0	1122.7	0.0	0.0
67	16.2	9900.4	0.0	0.0	0.0	0.0	792.0	0.0	0.0
68	4.5	1372.8	0.0	0.0	0.0	0.0	109.8	0.0	0.0
69	4.0	471.8	0.0	0.0	0.0	0.0	37.7	0.0	0.0

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.64	30.57
2	43.45	27.84
3	63.32	25.55
4	83.23	23.70
5	103.18	22.29
6	123.16	21.32
7	143.15	20.79
8	163.15	20.71
9	183.15	21.07
10	203.13	21.87

11	223.09	23.11
12	243.02	24.79
13	262.91	26.91
14	282.75	29.48
15	302.52	32.48
16	322.22	35.92
17	341.84	39.79
18	361.37	44.09
19	380.81	48.83
20	400.13	53.99
21	419.33	59.58
22	438.40	65.60
23	457.34	72.03
24	476.13	78.88
25	494.76	86.15
26	513.23	93.83
27	531.53	101.91
28	549.64	110.39
29	567.56	119.28
30	585.27	128.55
31	602.78	138.22
32	620.07	148.27
33	637.14	158.70
34	653.97	169.51
35	670.55	180.69
36	686.89	192.23
37	702.96	204.13
38	718.77	216.38
39	723.63	220.32

Circle Center At X = 157.0 ; Y = 925.0 and Radius, 904.3

*** 1.676 ***

1

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.64	30.57
2	43.45	27.83
3	63.31	25.47
4	83.21	23.51

5	103.15	21.93
6	123.11	20.75
7	143.10	19.95
8	163.10	19.55
9	183.10	19.54
10	203.09	19.92
11	223.08	20.69
12	243.04	21.86
13	262.98	23.41
14	282.89	25.35
15	302.75	27.69
16	322.57	30.41
17	342.32	33.52
18	362.01	37.01
19	381.63	40.89
20	401.17	45.15
21	420.63	49.80
22	439.99	54.82
23	459.24	60.23
24	478.39	66.00
25	497.42	72.16
26	516.33	78.68
27	535.10	85.57
28	553.74	92.83
29	572.23	100.45
30	590.57	108.43
31	608.75	116.77
32	626.76	125.47
33	644.59	134.51
34	662.25	143.90
35	679.72	153.64
36	697.00	163.72
37	714.07	174.13
38	730.94	184.87
39	747.60	195.95
40	764.03	207.34
41	780.24	219.06
42	796.22	231.09
43	808.56	240.77

Circle Center At X = 173.6 ; Y = 1041.2 and Radius, 1021.7

*** 1.686 ***

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.46	30.58
2	45.23	27.60
3	65.07	25.03
4	84.95	22.86
5	104.87	21.10
6	124.83	19.75
7	144.80	18.81
8	164.80	18.28
9	184.80	18.16
10	204.79	18.45
11	224.78	19.15
12	244.75	20.25
13	264.69	21.77
14	284.60	23.69
15	304.46	26.02
16	324.28	28.76
17	344.03	31.90
18	363.71	35.45
19	383.32	39.40
20	402.84	43.75
21	422.27	48.49
22	441.59	53.64
23	460.81	59.18
24	479.91	65.11
25	498.89	71.43
26	517.73	78.14
27	536.43	85.24
28	554.98	92.71
29	573.37	100.56
30	591.60	108.79
31	609.66	117.39
32	627.53	126.36
33	645.22	135.69
34	662.72	145.39
35	680.01	155.44
36	697.09	165.84
37	713.96	176.59
38	730.60	187.68
39	747.01	199.11
40	763.18	210.87
41	779.11	222.97
42	794.79	235.38
43	798.33	238.30

Circle Center At X = 180.7 ; Y = 994.7 and Radius, 976.5

*** 1.711 ***

1

Failure Surface Specified By 44 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.46	30.58
2	45.22	27.54
3	65.05	24.90
4	84.92	22.65
5	104.83	20.79
6	124.78	19.33
7	144.75	18.27
8	164.74	17.60
9	184.74	17.33
10	204.74	17.46
11	224.73	17.98
12	244.71	18.90
13	264.67	20.22
14	284.59	21.93
15	304.48	24.04
16	324.33	26.54
17	344.12	29.43
18	363.84	32.72
19	383.50	36.40
20	403.09	40.46
21	422.58	44.92
22	441.99	49.76
23	461.29	54.98
24	480.49	60.59
25	499.58	66.57
26	518.54	72.94
27	537.37	79.68
28	556.06	86.79
29	574.61	94.27
30	593.01	102.11
31	611.24	110.32
32	629.31	118.89
33	647.21	127.82
34	664.93	137.10

35	682.46	146.73
36	699.79	156.71
37	716.92	167.02
38	733.85	177.68
39	750.56	188.67
40	767.05	199.99
41	783.31	211.63
42	799.34	223.60
43	815.12	235.88
44	826.48	245.08

Circle Center At X = 188.4 ; Y = 1025.1 and Radius, 1007.8

*** 1.721 ***

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.46	30.58
2	45.18	27.28
3	64.98	24.45
4	84.84	22.08
5	104.75	20.18
6	124.70	18.74
7	144.67	17.77
8	164.67	17.27
9	184.67	17.23
10	204.66	17.66
11	224.64	18.56
12	244.60	19.92
13	264.51	21.76
14	284.38	24.05
15	304.19	26.81
16	323.93	30.03
17	343.59	33.72
18	363.15	37.86
19	382.62	42.45
20	401.97	47.50
21	421.20	53.01
22	440.29	58.95
23	459.24	65.35
24	478.04	72.18

25	496.67	79.46
26	515.12	87.16
27	533.39	95.30
28	551.47	103.86
29	569.34	112.84
30	587.00	122.24
31	604.43	132.04
32	621.62	142.25
33	638.58	152.86
34	655.28	163.86
35	671.72	175.25
36	687.89	187.03
37	703.78	199.17
38	719.38	211.69
39	732.05	222.34

Circle Center At X = 176.2 ; Y = 872.8 and Radius, 855.6

*** 1.737 ***

1

Failure Surface Specified By 44 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.00	30.55
2	39.73	27.25
3	59.52	24.35
4	79.36	21.86
5	99.25	19.77
6	119.18	18.09
7	139.14	16.82
8	159.12	15.95
9	179.11	15.49
10	199.11	15.43
11	219.11	15.79
12	239.10	16.55
13	259.06	17.72
14	279.00	19.29
15	298.90	21.28
16	318.76	23.66
17	338.56	26.45
18	358.31	29.65

19	377.98	33.24
20	397.58	37.24
21	417.09	41.63
22	436.51	46.42
23	455.82	51.61
24	475.03	57.19
25	494.12	63.15
26	513.08	69.51
27	531.91	76.25
28	550.60	83.38
29	569.14	90.88
30	587.52	98.76
31	605.74	107.01
32	623.79	115.63
33	641.65	124.62
34	659.33	133.97
35	676.82	143.68
36	694.10	153.74
37	711.18	164.15
38	728.04	174.91
39	744.67	186.01
40	761.08	197.45
41	777.25	209.22
42	793.18	221.31
43	808.86	233.73
44	821.01	243.76

Circle Center At X = 191.7 ; Y = 996.6 and Radius, 981.2

*** 1.749 ***

Failure Surface Specified By 48 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.64	30.57
2	43.39	27.46
3	63.20	24.71
4	83.06	22.30
5	102.95	20.25
6	122.88	18.55
7	142.83	17.20
8	162.81	16.20

9	182.80	15.56
10	202.80	15.27
11	222.80	15.34
12	242.79	15.75
13	262.78	16.53
14	282.75	17.65
15	302.69	19.13
16	322.61	20.96
17	342.49	23.14
18	362.33	25.68
19	382.12	28.56
20	401.85	31.80
21	421.53	35.38
22	441.14	39.31
23	460.68	43.58
24	480.14	48.21
25	499.51	53.17
26	518.80	58.48
27	537.98	64.12
28	557.07	70.11
29	576.04	76.43
30	594.90	83.08
31	613.64	90.07
32	632.25	97.39
33	650.73	105.04
34	669.08	113.01
35	687.27	121.30
36	705.32	129.92
37	723.22	138.85
38	740.95	148.10
39	758.52	157.66
40	775.91	167.53
41	793.13	177.71
42	810.16	188.19
43	827.01	198.97
44	843.67	210.04
45	860.12	221.41
46	876.37	233.06
47	892.42	245.01
48	897.37	248.83

Circle Center At X = 209.1 ; Y = 1146.0 and Radius, 1130.7

*** 1.759 ***

Failure Surface Specified By 52 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.00	30.55
2	39.86	28.19
3	59.75	26.09
4	79.67	24.27
5	99.61	22.72
6	119.57	21.44
7	139.54	20.43
8	159.53	19.69
9	179.52	19.23
10	199.52	19.03
11	219.52	19.11
12	239.52	19.46
13	259.51	20.08
14	279.49	20.98
15	299.45	22.14
16	319.40	23.58
17	339.33	25.28
18	359.23	27.26
19	379.10	29.51
20	398.95	32.03
21	418.75	34.81
22	438.52	37.87
23	458.24	41.19
24	477.91	44.79
25	497.54	48.65
26	517.11	52.77
27	536.62	57.16
28	556.07	61.82
29	575.45	66.74
30	594.77	71.92
31	614.02	77.37
32	633.18	83.07
33	652.27	89.04
34	671.28	95.26
35	690.20	101.74
36	709.03	108.48
37	727.77	115.48
38	746.41	122.73
39	764.95	130.23
40	783.38	137.98
41	801.71	145.98
42	819.93	154.23

43	838.04	162.73
44	856.03	171.47
45	873.89	180.46
46	891.64	189.69
47	909.25	199.16
48	926.74	208.86
49	944.09	218.81
50	961.31	228.99
51	978.38	239.40
52	994.11	249.29

Circle Center At X = 203.8 ; Y = 1490.5 and Radius, 1471.5

*** 1.764 ***

Failure Surface Specified By 49 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.46	30.58
2	45.22	27.52
3	65.03	24.80
4	84.89	22.43
5	104.79	20.39
6	124.72	18.69
7	144.67	17.34
8	164.65	16.33
9	184.63	15.66
10	204.63	15.33
11	224.63	15.34
12	244.63	15.70
13	264.62	16.40
14	284.59	17.44
15	304.54	18.82
16	324.47	20.55
17	344.36	22.61
18	364.21	25.02
19	384.03	27.76
20	403.79	30.85
21	423.49	34.27
22	443.13	38.03
23	462.71	42.12
24	482.21	46.55

Page 18

		.31	
		.51	
		.821	*
A	447.72	.*11	*
		-.831	
		-.9411	
		-.8311	*
		-.9731	
		-.85311*	
X	671.58	+ .98331*	
		- *.983311	
		- *.908336	
		-* .988534	
		- .9887*	
		- .988.	
I	895.44	+ .9908	
		- * .99*	
		- .99	
		- .9	
		- *	
		-	
S	1119.30	+ *	*
		-	
		- *	*
		- *	*
		-	
	1343.16	+ **	
		-	
		- *	
		- *	
		-	
F	1567.02	+ *	
		- * *	
		- *	
		-	
		-	
T	1790.88	+ *	

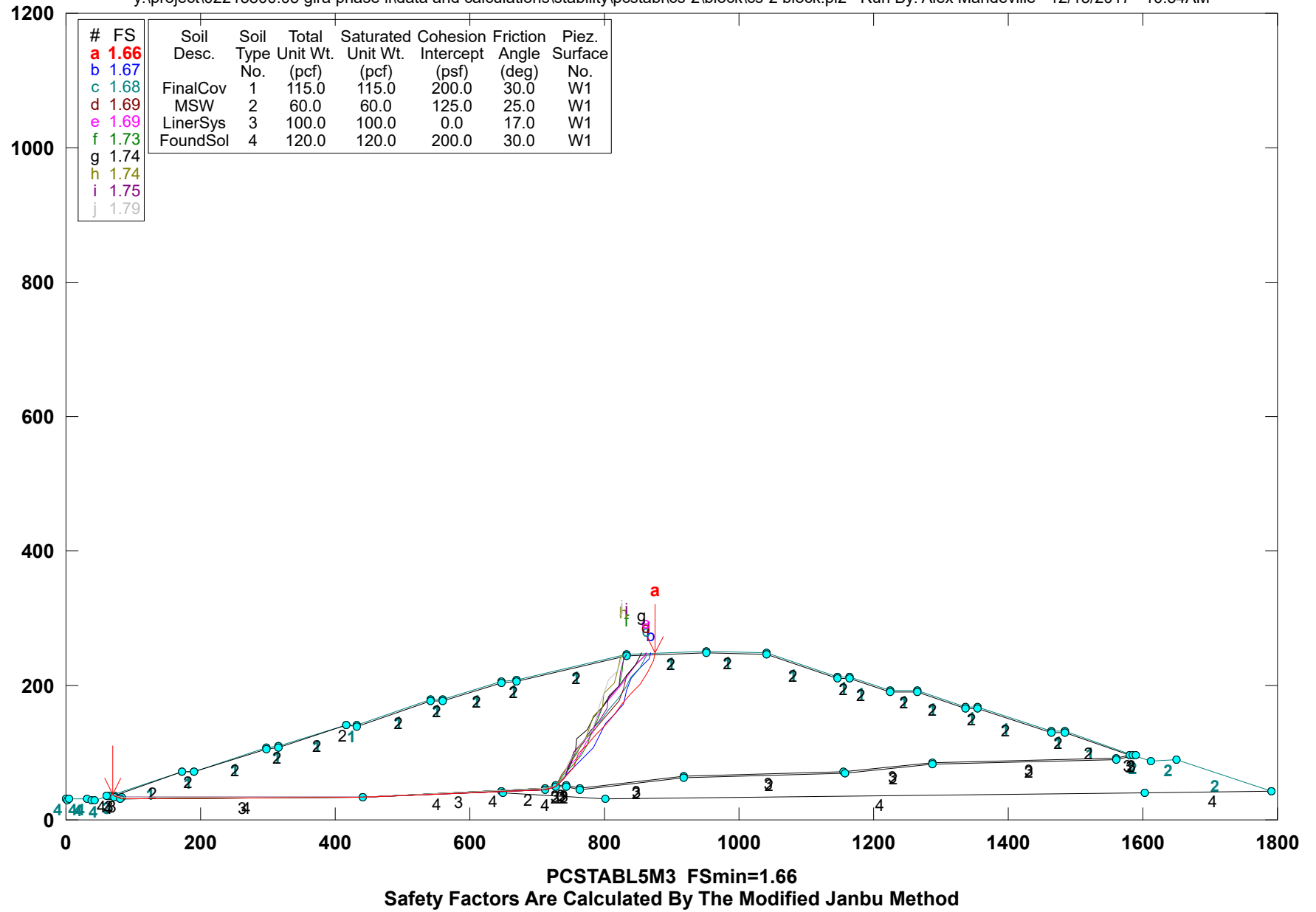
Section CS-2

Final Slope Stability Analysis

Block-Type Failure Surface within Liner System, Static

GLRA - CS-2 Block Failure

y:\project\02215800.05 glra phase i\data and calculations\stability\pcstabl\cs-2\block\cs-2 block.pl2 Run By: Alex Mandeville 12/15/2017 10:34AM



** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:34AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-2 block.

Output Filename: Y:cs-2 block.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-2 block.PLT

PROBLEM DESCRIPTION GLRA - CS-2
Block Failure

BOUNDARY COORDINATES

31 Top Boundaries
83 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.90	30.39	3.31	30.01	4
2	3.31	30.01	4.70	30.47	4
3	4.70	30.47	31.67	30.61	4

4	31.67	30.61	37.54	28.83	4
5	37.54	28.83	42.39	29.02	4
6	42.39	29.02	65.68	36.80	3
7	65.68	36.80	172.94	72.65	1
8	172.94	72.65	190.09	72.65	1
9	190.09	72.65	297.45	107.87	1
10	297.45	107.87	315.27	108.65	1
11	315.27	108.65	415.36	142.00	1
12	415.36	142.00	431.14	141.66	1
13	431.14	141.66	541.53	178.46	1
14	541.53	178.46	559.45	178.91	1
15	559.45	178.91	647.60	206.65	1
16	647.60	206.65	669.44	207.27	1
17	669.44	207.27	833.00	246.65	1
18	833.00	246.65	950.98	250.65	1
19	950.98	250.65	1040.41	247.82	1
20	1040.41	247.82	1146.90	212.65	1
21	1146.90	212.65	1163.56	212.65	1
22	1163.56	212.65	1224.09	192.65	1
23	1224.09	192.65	1264.14	192.63	1
24	1264.14	192.63	1337.37	168.65	1
25	1337.37	168.65	1354.60	168.65	1
26	1354.60	168.65	1464.40	132.52	1
27	1464.40	132.52	1483.66	131.37	1
28	1483.66	131.37	1584.52	96.62	1
29	1584.52	96.62	1612.71	86.91	2
30	1612.71	86.91	1650.92	88.65	2
31	1650.92	88.65	1790.88	42.13	2
32	71.63	36.64	173.27	70.65	2
33	173.27	70.65	190.41	70.65	2
34	190.41	70.65	297.81	105.88	2
35	297.81	105.88	315.64	106.66	2
36	315.64	106.66	415.66	139.99	2
37	415.66	139.99	431.45	139.65	2
38	431.45	139.65	541.88	176.47	2
39	541.88	176.47	559.78	176.92	2
40	559.78	176.92	647.93	204.66	2
41	647.93	204.66	669.70	205.27	2
42	669.70	205.27	833.27	244.66	2
43	833.27	244.66	950.98	248.65	2
44	950.98	248.65	1040.05	245.83	2
45	1040.05	245.83	1146.57	210.65	2
46	1146.57	210.65	1163.23	210.65	2
47	1163.23	210.65	1223.77	190.65	2
48	1223.77	190.65	1263.82	190.93	2
49	1263.82	190.93	1337.05	166.65	2
50	1337.05	166.65	1354.28	166.65	2
51	1354.28	166.65	1464.02	130.53	2
52	1464.02	130.53	1483.27	129.39	2

53	1483.27	129.39	1580.42	95.92	2
54	65.68	36.80	71.63	36.64	3
55	71.63	36.64	81.84	33.32	3
56	81.84	33.32	439.97	34.65	3
57	439.97	34.65	711.88	46.64	3
58	711.88	46.64	727.23	50.51	3
59	727.23	50.51	743.99	50.51	3
60	743.99	50.51	763.56	46.67	3
61	763.56	46.67	918.62	65.43	3
62	918.62	65.43	1156.14	70.93	3
63	1156.14	70.93	1286.37	84.65	3
64	1286.37	84.65	1561.21	92.65	3
65	1561.21	92.65	1580.42	95.92	3
66	1580.42	95.92	1584.52	96.62	3
67	59.82	34.96	71.29	34.65	4
68	71.29	34.65	81.52	31.32	4
69	81.52	31.32	440.01	32.65	4
70	440.01	32.65	647.23	41.54	4
71	647.23	41.54	712.17	44.65	2
72	712.17	44.65	727.48	48.51	2
73	727.48	48.51	743.79	48.51	2
74	743.79	48.51	763.48	44.65	2
75	763.48	44.65	918.76	63.43	2
76	918.76	63.43	1156.27	68.94	2
77	1156.27	68.94	1286.51	82.65	2
78	1286.51	82.65	1561.41	90.65	2
79	1561.41	90.65	1588.46	95.26	2
80	647.23	41.54	648.95	40.65	4
81	648.95	40.65	802.15	32.18	4
82	802.15	32.18	1603.66	40.05	4
83	1603.66	40.05	1790.88	42.13	4

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ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

20 Trial Surfaces Have Been Generated.

5 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	71.69	35.60	71.69	35.60	1.00
2	82.10	32.34	82.10	32.34	1.00
3	440.21	33.58	440.21	33.58	1.00
4	712.11	45.64	712.11	45.64	1.00
5	727.01	49.56	727.01	49.56	1.00

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Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.37	38.03
2	71.69	35.77
3	82.10	32.43
4	440.21	33.32
5	712.11	45.23
6	727.01	49.41
7	741.15	63.55

8	754.00	78.88
9	760.50	97.80
10	773.68	112.83
11	787.73	127.07
12	801.80	141.29
13	815.41	155.94
14	825.66	173.11
15	839.68	187.37
16	852.67	202.58
17	864.16	218.95
18	872.10	237.31
19	875.44	248.09

*** 1.655 ***

Individual data on the 48 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	1.4	148.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.9	229.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.1	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	10.2	5407.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.3	191.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	90.8	149916.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.3	842.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	16.8	42870.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.3	817.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	107.0	386223.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.4	1675.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	17.5	81604.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.4	1739.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	99.7	568489.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.3	2007.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	15.5	103337.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.3	2067.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	8.5	57610.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.2	1643.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	101.3	783439.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.3	3013.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	17.6	151047.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

23	0.3	2835.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	87.8	817778.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.3	3308.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	21.5	215339.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.3	2601.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	42.2	432645.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.2	2416.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	14.9	156222.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.2	2299.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.9	9136.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	13.0	131341.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	12.9	120866.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	6.5	55306.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	13.2	100773.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	14.0	97762.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	14.1	88740.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	13.6	76796.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	10.3	49830.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	7.3	31187.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.3	1098.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	6.4	24809.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	13.0	42043.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	11.5	26593.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	7.9	10267.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	2.7	1329.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.6	72.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.65	37.12
2	71.69	35.37
3	82.10	32.61
4	440.21	34.07
5	712.11	45.90
6	727.01	49.75
7	741.01	64.03
8	754.78	78.54
9	768.74	92.86
10	782.63	107.25
11	792.70	124.53
12	801.82	142.33
13	815.94	156.49
14	828.73	171.87
15	831.92	191.61
16	838.65	210.45

17	852.33	225.04
18	866.40	239.25
19	868.66	247.86

*** 1.666 ***

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Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.97	37.23
2	71.69	36.02
3	82.10	32.38
4	440.21	33.92
5	712.11	45.91
6	727.01	49.12
7	740.81	63.60
8	747.00	82.62
9	759.88	97.92
10	768.48	115.97
11	779.62	132.58
12	793.71	146.78
13	806.01	162.55
14	818.70	178.01
15	829.91	194.57
16	839.53	212.10
17	853.67	226.25
18	862.31	244.28
19	862.77	247.66

*** 1.676 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	66.20	36.97
2	71.69	35.97
3	82.10	32.69
4	440.21	33.36
5	712.11	45.16
6	727.01	49.73
7	737.25	66.91
8	749.53	82.69
9	755.26	101.85
10	768.91	116.47
11	782.56	131.10
12	795.78	146.10
13	808.02	161.92
14	820.84	177.26
15	828.31	195.82
16	832.88	215.29
17	846.34	230.08
18	860.48	244.23
19	861.31	247.61

*** 1.687 ***

1

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.20	37.98
2	71.69	35.48
3	82.10	32.77
4	440.21	33.23
5	712.11	45.80
6	727.01	49.85
7	736.17	67.63
8	749.67	82.38
9	763.80	96.54
10	773.28	114.14
11	783.24	131.49
12	787.95	150.93
13	797.10	168.71
14	809.50	184.40
15	822.83	199.31
16	834.22	215.76

17	847.03	231.11
18	861.10	245.33
19	862.81	247.66

*** 1.688 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.28	38.00
2	71.69	35.66
3	82.10	31.89
4	440.21	33.57
5	712.11	45.24
6	727.01	49.90
7	738.80	66.06
8	752.91	80.23
9	765.45	95.81
10	775.67	113.00
11	780.30	132.46
12	791.28	149.18
13	796.42	168.51
14	807.73	185.00
15	821.86	199.15
16	826.71	218.55
17	828.59	238.47
18	832.65	246.57

*** 1.729 ***

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Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.61	37.11

2	71.69	35.68
3	82.10	32.54
4	440.21	33.76
5	712.11	46.12
6	727.01	49.88
7	740.80	64.37
8	749.45	82.40
9	755.90	101.33
10	759.52	121.00
11	773.64	135.17
12	783.88	152.35
13	797.31	167.17
14	807.65	184.29
15	820.46	199.65
16	832.17	215.86
17	846.30	230.02
18	856.02	247.43

*** 1.735 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	68.62	37.78
2	71.69	35.40
3	82.10	32.62
4	440.21	33.39
5	712.11	46.00
6	727.01	49.19
7	736.61	66.74
8	747.42	83.56
9	758.63	100.13
10	770.31	116.36
11	776.62	135.34
12	782.50	154.45
13	796.39	168.85
14	800.28	188.47
15	814.29	202.74
16	820.20	221.84
17	824.32	241.41
18	827.38	245.30

*** 1.743 ***

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Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.64	37.12
2	71.69	35.86
3	82.10	32.62
4	440.21	33.13
5	712.11	45.79
6	727.01	49.50
7	741.15	63.65
8	747.69	82.55
9	755.47	100.97
10	769.40	115.32
11	778.97	132.89
12	792.73	147.40
13	802.89	164.63
14	806.77	184.25
15	820.54	198.75
16	823.36	218.55
17	829.12	237.70
18	832.03	246.42

*** 1.745 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	68.17	37.63
2	71.69	35.30
3	82.10	32.68
4	440.21	33.94
5	712.11	46.14

6	727.01	49.76
7	740.69	64.35
8	744.81	83.92
9	756.39	100.23
10	767.65	116.75
11	781.32	131.35
12	788.29	150.10
13	791.40	169.86
14	799.07	188.33
15	805.72	207.19
16	819.26	221.91
17	826.00	240.74
18	826.61	245.11

*** 1.786 ***

1

	Y		A	X	I	S		F	T
	0.00		223.86	447.72	671.58	895.44		1119.30	

X	0.00	+	*	-----	+	-----	+	-----	+	-----	+	-----	+
		-	*										
		-	**										
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A	447.72	+	**	*									
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X	671.58	+		*									
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I	895.44	+		
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S	1119.30	+		
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	1343.16	+		**
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F	1567.02	+	*	
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T	1790.88	+	*	

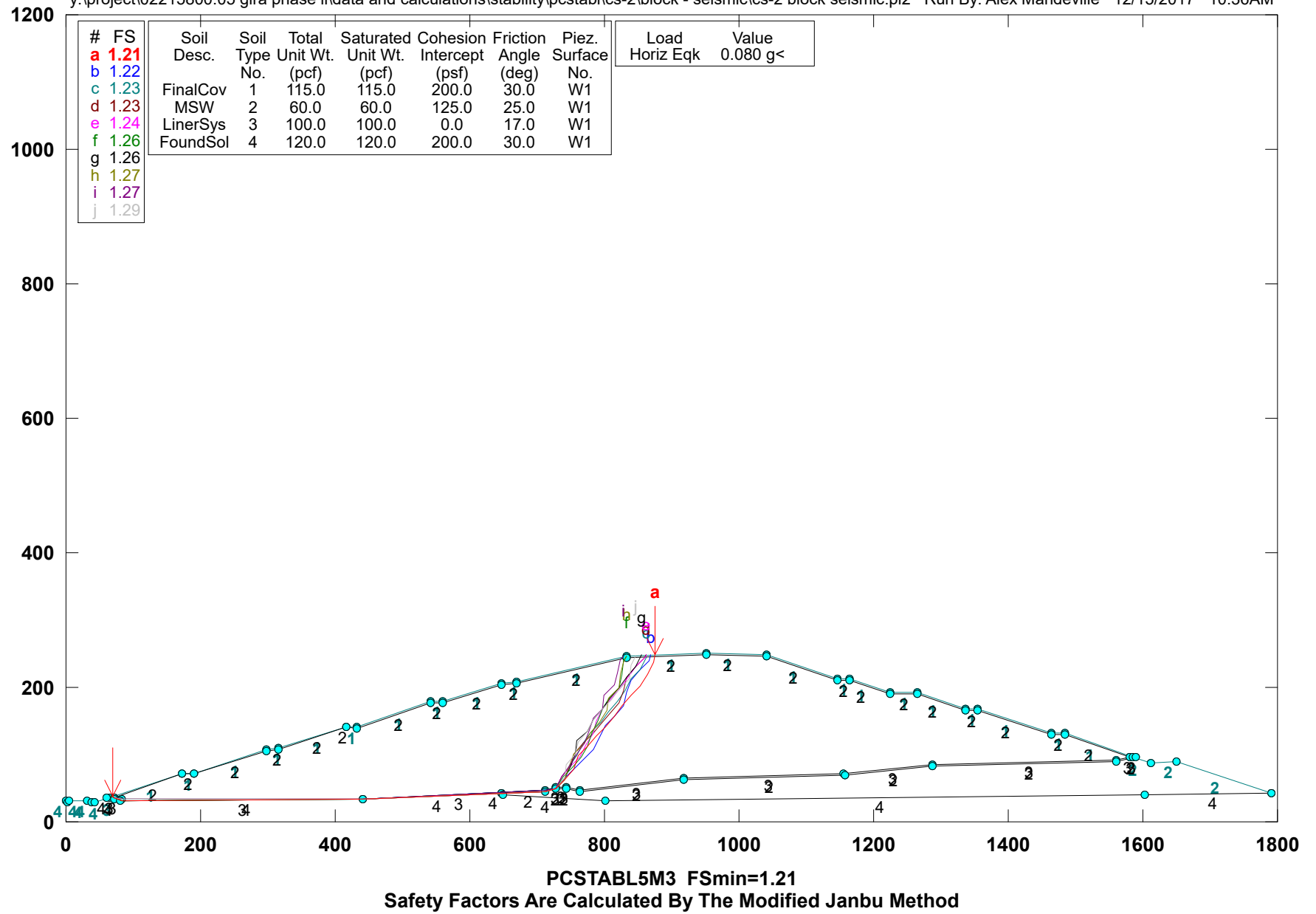
Section CS-2

Final Slope Stability Analysis

Block-Type Failure Surface within Liner System, Seismic =
0.08g

GLRA - CS-2 Block Failure - Seismic

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-2\block - seismic\cs-2 block seismic.pl2 Run By: Alex Mandeville 12/15/2017 10:36AM



** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

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--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date: 12/15/2017
Time of Run: 10:36AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-2 block seismic.

Output Filename: Y:cs-2 block seismic.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-2 block seismic.PLT

PROBLEM DESCRIPTION GLRA - CS-2
Block Failure - Seismic

BOUNDARY COORDINATES

31 Top Boundaries
83 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.90	30.39	3.31	30.01	4
2	3.31	30.01	4.70	30.47	4
3	4.70	30.47	31.67	30.61	4

4	31.67	30.61	37.54	28.83	4
5	37.54	28.83	42.39	29.02	4
6	42.39	29.02	65.68	36.80	3
7	65.68	36.80	172.94	72.65	1
8	172.94	72.65	190.09	72.65	1
9	190.09	72.65	297.45	107.87	1
10	297.45	107.87	315.27	108.65	1
11	315.27	108.65	415.36	142.00	1
12	415.36	142.00	431.14	141.66	1
13	431.14	141.66	541.53	178.46	1
14	541.53	178.46	559.45	178.91	1
15	559.45	178.91	647.60	206.65	1
16	647.60	206.65	669.44	207.27	1
17	669.44	207.27	833.00	246.65	1
18	833.00	246.65	950.98	250.65	1
19	950.98	250.65	1040.41	247.82	1
20	1040.41	247.82	1146.90	212.65	1
21	1146.90	212.65	1163.56	212.65	1
22	1163.56	212.65	1224.09	192.65	1
23	1224.09	192.65	1264.14	192.63	1
24	1264.14	192.63	1337.37	168.65	1
25	1337.37	168.65	1354.60	168.65	1
26	1354.60	168.65	1464.40	132.52	1
27	1464.40	132.52	1483.66	131.37	1
28	1483.66	131.37	1584.52	96.62	1
29	1584.52	96.62	1612.71	86.91	2
30	1612.71	86.91	1650.92	88.65	2
31	1650.92	88.65	1790.88	42.13	2
32	71.63	36.64	173.27	70.65	2
33	173.27	70.65	190.41	70.65	2
34	190.41	70.65	297.81	105.88	2
35	297.81	105.88	315.64	106.66	2
36	315.64	106.66	415.66	139.99	2
37	415.66	139.99	431.45	139.65	2
38	431.45	139.65	541.88	176.47	2
39	541.88	176.47	559.78	176.92	2
40	559.78	176.92	647.93	204.66	2
41	647.93	204.66	669.70	205.27	2
42	669.70	205.27	833.27	244.66	2
43	833.27	244.66	950.98	248.65	2
44	950.98	248.65	1040.05	245.83	2
45	1040.05	245.83	1146.57	210.65	2
46	1146.57	210.65	1163.23	210.65	2
47	1163.23	210.65	1223.77	190.65	2
48	1223.77	190.65	1263.82	190.93	2
49	1263.82	190.93	1337.05	166.65	2
50	1337.05	166.65	1354.28	166.65	2
51	1354.28	166.65	1464.02	130.53	2
52	1464.02	130.53	1483.27	129.39	2

53	1483.27	129.39	1580.42	95.92	2
54	65.68	36.80	71.63	36.64	3
55	71.63	36.64	81.84	33.32	3
56	81.84	33.32	439.97	34.65	3
57	439.97	34.65	711.88	46.64	3
58	711.88	46.64	727.23	50.51	3
59	727.23	50.51	743.99	50.51	3
60	743.99	50.51	763.56	46.67	3
61	763.56	46.67	918.62	65.43	3
62	918.62	65.43	1156.14	70.93	3
63	1156.14	70.93	1286.37	84.65	3
64	1286.37	84.65	1561.21	92.65	3
65	1561.21	92.65	1580.42	95.92	3
66	1580.42	95.92	1584.52	96.62	3
67	59.82	34.96	71.29	34.65	4
68	71.29	34.65	81.52	31.32	4
69	81.52	31.32	440.01	32.65	4
70	440.01	32.65	647.23	41.54	4
71	647.23	41.54	712.17	44.65	2
72	712.17	44.65	727.48	48.51	2
73	727.48	48.51	743.79	48.51	2
74	743.79	48.51	763.48	44.65	2
75	763.48	44.65	918.76	63.43	2
76	918.76	63.43	1156.27	68.94	2
77	1156.27	68.94	1286.51	82.65	2
78	1286.51	82.65	1561.41	90.65	2
79	1561.41	90.65	1588.46	95.26	2
80	647.23	41.54	648.95	40.65	4
81	648.95	40.65	802.15	32.18	4
82	802.15	32.18	1603.66	40.05	4
83	1603.66	40.05	1790.88	42.13	4

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ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

A Horizontal Earthquake Loading Coefficient
Of 0.080 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of 0.000 Has Been Assigned

Cavitation Pressure = 0.0 (psf)

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A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Sliding Block Surfaces, Has Been
Specified.

20 Trial Surfaces Have Been Generated.

5 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of
Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	71.69	35.60	71.69	35.60	1.00
2	82.10	32.34	82.10	32.34	1.00
3	440.21	33.58	440.21	33.58	1.00
4	712.11	45.64	712.11	45.64	1.00
5	727.01	49.56	727.01	49.56	1.00

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Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.37	38.03
2	71.69	35.77
3	82.10	32.43
4	440.21	33.32
5	712.11	45.23
6	727.01	49.41
7	741.15	63.55
8	754.00	78.88
9	760.50	97.80
10	773.68	112.83
11	787.73	127.07
12	801.80	141.29
13	815.41	155.94
14	825.66	173.11
15	839.68	187.37
16	852.67	202.58
17	864.16	218.95
18	872.10	237.31
19	875.44	248.09

*** 1.212 ***

Individual data on the 48 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Surcharge Ver (lbs)	Load (lbs)
1	1.4	148.8	0.0	0.0	0.0	0.0	11.9	0.0	0.0
2	0.9	229.6	0.0	0.0	0.0	0.0	18.4	0.0	0.0
3	0.1	19.9	0.0	0.0	0.0	0.0	1.6	0.0	0.0
4	10.2	5407.2	0.0	0.0	0.0	0.0	432.6	0.0	0.0
5	0.3	191.9	0.0	0.0	0.0	0.0	15.4	0.0	0.0
6	90.8	149916.5	0.0	0.0	0.0	0.0	11993.3	0.0	0.0
7	0.3	842.4	0.0	0.0	0.0	0.0	67.4	0.0	0.0
8	16.8	42870.6	0.0	0.0	0.0	0.0	3429.7	0.0	0.0
9	0.3	817.3	0.0	0.0	0.0	0.0	65.4	0.0	0.0
10	107.0	386223.0	0.0	0.0	0.0	0.0	30897.8	0.0	0.0
11	0.4	1675.5	0.0	0.0	0.0	0.0	134.0	0.0	0.0
12	17.5	81604.3	0.0	0.0	0.0	0.0	6528.3	0.0	0.0

13	0.4	1739.9	0.0	0.0	0.0	0.0	139.2	0.0	0.0
14	99.7	568489.2	0.0	0.0	0.0	0.0	45479.1	0.0	0.0
15	0.3	2007.0	0.0	0.0	0.0	0.0	160.6	0.0	0.0
16	15.5	103337.7	0.0	0.0	0.0	0.0	8267.0	0.0	0.0
17	0.3	2067.8	0.0	0.0	0.0	0.0	165.4	0.0	0.0
18	8.5	57610.4	0.0	0.0	0.0	0.0	4608.8	0.0	0.0
19	0.2	1643.9	0.0	0.0	0.0	0.0	131.5	0.0	0.0
20	101.3	783439.4	0.0	0.0	0.0	0.0	62675.1	0.0	0.0
21	0.3	3013.2	0.0	0.0	0.0	0.0	241.1	0.0	0.0
22	17.6	151047.2	0.0	0.0	0.0	0.0	12083.8	0.0	0.0
23	0.3	2835.6	0.0	0.0	0.0	0.0	226.9	0.0	0.0
24	87.8	817778.2	0.0	0.0	0.0	0.0	65422.3	0.0	0.0
25	0.3	3308.5	0.0	0.0	0.0	0.0	264.7	0.0	0.0
26	21.5	215339.1	0.0	0.0	0.0	0.0	17227.1	0.0	0.0
27	0.3	2601.3	0.0	0.0	0.0	0.0	208.1	0.0	0.0
28	42.2	432645.2	0.0	0.0	0.0	0.0	34611.6	0.0	0.0
29	0.2	2416.8	0.0	0.0	0.0	0.0	193.3	0.0	0.0
30	14.9	156222.1	0.0	0.0	0.0	0.0	12497.8	0.0	0.0
31	0.2	2299.3	0.0	0.0	0.0	0.0	183.9	0.0	0.0
32	0.9	9136.5	0.0	0.0	0.0	0.0	730.9	0.0	0.0
33	13.0	131341.5	0.0	0.0	0.0	0.0	10507.3	0.0	0.0
34	12.9	120866.8	0.0	0.0	0.0	0.0	9669.3	0.0	0.0
35	6.5	55306.3	0.0	0.0	0.0	0.0	4424.5	0.0	0.0
36	13.2	100773.2	0.0	0.0	0.0	0.0	8061.9	0.0	0.0
37	14.0	97762.8	0.0	0.0	0.0	0.0	7821.0	0.0	0.0
38	14.1	88740.9	0.0	0.0	0.0	0.0	7099.3	0.0	0.0
39	13.6	76796.4	0.0	0.0	0.0	0.0	6143.7	0.0	0.0
40	10.3	49830.0	0.0	0.0	0.0	0.0	3986.4	0.0	0.0
41	7.3	31187.4	0.0	0.0	0.0	0.0	2495.0	0.0	0.0
42	0.3	1098.4	0.0	0.0	0.0	0.0	87.9	0.0	0.0
43	6.4	24809.2	0.0	0.0	0.0	0.0	1984.7	0.0	0.0
44	13.0	42043.2	0.0	0.0	0.0	0.0	3363.5	0.0	0.0
45	11.5	26593.7	0.0	0.0	0.0	0.0	2127.5	0.0	0.0
46	7.9	10267.3	0.0	0.0	0.0	0.0	821.4	0.0	0.0
47	2.7	1329.6	0.0	0.0	0.0	0.0	106.4	0.0	0.0
48	0.6	72.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.65	37.12
2	71.69	35.37
3	82.10	32.61
4	440.21	34.07
5	712.11	45.90
6	727.01	49.75

7	741.01	64.03
8	754.78	78.54
9	768.74	92.86
10	782.63	107.25
11	792.70	124.53
12	801.82	142.33
13	815.94	156.49
14	828.73	171.87
15	831.92	191.61
16	838.65	210.45
17	852.33	225.04
18	866.40	239.25
19	868.66	247.86

*** 1.219 ***

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Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.97	37.23
2	71.69	36.02
3	82.10	32.38
4	440.21	33.92
5	712.11	45.91
6	727.01	49.12
7	740.81	63.60
8	747.00	82.62
9	759.88	97.92
10	768.48	115.97
11	779.62	132.58
12	793.71	146.78
13	806.01	162.55
14	818.70	178.01
15	829.91	194.57
16	839.53	212.10
17	853.67	226.25
18	862.31	244.28
19	862.77	247.66

*** 1.227 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.20	36.97
2	71.69	35.97
3	82.10	32.69
4	440.21	33.36
5	712.11	45.16
6	727.01	49.73
7	737.25	66.91
8	749.53	82.69
9	755.26	101.85
10	768.91	116.47
11	782.56	131.10
12	795.78	146.10
13	808.02	161.92
14	820.84	177.26
15	828.31	195.82
16	832.88	215.29
17	846.34	230.08
18	860.48	244.23
19	861.31	247.61

*** 1.234 ***

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Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.20	37.98
2	71.69	35.48
3	82.10	32.77
4	440.21	33.23
5	712.11	45.80
6	727.01	49.85

7	736.17	67.63
8	749.67	82.38
9	763.80	96.54
10	773.28	114.14
11	783.24	131.49
12	787.95	150.93
13	797.10	168.71
14	809.50	184.40
15	822.83	199.31
16	834.22	215.76
17	847.03	231.11
18	861.10	245.33
19	862.81	247.66

*** 1.235 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.28	38.00
2	71.69	35.66
3	82.10	31.89
4	440.21	33.57
5	712.11	45.24
6	727.01	49.90
7	738.80	66.06
8	752.91	80.23
9	765.45	95.81
10	775.67	113.00
11	780.30	132.46
12	791.28	149.18
13	796.42	168.51
14	807.73	185.00
15	821.86	199.15
16	826.71	218.55
17	828.59	238.47
18	832.65	246.57

*** 1.257 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.61	37.11
2	71.69	35.68
3	82.10	32.54
4	440.21	33.76
5	712.11	46.12
6	727.01	49.88
7	740.80	64.37
8	749.45	82.40
9	755.90	101.33
10	759.52	121.00
11	773.64	135.17
12	783.88	152.35
13	797.31	167.17
14	807.65	184.29
15	820.46	199.65
16	832.17	215.86
17	846.30	230.02
18	856.02	247.43

*** 1.261 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.64	37.12
2	71.69	35.86
3	82.10	32.62
4	440.21	33.13
5	712.11	45.79
6	727.01	49.50
7	741.15	63.65
8	747.69	82.55
9	755.47	100.97

10	769.40	115.32
11	778.97	132.89
12	792.73	147.40
13	802.89	164.63
14	806.77	184.25
15	820.54	198.75
16	823.36	218.55
17	829.12	237.70
18	832.03	246.42

*** 1.267 ***

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Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	68.62	37.78
2	71.69	35.40
3	82.10	32.62
4	440.21	33.39
5	712.11	46.00
6	727.01	49.19
7	736.61	66.74
8	747.42	83.56
9	758.63	100.13
10	770.31	116.36
11	776.62	135.34
12	782.50	154.45
13	796.39	168.85
14	800.28	188.47
15	814.29	202.74
16	820.20	221.84
17	824.32	241.41
18	827.38	245.30

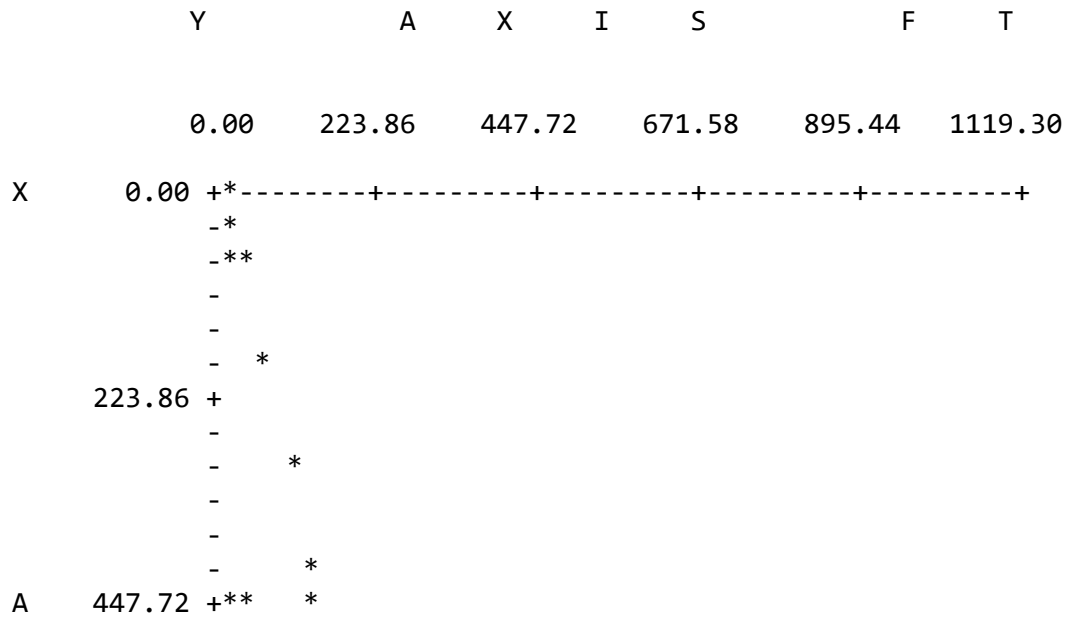
*** 1.268 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	68.92	37.88
2	71.69	35.61
3	82.10	32.52
4	440.21	33.70
5	712.11	45.82
6	727.01	50.02
7	740.11	65.14
8	742.69	84.97
9	755.87	100.02
10	760.77	119.41
11	774.04	134.38
12	784.23	151.59
13	796.92	167.04
14	809.68	182.44
15	822.29	197.96
16	836.22	212.32
17	839.24	232.09
18	846.34	247.10

*** 1.289 ***

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I	895.44	+		
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S	1119.30	+		
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F	1567.02	+	*	
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T	1790.88	+	*	

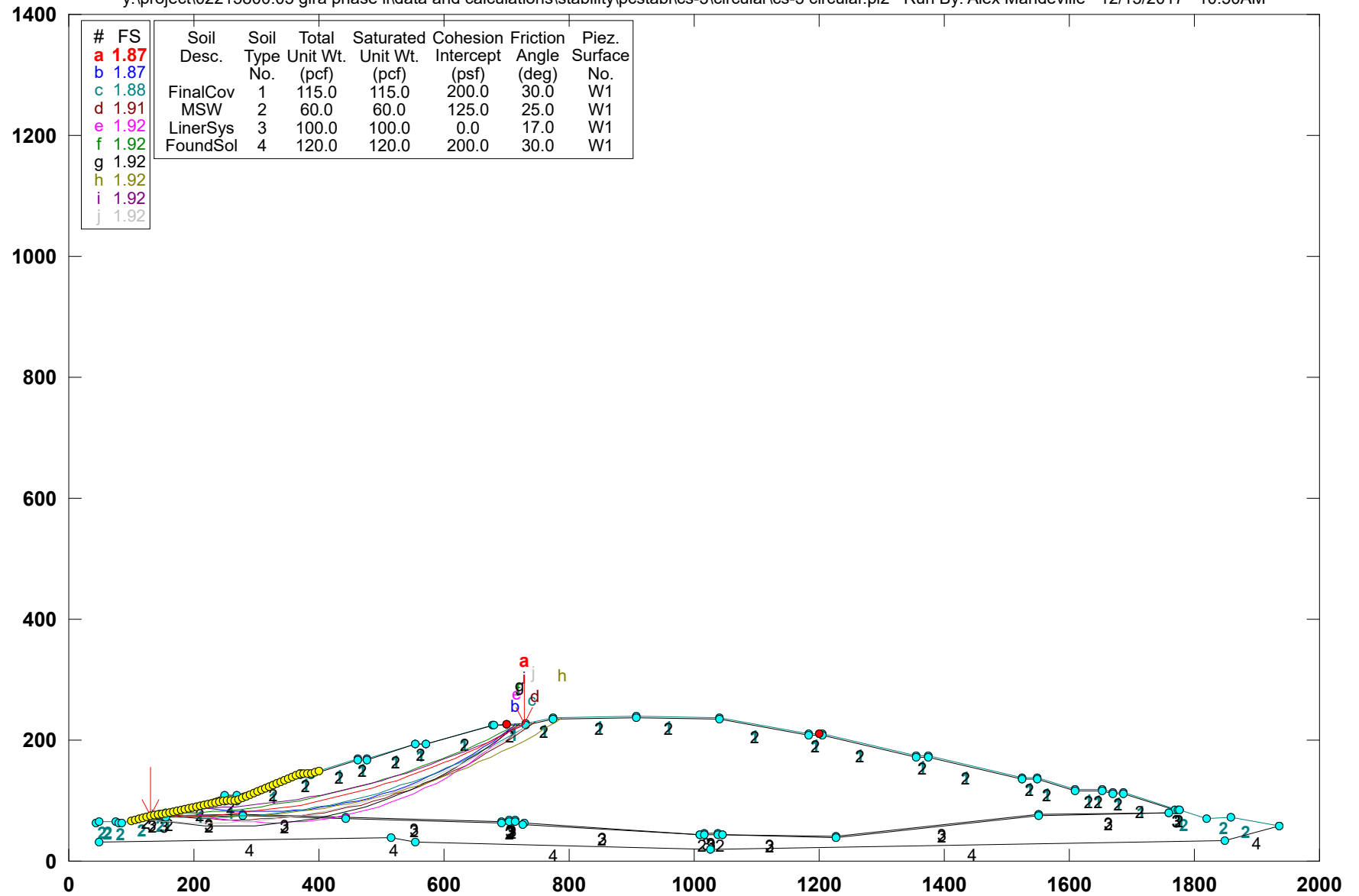
Section CS-3

Final Slope Stability Analysis

Circular Failure Surface, Static

GLRA - CS-3 Circular Failure

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstab\cs-3\circular\cs-3 circular.pl2 Run By: Alex Mandeville 12/15/2017 10:50AM



PCSTABL5M3 FSmin=1.87

Safety Factors Are Calculated By The Modified Bishop Method

** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

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--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:50AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-3 circular.

Output Filename: Y:cs-3 circular.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-3 circular.PLT

PROBLEM DESCRIPTION GLRA - CS-3
Circular Failure

BOUNDARY COORDINATES

35 Top Boundaries
98 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	44.16	63.02	48.99	64.66	2
2	48.99	64.66	73.85	64.43	2
3	73.85	64.43	80.89	62.66	2

4	80.89	62.66	85.82	62.66	2
5	85.82	62.66	133.57	75.64	2
6	133.57	75.64	145.01	77.36	2
7	145.01	77.36	153.88	78.68	1
8	153.88	78.68	249.67	100.21	1
9	249.67	100.21	267.70	100.21	1
10	267.70	100.21	369.89	144.57	1
11	369.89	144.57	387.37	144.91	1
12	387.37	144.91	461.22	169.10	1
13	461.22	169.10	476.72	168.66	1
14	476.72	168.66	554.79	194.58	1
15	554.79	194.58	570.80	194.42	1
16	570.80	194.42	678.66	226.05	1
17	678.66	226.05	730.66	226.80	1
18	730.66	226.80	773.28	236.66	1
19	773.28	236.66	907.53	238.66	1
20	907.53	238.66	1040.17	236.66	1
21	1040.17	236.66	1182.84	210.66	1
22	1182.84	210.66	1204.94	210.65	1
23	1204.94	210.65	1354.07	174.66	1
24	1354.07	174.66	1374.21	174.77	1
25	1374.21	174.77	1525.14	138.65	1
26	1525.14	138.65	1549.21	137.36	1
27	1549.21	137.36	1609.02	118.63	1
28	1609.02	118.63	1651.98	118.66	1
29	1651.98	118.66	1669.11	112.66	1
30	1669.11	112.66	1685.91	112.77	1
31	1685.91	112.77	1773.14	85.10	1
32	1773.14	85.10	1776.43	84.06	3
33	1776.43	84.06	1818.65	70.66	2
34	1818.65	70.66	1859.12	72.39	2
35	1859.12	72.39	1935.71	58.66	2
36	149.37	75.99	154.34	76.73	2
37	154.34	76.73	249.99	108.21	2
38	249.99	108.21	268.03	108.21	2
39	268.03	108.21	370.23	142.58	2
40	370.23	142.58	387.71	142.92	2
41	387.71	142.92	461.51	167.09	2
42	461.51	167.09	477.01	166.66	2
43	477.01	166.66	555.10	192.57	2
44	555.10	192.57	571.08	192.42	2
45	571.08	192.42	678.96	224.05	2
46	678.96	224.05	730.90	224.80	2
47	730.90	224.80	773.52	234.67	2
48	773.52	234.67	907.53	236.66	2
49	907.53	236.66	1039.97	234.67	2
50	1039.97	234.67	1182.66	208.66	2
51	1182.66	208.66	1204.71	208.65	2
52	1204.71	208.65	1353.84	172.66	2

53	1353.84	172.66	1373.98	172.77	2
54	1373.98	172.77	1524.85	136.66	2
55	1524.85	136.66	1548.85	135.37	2
56	1548.85	135.37	1608.71	116.63	2
57	1608.71	116.63	1651.64	116.66	2
58	1651.64	116.66	1668.78	110.66	2
59	1668.78	110.66	1685.60	110.77	2
60	1685.60	110.77	1769.85	84.04	2
61	145.01	77.36	149.37	75.99	3
62	149.37	75.99	154.90	74.25	3
63	154.90	74.25	277.99	76.61	3
64	277.99	76.61	441.71	72.94	3
65	441.71	72.94	691.81	64.67	3
66	691.81	64.67	703.78	68.21	3
67	703.78	68.21	714.75	67.69	3
68	714.75	67.69	727.18	63.35	3
69	727.18	63.35	1009.30	44.63	3
70	1009.30	44.63	1016.80	46.66	3
71	1016.80	46.66	1038.87	46.66	3
72	1038.87	46.66	1045.40	44.66	3
73	1045.40	44.66	1227.50	40.67	3
74	1227.50	40.67	1550.81	76.66	3
75	1550.81	76.66	1759.32	80.66	3
76	1759.32	80.66	1769.85	84.04	3
77	1769.85	84.04	1773.14	85.10	3
78	133.57	85.64	142.88	75.93	2
79	142.88	75.93	154.61	72.25	2
80	154.61	72.25	277.99	74.61	2
81	277.99	74.61	441.66	70.95	2
82	441.66	70.95	692.07	62.66	2
83	692.07	62.66	704.03	66.19	2
84	704.03	66.19	714.37	65.71	2
85	714.37	65.71	726.78	61.37	2
86	726.78	61.37	1009.50	42.61	2
87	1009.50	42.61	1017.07	44.66	2
88	1017.07	44.66	1038.57	44.66	2
89	1038.57	44.66	1045.08	42.66	2
90	1045.08	42.66	1227.59	38.66	2
91	1227.59	38.66	1550.94	74.66	2
92	1550.94	74.66	1759.65	78.66	2
93	1759.65	78.66	1776.43	84.06	2
94	48.01	32.66	515.68	38.66	4
95	515.68	38.66	554.87	30.66	4
96	554.87	30.66	1026.78	19.64	4
97	1026.78	19.64	1848.99	34.66	4
98	1848.99	34.66	1935.71	58.66	4

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

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A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

1000 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 50 Points Equally Spaced
Along The Ground Surface Between X = 100.00 ft.
and X = 400.00 ft.

Each Surface Terminates Between X = 700.00 ft.
and X = 1200.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

20.00 ft. Line Segments Define Each Trial Failure Surface.

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Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	130.61	74.84
2	150.61	74.37
3	170.61	74.27
4	190.61	74.52
5	210.60	75.14
6	230.57	76.12
7	250.53	77.46
8	270.45	79.15
9	290.35	81.21
10	310.20	83.63
11	330.01	86.40
12	349.76	89.54
13	369.46	93.02
14	389.08	96.87
15	408.64	101.06
16	428.11	105.61
17	447.50	110.51
18	466.80	115.76
19	486.00	121.36
20	505.10	127.30
21	524.09	133.59
22	542.96	140.21
23	561.70	147.18
24	580.32	154.49
25	598.81	162.13
26	617.15	170.10
27	635.34	178.40
28	653.39	187.03
29	671.27	195.98
30	688.99	205.26
31	706.54	214.85
32	723.91	224.76
33	727.26	226.75

Circle Center At X = 166.4 ; Y = 1182.1 and Radius, 1107.8

*** 1.868 ***

Individual data on the 61 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	3.0	77.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	9.3	939.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.1	341.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.6	792.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.7	644.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.2	483.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	3.3	1258.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.5	175.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.2	93.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	4.3	1720.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	11.7	5483.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	20.0	11874.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	20.0	14399.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	6.0	4719.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	14.0	11590.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	19.1	17168.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.3	297.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.5	497.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	17.2	15135.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.3	278.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	2.4	2143.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	19.9	23213.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	19.9	32900.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	19.8	42079.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	19.8	50744.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	19.7	58885.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.4	1390.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.3	1087.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	17.1	53189.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.3	1025.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	1.4	4154.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	19.6	60583.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	19.5	62699.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	19.4	64335.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	13.7	46420.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.3	986.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	5.3	17723.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	9.9	31788.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.3	902.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	9.0	28128.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

41	19.1	60165.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	19.0	60058.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	18.9	59498.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	11.8	37017.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.3	963.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	6.6	19981.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	9.1	25832.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.3	764.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	9.2	25005.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	18.5	48270.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	18.3	45255.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	18.2	41859.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	18.0	38096.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	17.9	33981.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	7.4	12842.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	0.3	504.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	10.0	15244.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	17.5	19067.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	17.3	8950.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.1	24.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	3.4	374.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	204.08	89.96
2	223.86	87.02
3	243.73	84.70
4	263.66	82.99
5	283.63	81.91
6	303.62	81.45
7	323.62	81.62
8	343.61	82.40
9	363.56	83.81
10	383.45	85.84
11	403.28	88.49
12	423.01	91.76
13	442.63	95.64
14	462.12	100.13
15	481.46	105.22
16	500.63	110.92
17	519.61	117.21
18	538.40	124.09
19	556.95	131.55
20	575.27	139.58
21	593.32	148.18

22	611.10	157.34
23	628.59	167.05
24	645.76	177.30
25	662.61	188.08
26	679.11	199.38
27	695.25	211.19
28	711.01	223.50
29	714.71	226.57

Circle Center At X = 308.4 ; Y = 723.1 and Radius, 641.7

*** 1.874 ***

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Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	136.74	76.12
2	156.67	74.52
3	176.64	73.35
4	196.62	72.61
5	216.62	72.30
6	236.62	72.41
7	256.61	72.95
8	276.59	73.91
9	296.54	75.30
10	316.46	77.12
11	336.33	79.36
12	356.16	82.02
13	375.92	85.10
14	395.61	88.61
15	415.22	92.54
16	434.74	96.88
17	454.17	101.64
18	473.49	106.81
19	492.69	112.39
20	511.77	118.39
21	530.72	124.78
22	549.53	131.58
23	568.19	138.78
24	586.69	146.38
25	605.02	154.37

26	623.19	162.75
27	641.16	171.51
28	658.95	180.66
29	676.54	190.18
30	693.92	200.07
31	711.08	210.34
32	728.02	220.97
33	740.28	229.03

Circle Center At X = 221.4 ; Y = 1009.7 and Radius, 937.5

*** 1.882 ***

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.98	77.95
2	168.77	75.04
3	188.62	72.64
4	208.53	70.75
5	228.49	69.38
6	248.47	68.53
7	268.47	68.19
8	288.46	68.37
9	308.45	69.06
10	328.42	70.28
11	348.34	72.01
12	368.21	74.25
13	388.02	77.01
14	407.75	80.27
15	427.39	84.05
16	446.93	88.33
17	466.35	93.12
18	485.64	98.41
19	504.78	104.19
20	523.77	110.47
21	542.59	117.23
22	561.23	124.48
23	579.68	132.21
24	597.92	140.41
25	615.94	149.09
26	633.73	158.22

27	651.28	167.82
28	668.58	177.86
29	685.61	188.34
30	702.36	199.27
31	718.83	210.62
32	734.99	222.40
33	745.06	230.13

Circle Center At X = 271.5 ; Y = 841.7 and Radius, 773.6

*** 1.908 ***

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Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	179.59	84.46
2	198.92	79.33
3	218.43	74.92
4	238.09	71.23
5	257.87	68.26
6	277.74	66.03
7	297.68	64.53
8	317.67	63.76
9	337.67	63.73
10	357.66	64.44
11	377.61	65.88
12	397.49	68.06
13	417.27	70.97
14	436.94	74.60
15	456.46	78.96
16	475.81	84.03
17	494.95	89.81
18	513.87	96.29
19	532.54	103.47
20	550.93	111.33
21	569.02	119.86
22	586.79	129.05
23	604.20	138.88
24	621.24	149.36
25	637.88	160.45
26	654.10	172.15

27	669.88	184.43
28	685.20	197.29
29	700.03	210.71
30	714.36	224.66
31	716.20	226.59

Circle Center At X = 328.5 ; Y = 606.6 and Radius, 543.0

*** 1.917 ***

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.98	77.95
2	168.98	78.35
3	188.96	79.08
4	208.94	80.13
5	228.89	81.51
6	248.82	83.21
7	268.71	85.24
8	288.57	87.59
9	308.39	90.27
10	328.17	93.27
11	347.89	96.59
12	367.55	100.23
13	387.16	104.20
14	406.69	108.48
15	426.16	113.09
16	445.54	118.01
17	464.84	123.24
18	484.06	128.79
19	503.18	134.65
20	522.20	140.83
21	541.12	147.31
22	559.93	154.10
23	578.63	161.20
24	597.21	168.60
25	615.67	176.31
26	634.00	184.31
27	652.19	192.62
28	670.25	201.22
29	688.16	210.11

30	705.93	219.29
31	719.59	226.64

Circle Center At X = 134.5 ; Y = 1302.9 and Radius, 1225.1

*** 1.918 ***

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Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	118.37	71.51
2	138.03	67.84
3	157.78	64.72
4	177.62	62.16
5	197.52	60.16
6	217.47	58.72
7	237.45	57.84
8	257.45	57.51
9	277.44	57.75
10	297.43	58.55
11	317.38	59.91
12	337.29	61.83
13	357.14	64.30
14	376.90	67.34
15	396.58	70.92
16	416.15	75.06
17	435.59	79.74
18	454.90	84.97
19	474.05	90.73
20	493.03	97.04
21	511.83	103.87
22	530.42	111.22
23	548.81	119.10
24	566.97	127.48
25	584.88	136.38
26	602.54	145.77
27	619.92	155.65
28	637.03	166.02
29	653.83	176.86
30	670.33	188.17
31	686.50	199.94

32	702.33	212.16
33	717.82	224.81
34	719.94	226.65

Circle Center At X = 258.9 ; Y = 770.3 and Radius, 712.8

*** 1.920 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.98	77.95
2	168.91	76.32
3	188.88	75.09
4	208.86	74.26
5	228.85	73.83
6	248.85	73.79
7	268.85	74.15
8	288.84	74.91
9	308.80	76.06
10	328.74	77.61
11	348.65	79.56
12	368.51	81.90
13	388.32	84.64
14	408.08	87.77
15	427.76	91.29
16	447.38	95.21
17	466.91	99.51
18	486.35	104.20
19	505.70	109.27
20	524.94	114.73
21	544.06	120.57
22	563.07	126.79
23	581.95	133.39
24	600.70	140.36
25	619.30	147.70
26	637.76	155.41
27	656.06	163.48
28	674.19	171.92
29	692.15	180.72
30	709.93	189.87
31	727.53	199.37

32	744.94	209.22
33	762.14	219.42
34	779.14	229.95
35	789.88	236.91

Circle Center At X = 240.7 ; Y = 1079.8 and Radius, 1006.0

*** 1.921 ***

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Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	185.71	85.84
2	205.71	86.34
3	225.69	87.18
4	245.66	88.36
5	265.60	89.87
6	285.51	91.71
7	305.40	93.88
8	325.24	96.39
9	345.04	99.23
10	364.78	102.40
11	384.47	105.89
12	404.11	109.72
13	423.67	113.88
14	443.16	118.36
15	462.57	123.16
16	481.91	128.29
17	501.15	133.74
18	520.30	139.52
19	539.35	145.61
20	558.29	152.02
21	577.13	158.75
22	595.85	165.79
23	614.45	173.14
24	632.92	180.80
25	651.26	188.77
26	669.47	197.04
27	687.54	205.62
28	705.46	214.50
29	723.23	223.68

30 728.99 226.78

Circle Center At X = 165.5 ; Y = 1281.4 and Radius, 1195.7

*** 1.922 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.25	69.84
2	132.12	67.61
3	152.04	65.82
4	172.00	64.48
5	191.98	63.58
6	211.97	63.13
7	231.97	63.13
8	251.97	63.57
9	271.95	64.45
10	291.90	65.78
11	311.82	67.56
12	331.70	69.78
13	351.52	72.44
14	371.28	75.54
15	390.96	79.09
16	410.56	83.07
17	430.07	87.49
18	449.47	92.34
19	468.76	97.62
20	487.93	103.33
21	506.96	109.47
22	525.86	116.03
23	544.60	123.01
24	563.18	130.40
25	581.60	138.21
26	599.83	146.43
27	617.88	155.05
28	635.73	164.07
29	653.37	173.48
30	670.80	183.29
31	688.01	193.49
32	704.98	204.06
33	721.72	215.01

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F	1693.75	+		*
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T	1935.71	+	*	

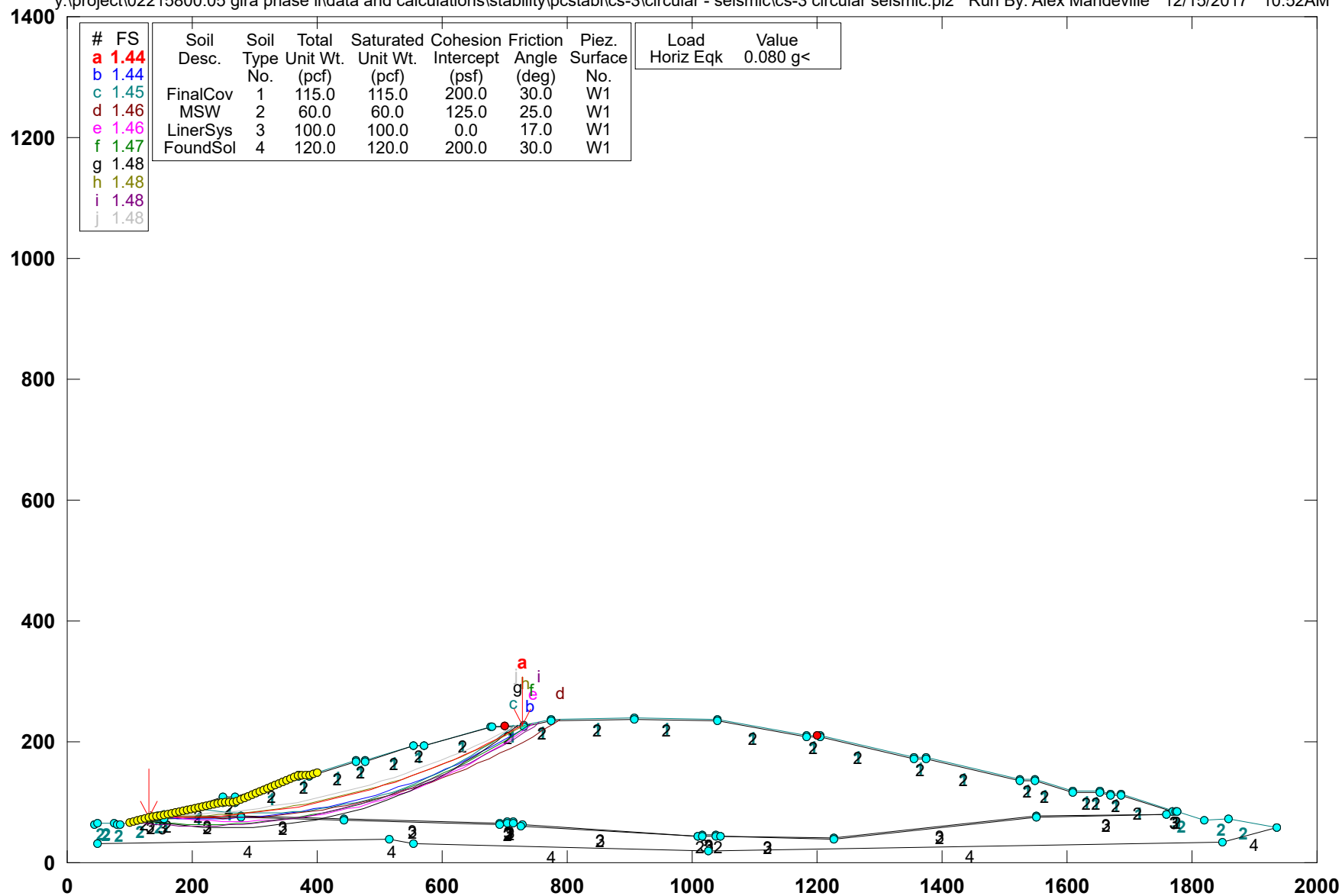
Section CS-3

Final Slope Stability Analysis

Circular Failure Surface, Seismic = 0.08g

GLRA - CS-3 Circular Failure - Seismic

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-3\circular - seismic\cs-3 circular seismic.pl2 Run By: Alex Mandeville 12/15/2017 10:52AM



PCSTABL5M3 FSmin=1.44

Safety Factors Are Calculated By The Modified Bishop Method

** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:52AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-3 circular seismic.

Output Filename: Y:cs-3 circular seismic.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-3 circular seismic.PLT

PROBLEM DESCRIPTION GLRA - CS-3
Circular Failure - Seismic

BOUNDARY COORDINATES

35 Top Boundaries
98 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	44.16	63.02	48.99	64.66	2
2	48.99	64.66	73.85	64.43	2
3	73.85	64.43	80.89	62.66	2

4	80.89	62.66	85.82	62.66	2
5	85.82	62.66	133.57	75.64	2
6	133.57	75.64	145.01	77.36	2
7	145.01	77.36	153.88	78.68	1
8	153.88	78.68	249.67	100.21	1
9	249.67	100.21	267.70	100.21	1
10	267.70	100.21	369.89	144.57	1
11	369.89	144.57	387.37	144.91	1
12	387.37	144.91	461.22	169.10	1
13	461.22	169.10	476.72	168.66	1
14	476.72	168.66	554.79	194.58	1
15	554.79	194.58	570.80	194.42	1
16	570.80	194.42	678.66	226.05	1
17	678.66	226.05	730.66	226.80	1
18	730.66	226.80	773.28	236.66	1
19	773.28	236.66	907.53	238.66	1
20	907.53	238.66	1040.17	236.66	1
21	1040.17	236.66	1182.84	210.66	1
22	1182.84	210.66	1204.94	210.65	1
23	1204.94	210.65	1354.07	174.66	1
24	1354.07	174.66	1374.21	174.77	1
25	1374.21	174.77	1525.14	138.65	1
26	1525.14	138.65	1549.21	137.36	1
27	1549.21	137.36	1609.02	118.63	1
28	1609.02	118.63	1651.98	118.66	1
29	1651.98	118.66	1669.11	112.66	1
30	1669.11	112.66	1685.91	112.77	1
31	1685.91	112.77	1773.14	85.10	1
32	1773.14	85.10	1776.43	84.06	3
33	1776.43	84.06	1818.65	70.66	2
34	1818.65	70.66	1859.12	72.39	2
35	1859.12	72.39	1935.71	58.66	2
36	149.37	75.99	154.34	76.73	2
37	154.34	76.73	249.99	108.21	2
38	249.99	108.21	268.03	108.21	2
39	268.03	108.21	370.23	142.58	2
40	370.23	142.58	387.71	142.92	2
41	387.71	142.92	461.51	167.09	2
42	461.51	167.09	477.01	166.66	2
43	477.01	166.66	555.10	192.57	2
44	555.10	192.57	571.08	192.42	2
45	571.08	192.42	678.96	224.05	2
46	678.96	224.05	730.90	224.80	2
47	730.90	224.80	773.52	234.67	2
48	773.52	234.67	907.53	236.66	2
49	907.53	236.66	1039.97	234.67	2
50	1039.97	234.67	1182.66	208.66	2
51	1182.66	208.66	1204.71	208.65	2
52	1204.71	208.65	1353.84	172.66	2

53	1353.84	172.66	1373.98	172.77	2
54	1373.98	172.77	1524.85	136.66	2
55	1524.85	136.66	1548.85	135.37	2
56	1548.85	135.37	1608.71	116.63	2
57	1608.71	116.63	1651.64	116.66	2
58	1651.64	116.66	1668.78	110.66	2
59	1668.78	110.66	1685.60	110.77	2
60	1685.60	110.77	1769.85	84.04	2
61	145.01	77.36	149.37	75.99	3
62	149.37	75.99	154.90	74.25	3
63	154.90	74.25	277.99	76.61	3
64	277.99	76.61	441.71	72.94	3
65	441.71	72.94	691.81	64.67	3
66	691.81	64.67	703.78	68.21	3
67	703.78	68.21	714.75	67.69	3
68	714.75	67.69	727.18	63.35	3
69	727.18	63.35	1009.30	44.63	3
70	1009.30	44.63	1016.80	46.66	3
71	1016.80	46.66	1038.87	46.66	3
72	1038.87	46.66	1045.40	44.66	3
73	1045.40	44.66	1227.50	40.67	3
74	1227.50	40.67	1550.81	76.66	3
75	1550.81	76.66	1759.32	80.66	3
76	1759.32	80.66	1769.85	84.04	3
77	1769.85	84.04	1773.14	85.10	3
78	133.57	85.64	142.88	75.93	2
79	142.88	75.93	154.61	72.25	2
80	154.61	72.25	277.99	74.61	2
81	277.99	74.61	441.66	70.95	2
82	441.66	70.95	692.07	62.66	2
83	692.07	62.66	704.03	66.19	2
84	704.03	66.19	714.37	65.71	2
85	714.37	65.71	726.78	61.37	2
86	726.78	61.37	1009.50	42.61	2
87	1009.50	42.61	1017.07	44.66	2
88	1017.07	44.66	1038.57	44.66	2
89	1038.57	44.66	1045.08	42.66	2
90	1045.08	42.66	1227.59	38.66	2
91	1227.59	38.66	1550.94	74.66	2
92	1550.94	74.66	1759.65	78.66	2
93	1759.65	78.66	1776.43	84.06	2
94	48.01	32.66	515.68	38.66	4
95	515.68	38.66	554.87	30.66	4
96	554.87	30.66	1026.78	19.64	4
97	1026.78	19.64	1848.99	34.66	4
98	1848.99	34.66	1935.71	58.66	4

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

A Horizontal Earthquake Loading Coefficient
Of 0.080 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of 0.000 Has Been Assigned

Cavitation Pressure = 0.0 (psf)

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

1000 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 50 Points Equally Spaced
Along The Ground Surface Between X = 100.00 ft.
and X = 400.00 ft.

Each Surface Terminates Between X = 700.00 ft.
and X = 1200.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

20.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	130.61	74.84
2	150.61	74.37
3	170.61	74.27
4	190.61	74.52
5	210.60	75.14
6	230.57	76.12
7	250.53	77.46
8	270.45	79.15
9	290.35	81.21
10	310.20	83.63
11	330.01	86.40
12	349.76	89.54
13	369.46	93.02
14	389.08	96.87
15	408.64	101.06
16	428.11	105.61
17	447.50	110.51
18	466.80	115.76
19	486.00	121.36
20	505.10	127.30
21	524.09	133.59
22	542.96	140.21
23	561.70	147.18
24	580.32	154.49
25	598.81	162.13
26	617.15	170.10
27	635.34	178.40
28	653.39	187.03
29	671.27	195.98
30	688.99	205.26
31	706.54	214.85

32	723.91	224.76
33	727.26	226.75

Circle Center At X = 166.4 ; Y = 1182.1 and Radius, 1107.8

*** 1.435 ***

Individual data on the 61 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	3.0	77.4	0.0	0.0	0.0	0.0	6.2	0.0	0.0
2	9.3	939.1	0.0	0.0	0.0	0.0	75.1	0.0	0.0
3	2.1	341.8	0.0	0.0	0.0	0.0	27.3	0.0	0.0
4	2.6	792.4	0.0	0.0	0.0	0.0	63.4	0.0	0.0
5	1.7	644.0	0.0	0.0	0.0	0.0	51.5	0.0	0.0
6	1.2	483.1	0.0	0.0	0.0	0.0	38.6	0.0	0.0
7	3.3	1258.3	0.0	0.0	0.0	0.0	100.7	0.0	0.0
8	0.5	175.1	0.0	0.0	0.0	0.0	14.0	0.0	0.0
9	0.2	93.1	0.0	0.0	0.0	0.0	7.4	0.0	0.0
10	4.3	1720.3	0.0	0.0	0.0	0.0	137.6	0.0	0.0
11	11.7	5483.9	0.0	0.0	0.0	0.0	438.7	0.0	0.0
12	20.0	11874.4	0.0	0.0	0.0	0.0	949.9	0.0	0.0
13	20.0	14399.4	0.0	0.0	0.0	0.0	1151.9	0.0	0.0
14	6.0	4719.8	0.0	0.0	0.0	0.0	377.6	0.0	0.0
15	14.0	11590.4	0.0	0.0	0.0	0.0	927.2	0.0	0.0
16	19.1	17168.8	0.0	0.0	0.0	0.0	1373.5	0.0	0.0
17	0.3	297.9	0.0	0.0	0.0	0.0	23.8	0.0	0.0
18	0.5	497.6	0.0	0.0	0.0	0.0	39.8	0.0	0.0
19	17.2	15135.6	0.0	0.0	0.0	0.0	1210.9	0.0	0.0
20	0.3	278.8	0.0	0.0	0.0	0.0	22.3	0.0	0.0
21	2.4	2143.9	0.0	0.0	0.0	0.0	171.5	0.0	0.0
22	19.9	23213.7	0.0	0.0	0.0	0.0	1857.1	0.0	0.0
23	19.9	32900.1	0.0	0.0	0.0	0.0	2632.0	0.0	0.0
24	19.8	42079.9	0.0	0.0	0.0	0.0	3366.4	0.0	0.0
25	19.8	50744.4	0.0	0.0	0.0	0.0	4059.5	0.0	0.0
26	19.7	58885.7	0.0	0.0	0.0	0.0	4710.9	0.0	0.0
27	0.4	1390.0	0.0	0.0	0.0	0.0	111.2	0.0	0.0
28	0.3	1087.6	0.0	0.0	0.0	0.0	87.0	0.0	0.0
29	17.1	53189.5	0.0	0.0	0.0	0.0	4255.2	0.0	0.0
30	0.3	1025.8	0.0	0.0	0.0	0.0	82.1	0.0	0.0

31	1.4	4154.7	0.0	0.0	0.0	0.0	332.4	0.0	0.0
32	19.6	60583.6	0.0	0.0	0.0	0.0	4846.7	0.0	0.0
33	19.5	62699.9	0.0	0.0	0.0	0.0	5016.0	0.0	0.0
34	19.4	64335.6	0.0	0.0	0.0	0.0	5146.8	0.0	0.0
35	13.7	46420.2	0.0	0.0	0.0	0.0	3713.6	0.0	0.0
36	0.3	986.5	0.0	0.0	0.0	0.0	78.9	0.0	0.0
37	5.3	17723.0	0.0	0.0	0.0	0.0	1417.8	0.0	0.0
38	9.9	31788.8	0.0	0.0	0.0	0.0	2543.1	0.0	0.0
39	0.3	902.9	0.0	0.0	0.0	0.0	72.2	0.0	0.0
40	9.0	28128.0	0.0	0.0	0.0	0.0	2250.2	0.0	0.0
41	19.1	60165.3	0.0	0.0	0.0	0.0	4813.2	0.0	0.0
42	19.0	60058.4	0.0	0.0	0.0	0.0	4804.7	0.0	0.0
43	18.9	59498.4	0.0	0.0	0.0	0.0	4759.9	0.0	0.0
44	11.8	37017.9	0.0	0.0	0.0	0.0	2961.4	0.0	0.0
45	0.3	963.2	0.0	0.0	0.0	0.0	77.1	0.0	0.0
46	6.6	19981.4	0.0	0.0	0.0	0.0	1598.5	0.0	0.0
47	9.1	25832.6	0.0	0.0	0.0	0.0	2066.6	0.0	0.0
48	0.3	764.9	0.0	0.0	0.0	0.0	61.2	0.0	0.0
49	9.2	25005.7	0.0	0.0	0.0	0.0	2000.5	0.0	0.0
50	18.5	48270.7	0.0	0.0	0.0	0.0	3861.7	0.0	0.0
51	18.3	45255.4	0.0	0.0	0.0	0.0	3620.4	0.0	0.0
52	18.2	41859.3	0.0	0.0	0.0	0.0	3348.7	0.0	0.0
53	18.0	38096.4	0.0	0.0	0.0	0.0	3047.7	0.0	0.0
54	17.9	33981.4	0.0	0.0	0.0	0.0	2718.5	0.0	0.0
55	7.4	12842.0	0.0	0.0	0.0	0.0	1027.4	0.0	0.0
56	0.3	504.1	0.0	0.0	0.0	0.0	40.3	0.0	0.0
57	10.0	15244.3	0.0	0.0	0.0	0.0	1219.5	0.0	0.0
58	17.5	19067.7	0.0	0.0	0.0	0.0	1525.4	0.0	0.0
59	17.3	8950.1	0.0	0.0	0.0	0.0	716.0	0.0	0.0
60	0.1	24.3	0.0	0.0	0.0	0.0	1.9	0.0	0.0
61	3.4	374.6	0.0	0.0	0.0	0.0	30.0	0.0	0.0

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	136.74	76.12
2	156.67	74.52
3	176.64	73.35
4	196.62	72.61
5	216.62	72.30
6	236.62	72.41
7	256.61	72.95
8	276.59	73.91
9	296.54	75.30
10	316.46	77.12
11	336.33	79.36

12	356.16	82.02
13	375.92	85.10
14	395.61	88.61
15	415.22	92.54
16	434.74	96.88
17	454.17	101.64
18	473.49	106.81
19	492.69	112.39
20	511.77	118.39
21	530.72	124.78
22	549.53	131.58
23	568.19	138.78
24	586.69	146.38
25	605.02	154.37
26	623.19	162.75
27	641.16	171.51
28	658.95	180.66
29	676.54	190.18
30	693.92	200.07
31	711.08	210.34
32	728.02	220.97
33	740.28	229.03

Circle Center At X = 221.4 ; Y = 1009.7 and Radius, 937.5

*** 1.442 ***

1

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	204.08	89.96
2	223.86	87.02
3	243.73	84.70
4	263.66	82.99
5	283.63	81.91
6	303.62	81.45
7	323.62	81.62
8	343.61	82.40
9	363.56	83.81
10	383.45	85.84
11	403.28	88.49

12	423.01	91.76
13	442.63	95.64
14	462.12	100.13
15	481.46	105.22
16	500.63	110.92
17	519.61	117.21
18	538.40	124.09
19	556.95	131.55
20	575.27	139.58
21	593.32	148.18
22	611.10	157.34
23	628.59	167.05
24	645.76	177.30
25	662.61	188.08
26	679.11	199.38
27	695.25	211.19
28	711.01	223.50
29	714.71	226.57

Circle Center At X = 308.4 ; Y = 723.1 and Radius, 641.7

*** 1.452 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.98	77.95
2	168.91	76.32
3	188.88	75.09
4	208.86	74.26
5	228.85	73.83
6	248.85	73.79
7	268.85	74.15
8	288.84	74.91
9	308.80	76.06
10	328.74	77.61
11	348.65	79.56
12	368.51	81.90
13	388.32	84.64
14	408.08	87.77
15	427.76	91.29
16	447.38	95.21

17	466.91	99.51
18	486.35	104.20
19	505.70	109.27
20	524.94	114.73
21	544.06	120.57
22	563.07	126.79
23	581.95	133.39
24	600.70	140.36
25	619.30	147.70
26	637.76	155.41
27	656.06	163.48
28	674.19	171.92
29	692.15	180.72
30	709.93	189.87
31	727.53	199.37
32	744.94	209.22
33	762.14	219.42
34	779.14	229.95
35	789.88	236.91

Circle Center At X = 240.7 ; Y = 1079.8 and Radius, 1006.0

*** 1.460 ***

1

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.98	77.95
2	168.77	75.04
3	188.62	72.64
4	208.53	70.75
5	228.49	69.38
6	248.47	68.53
7	268.47	68.19
8	288.46	68.37
9	308.45	69.06
10	328.42	70.28
11	348.34	72.01
12	368.21	74.25
13	388.02	77.01
14	407.75	80.27

15	427.39	84.05
16	446.93	88.33
17	466.35	93.12
18	485.64	98.41
19	504.78	104.19
20	523.77	110.47
21	542.59	117.23
22	561.23	124.48
23	579.68	132.21
24	597.92	140.41
25	615.94	149.09
26	633.73	158.22
27	651.28	167.82
28	668.58	177.86
29	685.61	188.34
30	702.36	199.27
31	718.83	210.62
32	734.99	222.40
33	745.06	230.13

Circle Center At X = 271.5 ; Y = 841.7 and Radius, 773.6

*** 1.462 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.25	69.84
2	132.12	67.61
3	152.04	65.82
4	172.00	64.48
5	191.98	63.58
6	211.97	63.13
7	231.97	63.13
8	251.97	63.57
9	271.95	64.45
10	291.90	65.78
11	311.82	67.56
12	331.70	69.78
13	351.52	72.44
14	371.28	75.54
15	390.96	79.09

16	410.56	83.07
17	430.07	87.49
18	449.47	92.34
19	468.76	97.62
20	487.93	103.33
21	506.96	109.47
22	525.86	116.03
23	544.60	123.01
24	563.18	130.40
25	581.60	138.21
26	599.83	146.43
27	617.88	155.05
28	635.73	164.07
29	653.37	173.48
30	670.80	183.29
31	688.01	193.49
32	704.98	204.06
33	721.72	215.01
34	738.20	226.34
35	742.73	229.59

Circle Center At X = 222.2 ; Y = 960.0 and Radius, 897.0

*** 1.470 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	118.37	71.51
2	138.03	67.84
3	157.78	64.72
4	177.62	62.16
5	197.52	60.16
6	217.47	58.72
7	237.45	57.84
8	257.45	57.51
9	277.44	57.75
10	297.43	58.55
11	317.38	59.91
12	337.29	61.83
13	357.14	64.30

14	376.90	67.34
15	396.58	70.92
16	416.15	75.06
17	435.59	79.74
18	454.90	84.97
19	474.05	90.73
20	493.03	97.04
21	511.83	103.87
22	530.42	111.22
23	548.81	119.10
24	566.97	127.48
25	584.88	136.38
26	602.54	145.77
27	619.92	155.65
28	637.03	166.02
29	653.83	176.86
30	670.33	188.17
31	686.50	199.94
32	702.33	212.16
33	717.82	224.81
34	719.94	226.65

Circle Center At X = 258.9 ; Y = 770.3 and Radius, 712.8

*** 1.475 ***

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	142.86	77.04
2	162.86	76.81
3	182.86	76.93
4	202.85	77.40
5	222.83	78.22
6	242.80	79.39
7	262.74	80.91
8	282.65	82.78
9	302.53	84.99
10	322.37	87.55
11	342.15	90.45
12	361.89	93.71
13	381.56	97.30

14	401.17	101.24
15	420.71	105.52
16	440.17	110.14
17	459.54	115.10
18	478.83	120.40
19	498.02	126.03
20	517.11	132.00
21	536.09	138.30
22	554.96	144.93
23	573.71	151.89
24	592.33	159.18
25	610.83	166.79
26	629.19	174.72
27	647.41	182.97
28	665.48	191.54
29	683.40	200.42
30	701.16	209.61
31	718.76	219.12
32	733.64	227.49

Circle Center At X = 165.9 ; Y = 1221.7 and Radius, 1144.9

*** 1.477 ***

1

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	100.00	66.51
2	119.90	64.50
3	139.83	62.89
4	159.80	61.70
5	179.78	60.93
6	199.78	60.57
7	219.78	60.63
8	239.77	61.10
9	259.75	61.99
10	279.71	63.29
11	299.64	65.01
12	319.52	67.15
13	339.36	69.69
14	359.14	72.65

15	378.86	76.02
16	398.49	79.80
17	418.05	83.99
18	437.52	88.58
19	456.88	93.58
20	476.14	98.98
21	495.28	104.77
22	514.30	110.97
23	533.18	117.56
24	551.93	124.54
25	570.52	131.90
26	588.95	139.66
27	607.23	147.79
28	625.32	156.31
29	643.24	165.19
30	660.97	174.45
31	678.50	184.08
32	695.83	194.07
33	712.94	204.41
34	729.84	215.11
35	746.51	226.16
36	755.84	232.62

Circle Center At X = 207.0 ; Y = 1021.7 and Radius, 961.1

*** 1.477 ***

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.98	77.95
2	168.98	78.35
3	188.96	79.08
4	208.94	80.13
5	228.89	81.51
6	248.82	83.21
7	268.71	85.24
8	288.57	87.59
9	308.39	90.27
10	328.17	93.27
11	347.89	96.59
12	367.55	100.23

13	387.16	104.20
14	406.69	108.48
15	426.16	113.09
16	445.54	118.01
17	464.84	123.24
18	484.06	128.79
19	503.18	134.65
20	522.20	140.83
21	541.12	147.31
22	559.93	154.10
23	578.63	161.20
24	597.21	168.60
25	615.67	176.31
26	634.00	184.31
27	652.19	192.62
28	670.25	201.22
29	688.16	210.11
30	705.93	219.29
31	719.59	226.64

Circle Center At X = 134.5 ; Y = 1302.9 and Radius, 1225.1

*** 1.478 ***

1

	Y	A	X	I	S	F	T
	0.00	241.96	483.93	725.89	967.86	1209.82	
X	0.00	+	+	+	+	+	+
	- * *						
	- *						
	- . **						
	- . . *						
	- .713						
241.96	..71*						
	..7**.						
	..711.						
	...21.*						
	...41.*						
	...*11.*						
A	483.93	210*					
	..*.511.						
	.*...210*						

		21.
		411.
		...*...41*
X	725.89	...*....4*5
		4*
		4
		
		-.....
		-.....*
I	967.86	+.....
		-**.....
		-*.....*
		-.....
		-.....
		-.....*
S	1209.82	+*.....*
		-
		-
		-
		-*
		-
	1451.78	+
		-
		-* *
		-
		-*
		-*
F	1693.75	+*
		-
		-**
		-*
		-* *
		-
T	1935.71	+*

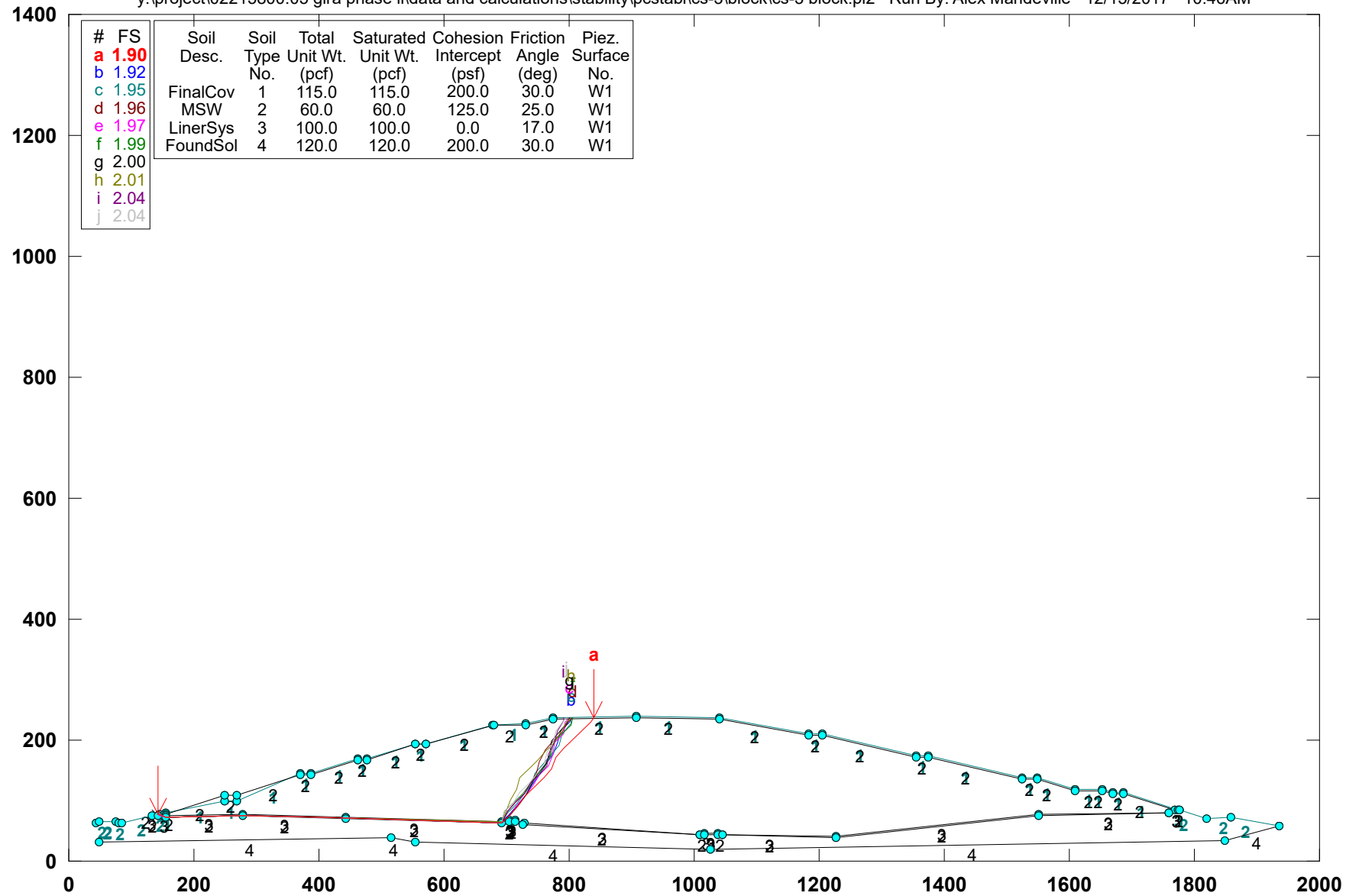
Section CS-3

Final Slope Stability Analysis

Block-Type Failure Surface within Liner System, Static

GLRA - CS-3 Block Failure

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-3\block\cs-3 block.pl2 Run By: Alex Mandeville 12/15/2017 10:46AM



PCSTABL5M3 FSmin=1.90
Safety Factors Are Calculated By The Modified Janbu Method

** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 12/15/2017
Time of Run: 10:46AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-3 block.

Output Filename: Y:cs-3 block.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-3 block.PLT

PROBLEM DESCRIPTION GLRA - CS-3
Block Failure

BOUNDARY COORDINATES

35 Top Boundaries
98 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	44.16	63.02	48.99	64.66	2
2	48.99	64.66	73.85	64.43	2
3	73.85	64.43	80.89	62.66	2

4	80.89	62.66	85.82	62.66	2
5	85.82	62.66	133.57	75.64	2
6	133.57	75.64	145.01	77.36	2
7	145.01	77.36	153.88	78.68	1
8	153.88	78.68	249.67	100.21	1
9	249.67	100.21	267.70	100.21	1
10	267.70	100.21	369.89	144.57	1
11	369.89	144.57	387.37	144.91	1
12	387.37	144.91	461.22	169.10	1
13	461.22	169.10	476.72	168.66	1
14	476.72	168.66	554.79	194.58	1
15	554.79	194.58	570.80	194.42	1
16	570.80	194.42	678.66	226.05	1
17	678.66	226.05	730.66	226.80	1
18	730.66	226.80	773.28	236.66	1
19	773.28	236.66	907.53	238.66	1
20	907.53	238.66	1040.17	236.66	1
21	1040.17	236.66	1182.84	210.66	1
22	1182.84	210.66	1204.94	210.65	1
23	1204.94	210.65	1354.07	174.66	1
24	1354.07	174.66	1374.21	174.77	1
25	1374.21	174.77	1525.14	138.65	1
26	1525.14	138.65	1549.21	137.36	1
27	1549.21	137.36	1609.02	118.63	1
28	1609.02	118.63	1651.98	118.66	1
29	1651.98	118.66	1669.11	112.66	1
30	1669.11	112.66	1685.91	112.77	1
31	1685.91	112.77	1773.14	85.10	1
32	1773.14	85.10	1776.43	84.06	3
33	1776.43	84.06	1818.65	70.66	2
34	1818.65	70.66	1859.12	72.39	2
35	1859.12	72.39	1935.71	58.66	2
36	149.37	75.99	154.34	76.73	2
37	154.34	76.73	249.99	108.21	2
38	249.99	108.21	268.03	108.21	2
39	268.03	108.21	370.23	142.58	2
40	370.23	142.58	387.71	142.92	2
41	387.71	142.92	461.51	167.09	2
42	461.51	167.09	477.01	166.66	2
43	477.01	166.66	555.10	192.57	2
44	555.10	192.57	571.08	192.42	2
45	571.08	192.42	678.96	224.05	2
46	678.96	224.05	730.90	224.80	2
47	730.90	224.80	773.52	234.67	2
48	773.52	234.67	907.53	236.66	2
49	907.53	236.66	1039.97	234.67	2
50	1039.97	234.67	1182.66	208.66	2
51	1182.66	208.66	1204.71	208.65	2
52	1204.71	208.65	1353.84	172.66	2

53	1353.84	172.66	1373.98	172.77	2
54	1373.98	172.77	1524.85	136.66	2
55	1524.85	136.66	1548.85	135.37	2
56	1548.85	135.37	1608.71	116.63	2
57	1608.71	116.63	1651.64	116.66	2
58	1651.64	116.66	1668.78	110.66	2
59	1668.78	110.66	1685.60	110.77	2
60	1685.60	110.77	1769.85	84.04	2
61	145.01	77.36	149.37	75.99	3
62	149.37	75.99	154.90	74.25	3
63	154.90	74.25	277.99	76.61	3
64	277.99	76.61	441.71	72.94	3
65	441.71	72.94	691.81	64.67	3
66	691.81	64.67	703.78	68.21	3
67	703.78	68.21	714.75	67.69	3
68	714.75	67.69	727.18	63.35	3
69	727.18	63.35	1009.30	44.63	3
70	1009.30	44.63	1016.80	46.66	3
71	1016.80	46.66	1038.87	46.66	3
72	1038.87	46.66	1045.40	44.66	3
73	1045.40	44.66	1227.50	40.67	3
74	1227.50	40.67	1550.81	76.66	3
75	1550.81	76.66	1759.32	80.66	3
76	1759.32	80.66	1769.85	84.04	3
77	1769.85	84.04	1773.14	85.10	3
78	133.57	85.64	142.88	75.93	2
79	142.88	75.93	154.61	72.25	2
80	154.61	72.25	277.99	74.61	2
81	277.99	74.61	441.66	70.95	2
82	441.66	70.95	692.07	62.66	2
83	692.07	62.66	704.03	66.19	2
84	704.03	66.19	714.37	65.71	2
85	714.37	65.71	726.78	61.37	2
86	726.78	61.37	1009.50	42.61	2
87	1009.50	42.61	1017.07	44.66	2
88	1017.07	44.66	1038.57	44.66	2
89	1038.57	44.66	1045.08	42.66	2
90	1045.08	42.66	1227.59	38.66	2
91	1227.59	38.66	1550.94	74.66	2
92	1550.94	74.66	1759.65	78.66	2
93	1759.65	78.66	1776.43	84.06	2
94	48.01	32.66	515.68	38.66	4
95	515.68	38.66	554.87	30.66	4
96	554.87	30.66	1026.78	19.64	4
97	1026.78	19.64	1848.99	34.66	4
98	1848.99	34.66	1935.71	58.66	4

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

20 Trial Surfaces Have Been Generated.

5 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	144.39	76.40	144.39	76.40	1.00
2	154.90	73.12	154.90	73.12	1.00
3	278.59	75.52	278.59	75.52	1.00
4	406.09	72.74	406.09	72.74	1.00
5	691.95	63.66	691.95	63.66	1.00

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.93	77.20
2	144.39	76.81
3	154.90	73.39
4	278.59	75.69
5	406.09	72.83
6	691.95	63.40
7	706.01	77.62
8	718.97	92.85
9	731.68	108.30
10	745.64	122.62
11	759.79	136.76
12	772.64	152.08
13	779.13	171.00
14	792.32	186.04
15	806.37	200.27
16	820.43	214.49
17	834.04	229.15
18	839.11	237.64

*** 1.896 ***

Individual data on the 48 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Surcharge Ver (lbs)	Load (lbs)
1	0.5	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.6	22.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	4.4	846.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	4.5	1703.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.5	207.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.6	261.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	94.8	74917.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.3	352.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

9	17.7	19299.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.3	359.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	10.0	12421.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.6	844.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	91.3	265814.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.3	1497.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	17.1	75827.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.3	1513.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	18.4	85494.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	35.6	186556.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	19.5	113963.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.3	1754.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	15.2	91998.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.3	1756.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	77.8	537808.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.3	2406.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	15.7	122015.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.3	2180.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	107.6	951577.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.3	2969.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	12.8	127378.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.1	1390.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	1.8	18050.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	12.2	114993.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	13.0	111352.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	11.7	90162.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.2	1749.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.8	5646.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	14.0	96430.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	14.1	88326.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	12.9	71308.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.6	3296.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.2	1212.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	5.6	25483.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	13.2	47600.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	14.0	38535.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	14.1	26757.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	13.6	14270.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	3.9	1633.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	1.2	138.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.09	77.07
2	144.39	76.79

3	154.90	73.25
4	278.59	75.39
5	406.09	72.44
6	691.95	64.12
7	705.43	78.89
8	719.38	93.22
9	731.64	109.02
10	741.24	126.57
11	752.05	143.40
12	763.26	159.96
13	774.94	176.19
14	781.24	195.17
15	787.13	214.29
16	801.02	228.68
17	802.69	237.10

*** 1.917 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.29	77.10
2	144.39	76.22
3	154.90	73.31
4	278.59	75.80
5	406.09	72.67
6	691.95	63.40
7	702.59	80.33
8	716.42	94.78
9	728.44	110.76
10	739.42	127.48
11	746.28	146.26
12	758.87	161.81
13	772.91	176.05
14	784.63	192.25
15	789.87	211.55
16	803.39	226.30
17	803.41	237.11

*** 1.949 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.53	77.14
2	144.39	76.28
3	154.90	73.55
4	278.59	75.17
5	406.09	72.90
6	691.95	63.95
7	701.11	81.73
8	714.61	96.48
9	728.74	110.64
10	738.22	128.24
11	748.18	145.59
12	752.89	165.03
13	762.04	182.81
14	774.44	198.50
15	787.77	213.41
16	799.16	229.86
17	805.23	237.14

*** 1.963 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	142.84	77.03
2	144.39	76.00
3	154.90	73.58
4	278.59	75.84
5	406.09	73.01
6	691.95	63.82
7	706.04	78.02
8	718.34	93.79

9	731.03	109.24
10	742.23	125.81
11	751.86	143.34
12	766.00	157.48
13	774.64	175.52
14	777.34	195.34
15	791.33	209.63
16	793.82	229.47
17	800.28	237.06

*** 1.969 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.83	77.18
2	144.39	76.75
3	154.90	72.90
4	278.59	75.04
5	406.09	72.91
6	691.95	63.72
7	697.68	82.88
8	711.32	97.50
9	724.97	112.12
10	738.20	127.13
11	750.43	142.95
12	763.26	158.29
13	770.72	176.85
14	775.29	196.32
15	788.75	211.11
16	802.89	225.26
17	805.82	237.14

*** 1.987 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.98	77.20
2	144.39	76.79
3	154.90	72.82
4	278.59	75.84
5	406.09	72.58
6	691.95	63.27
7	705.57	77.92
8	719.29	92.47
9	730.31	109.15
10	739.22	127.06
11	749.27	144.35
12	763.35	158.55
13	769.80	177.49
14	771.33	197.43
15	785.16	211.88
16	796.32	228.47
17	800.73	237.07

*** 1.999 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.76	77.17
2	144.39	76.69
3	154.90	73.01
4	278.59	75.29
5	406.09	73.01
6	691.95	64.15
7	698.42	83.07
8	707.07	101.10
9	715.08	119.43
10	721.66	138.32
11	735.66	152.60
12	749.43	167.10
13	763.40	181.42
14	777.28	195.81
15	787.36	213.09

16	796.47	230.90
17	802.65	237.10

*** 2.013 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.54	77.14
2	144.39	76.34
3	154.90	73.53
4	278.59	75.86
5	406.09	72.33
6	691.95	63.39
7	701.17	81.14
8	714.82	95.76
9	727.48	111.24
10	738.30	128.06
11	751.60	143.00
12	765.64	157.24
13	766.72	177.21
14	775.50	195.19
15	781.58	214.24
16	790.29	232.25
17	791.60	236.93

*** 2.035 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	142.96	77.05
2	144.39	76.45
3	154.90	73.18

4	278.59	75.07
5	406.09	72.73
6	691.95	63.26
7	696.44	82.75
8	710.41	97.07
9	722.19	113.22
10	736.31	127.39
11	748.85	142.97
12	759.07	160.17
13	763.70	179.62
14	774.68	196.34
15	779.81	215.67
16	791.13	232.16
17	795.96	237.00

*** 2.040 ***

1

	Y	A	X	I	S	F	T
	0.00	241.96	483.93	725.89	967.86	1209.82	
X	0.00						
	- *	*					
	-	*					
	-	**					
	-	*					
	-						
	241.96	+	*				
	-	**					
	-		*				
	-	1	*				
	-	*	*				
A	483.93	+	*				
	-	*					
	-	*	*				
	-						
	-		*				
X	725.89	+	*118..*				
	-		1127*				
	-		112				
	-		11				

		-		
		-		*
I	967.86	+		
		-	**	
		-	*	*
		-		
		-		
		-		*
S	1209.82	+	*	*
		-		
		-		
		-		
		-		*
		-		
	1451.78	+		
		-		
		-	*	*
		-		
		-		*
		-		*
F	1693.75	+		*
		-		
		-	**	
		-	*	
		-	*	*
		-		
T	1935.71	+	*	

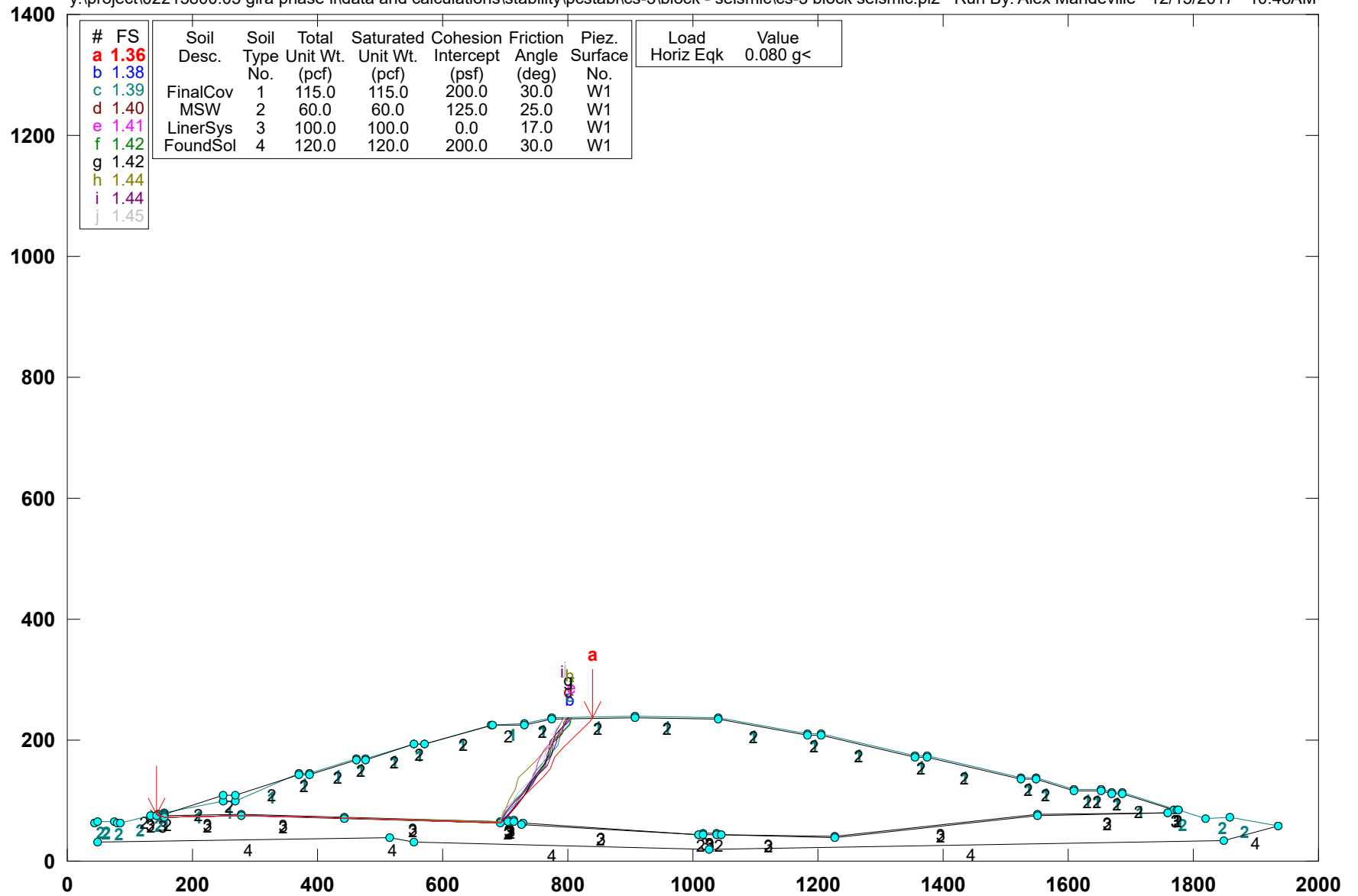
CS-3

Final Slope Stability Analysis

Block-Type Failure Surface within Liner System, Seismic =
0.08g

GLRA - CS-3 Block Failure - Seismic

y:\project\02215800.05 glra phase ii\data and calculations\stability\pcstabl\cs-3\block - seismic\cs-3 block seismic.pl2 Run By: Alex Mandeville 12/15/2017 10:48AM



PCSTABL5M3 FSmin=1.36
Safety Factors Are Calculated By The Modified Janbu Method

** PCSTABL5M3 **

by Purdue University 1985
rev. for SCS Engineers HVA 2008

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date: 12/15/2017
Time of Run: 10:48AM
Run By: Alex Mandeville
Input Data Filename: Y:cs-3 block seismic.

Output Filename: Y:cs-3 block seismic.OUT

Unit: ENGLISH
Plotted Output Filename: Y:cs-3 block seismic.PLT

PROBLEM DESCRIPTION GLRA - CS-3
Block Failure - Seismic

BOUNDARY COORDINATES

35 Top Boundaries
98 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	44.16	63.02	48.99	64.66	2
2	48.99	64.66	73.85	64.43	2
3	73.85	64.43	80.89	62.66	2

4	80.89	62.66	85.82	62.66	2
5	85.82	62.66	133.57	75.64	2
6	133.57	75.64	145.01	77.36	2
7	145.01	77.36	153.88	78.68	1
8	153.88	78.68	249.67	100.21	1
9	249.67	100.21	267.70	100.21	1
10	267.70	100.21	369.89	144.57	1
11	369.89	144.57	387.37	144.91	1
12	387.37	144.91	461.22	169.10	1
13	461.22	169.10	476.72	168.66	1
14	476.72	168.66	554.79	194.58	1
15	554.79	194.58	570.80	194.42	1
16	570.80	194.42	678.66	226.05	1
17	678.66	226.05	730.66	226.80	1
18	730.66	226.80	773.28	236.66	1
19	773.28	236.66	907.53	238.66	1
20	907.53	238.66	1040.17	236.66	1
21	1040.17	236.66	1182.84	210.66	1
22	1182.84	210.66	1204.94	210.65	1
23	1204.94	210.65	1354.07	174.66	1
24	1354.07	174.66	1374.21	174.77	1
25	1374.21	174.77	1525.14	138.65	1
26	1525.14	138.65	1549.21	137.36	1
27	1549.21	137.36	1609.02	118.63	1
28	1609.02	118.63	1651.98	118.66	1
29	1651.98	118.66	1669.11	112.66	1
30	1669.11	112.66	1685.91	112.77	1
31	1685.91	112.77	1773.14	85.10	1
32	1773.14	85.10	1776.43	84.06	3
33	1776.43	84.06	1818.65	70.66	2
34	1818.65	70.66	1859.12	72.39	2
35	1859.12	72.39	1935.71	58.66	2
36	149.37	75.99	154.34	76.73	2
37	154.34	76.73	249.99	108.21	2
38	249.99	108.21	268.03	108.21	2
39	268.03	108.21	370.23	142.58	2
40	370.23	142.58	387.71	142.92	2
41	387.71	142.92	461.51	167.09	2
42	461.51	167.09	477.01	166.66	2
43	477.01	166.66	555.10	192.57	2
44	555.10	192.57	571.08	192.42	2
45	571.08	192.42	678.96	224.05	2
46	678.96	224.05	730.90	224.80	2
47	730.90	224.80	773.52	234.67	2
48	773.52	234.67	907.53	236.66	2
49	907.53	236.66	1039.97	234.67	2
50	1039.97	234.67	1182.66	208.66	2
51	1182.66	208.66	1204.71	208.65	2
52	1204.71	208.65	1353.84	172.66	2

53	1353.84	172.66	1373.98	172.77	2
54	1373.98	172.77	1524.85	136.66	2
55	1524.85	136.66	1548.85	135.37	2
56	1548.85	135.37	1608.71	116.63	2
57	1608.71	116.63	1651.64	116.66	2
58	1651.64	116.66	1668.78	110.66	2
59	1668.78	110.66	1685.60	110.77	2
60	1685.60	110.77	1769.85	84.04	2
61	145.01	77.36	149.37	75.99	3
62	149.37	75.99	154.90	74.25	3
63	154.90	74.25	277.99	76.61	3
64	277.99	76.61	441.71	72.94	3
65	441.71	72.94	691.81	64.67	3
66	691.81	64.67	703.78	68.21	3
67	703.78	68.21	714.75	67.69	3
68	714.75	67.69	727.18	63.35	3
69	727.18	63.35	1009.30	44.63	3
70	1009.30	44.63	1016.80	46.66	3
71	1016.80	46.66	1038.87	46.66	3
72	1038.87	46.66	1045.40	44.66	3
73	1045.40	44.66	1227.50	40.67	3
74	1227.50	40.67	1550.81	76.66	3
75	1550.81	76.66	1759.32	80.66	3
76	1759.32	80.66	1769.85	84.04	3
77	1769.85	84.04	1773.14	85.10	3
78	133.57	85.64	142.88	75.93	2
79	142.88	75.93	154.61	72.25	2
80	154.61	72.25	277.99	74.61	2
81	277.99	74.61	441.66	70.95	2
82	441.66	70.95	692.07	62.66	2
83	692.07	62.66	704.03	66.19	2
84	704.03	66.19	714.37	65.71	2
85	714.37	65.71	726.78	61.37	2
86	726.78	61.37	1009.50	42.61	2
87	1009.50	42.61	1017.07	44.66	2
88	1017.07	44.66	1038.57	44.66	2
89	1038.57	44.66	1045.08	42.66	2
90	1045.08	42.66	1227.59	38.66	2
91	1227.59	38.66	1550.94	74.66	2
92	1550.94	74.66	1759.65	78.66	2
93	1759.65	78.66	1776.43	84.06	2
94	48.01	32.66	515.68	38.66	4
95	515.68	38.66	554.87	30.66	4
96	554.87	30.66	1026.78	19.64	4
97	1026.78	19.64	1848.99	34.66	4
98	1848.99	34.66	1935.71	58.66	4

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	115.0	115.0	200.0	30.0	0.00	0.0	1
2	60.0	60.0	125.0	25.0	0.00	0.0	1
3	100.0	100.0	0.0	17.0	0.00	0.0	1
4	120.0	120.0	200.0	30.0	0.00	0.0	1

A Horizontal Earthquake Loading Coefficient
Of 0.080 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of 0.000 Has Been Assigned

Cavitation Pressure = 0.0 (psf)

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Sliding Block Surfaces, Has Been
Specified.

20 Trial Surfaces Have Been Generated.

5 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of
Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	144.39	76.40	144.39	76.40	1.00
2	154.90	73.12	154.90	73.12	1.00
3	278.59	75.52	278.59	75.52	1.00
4	406.09	72.74	406.09	72.74	1.00

1

5 691.95 63.66 691.95 63.66 1.00

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.93	77.20
2	144.39	76.81
3	154.90	73.39
4	278.59	75.69
5	406.09	72.83
6	691.95	63.40
7	706.01	77.62
8	718.97	92.85
9	731.68	108.30
10	745.64	122.62
11	759.79	136.76
12	772.64	152.08
13	779.13	171.00
14	792.32	186.04
15	806.37	200.27
16	820.43	214.49
17	834.04	229.15
18	839.11	237.64

*** 1.359 ***

Individual data on the 48 slices

Slice	Width	Weight	Water Force Top	Water Force Bot	Tie Force Norm	Tie Force Tan	Earthquake Force Hor	Surcharge Ver	Load

No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	0.5	6.4	0.0	0.0	0.0	0.0	0.5	0.0	0.0
2	0.6	22.6	0.0	0.0	0.0	0.0	1.8	0.0	0.0
3	4.4	846.2	0.0	0.0	0.0	0.0	67.7	0.0	0.0
4	4.5	1703.0	0.0	0.0	0.0	0.0	136.2	0.0	0.0
5	0.5	207.6	0.0	0.0	0.0	0.0	16.6	0.0	0.0
6	0.6	261.9	0.0	0.0	0.0	0.0	21.0	0.0	0.0
7	94.8	74917.4	0.0	0.0	0.0	0.0	5993.4	0.0	0.0
8	0.3	352.8	0.0	0.0	0.0	0.0	28.2	0.0	0.0
9	17.7	19299.0	0.0	0.0	0.0	0.0	1543.9	0.0	0.0
10	0.3	359.0	0.0	0.0	0.0	0.0	28.7	0.0	0.0
11	10.0	12421.6	0.0	0.0	0.0	0.0	993.7	0.0	0.0
12	0.6	844.1	0.0	0.0	0.0	0.0	67.5	0.0	0.0
13	91.3	265814.9	0.0	0.0	0.0	0.0	21265.2	0.0	0.0
14	0.3	1497.8	0.0	0.0	0.0	0.0	119.8	0.0	0.0
15	17.1	75827.3	0.0	0.0	0.0	0.0	6066.2	0.0	0.0
16	0.3	1513.8	0.0	0.0	0.0	0.0	121.1	0.0	0.0
17	18.4	85494.3	0.0	0.0	0.0	0.0	6839.5	0.0	0.0
18	35.6	186556.2	0.0	0.0	0.0	0.0	14924.5	0.0	0.0
19	19.5	113963.6	0.0	0.0	0.0	0.0	9117.1	0.0	0.0
20	0.3	1754.4	0.0	0.0	0.0	0.0	140.4	0.0	0.0
21	15.2	91998.2	0.0	0.0	0.0	0.0	7359.9	0.0	0.0
22	0.3	1756.4	0.0	0.0	0.0	0.0	140.5	0.0	0.0
23	77.8	537808.8	0.0	0.0	0.0	0.0	43024.7	0.0	0.0
24	0.3	2406.3	0.0	0.0	0.0	0.0	192.5	0.0	0.0
25	15.7	122015.5	0.0	0.0	0.0	0.0	9761.2	0.0	0.0
26	0.3	2180.7	0.0	0.0	0.0	0.0	174.5	0.0	0.0
27	107.6	951577.4	0.0	0.0	0.0	0.0	76126.2	0.0	0.0
28	0.3	2969.4	0.0	0.0	0.0	0.0	237.6	0.0	0.0
29	12.8	127378.5	0.0	0.0	0.0	0.0	10190.3	0.0	0.0
30	0.1	1390.6	0.0	0.0	0.0	0.0	111.3	0.0	0.0
31	1.8	18050.1	0.0	0.0	0.0	0.0	1444.0	0.0	0.0
32	12.2	114993.4	0.0	0.0	0.0	0.0	9199.5	0.0	0.0
33	13.0	111352.7	0.0	0.0	0.0	0.0	8908.2	0.0	0.0
34	11.7	90162.1	0.0	0.0	0.0	0.0	7213.0	0.0	0.0
35	0.2	1749.7	0.0	0.0	0.0	0.0	140.0	0.0	0.0
36	0.8	5646.7	0.0	0.0	0.0	0.0	451.7	0.0	0.0
37	14.0	96430.9	0.0	0.0	0.0	0.0	7714.5	0.0	0.0
38	14.1	88326.5	0.0	0.0	0.0	0.0	7066.1	0.0	0.0
39	12.9	71308.4	0.0	0.0	0.0	0.0	5704.7	0.0	0.0
40	0.6	3296.0	0.0	0.0	0.0	0.0	263.7	0.0	0.0
41	0.2	1212.5	0.0	0.0	0.0	0.0	97.0	0.0	0.0
42	5.6	25483.3	0.0	0.0	0.0	0.0	2038.7	0.0	0.0
43	13.2	47600.3	0.0	0.0	0.0	0.0	3808.0	0.0	0.0
44	14.0	38535.9	0.0	0.0	0.0	0.0	3082.9	0.0	0.0
45	14.1	26757.2	0.0	0.0	0.0	0.0	2140.6	0.0	0.0
46	13.6	14270.1	0.0	0.0	0.0	0.0	1141.6	0.0	0.0
47	3.9	1633.9	0.0	0.0	0.0	0.0	130.7	0.0	0.0

48 1.2 138.1 0.0 0.0 0.0 0.0 11.0 0.0 0.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.09	77.07
2	144.39	76.79
3	154.90	73.25
4	278.59	75.39
5	406.09	72.44
6	691.95	64.12
7	705.43	78.89
8	719.38	93.22
9	731.64	109.02
10	741.24	126.57
11	752.05	143.40
12	763.26	159.96
13	774.94	176.19
14	781.24	195.17
15	787.13	214.29
16	801.02	228.68
17	802.69	237.10

*** 1.376 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.29	77.10
2	144.39	76.22
3	154.90	73.31
4	278.59	75.80
5	406.09	72.67
6	691.95	63.40
7	702.59	80.33
8	716.42	94.78
9	728.44	110.76
10	739.42	127.48

11	746.28	146.26
12	758.87	161.81
13	772.91	176.05
14	784.63	192.25
15	789.87	211.55
16	803.39	226.30
17	803.41	237.11

*** 1.394 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	142.84	77.03
2	144.39	76.00
3	154.90	73.58
4	278.59	75.84
5	406.09	73.01
6	691.95	63.82
7	706.04	78.02
8	718.34	93.79
9	731.03	109.24
10	742.23	125.81
11	751.86	143.34
12	766.00	157.48
13	774.64	175.52
14	777.34	195.34
15	791.33	209.63
16	793.82	229.47
17	800.28	237.06

*** 1.404 ***

1

Failure Surface Specified By 17 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	143.53	77.14
2	144.39	76.28
3	154.90	73.55
4	278.59	75.17
5	406.09	72.90
6	691.95	63.95
7	701.11	81.73
8	714.61	96.48
9	728.74	110.64
10	738.22	128.24
11	748.18	145.59
12	752.89	165.03
13	762.04	182.81
14	774.44	198.50
15	787.77	213.41
16	799.16	229.86
17	805.23	237.14

*** 1.406 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.83	77.18
2	144.39	76.75
3	154.90	72.90
4	278.59	75.04
5	406.09	72.91
6	691.95	63.72
7	697.68	82.88
8	711.32	97.50
9	724.97	112.12
10	738.20	127.13
11	750.43	142.95
12	763.26	158.29
13	770.72	176.85
14	775.29	196.32
15	788.75	211.11
16	802.89	225.26
17	805.82	237.14

*** 1.419 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.98	77.20
2	144.39	76.79
3	154.90	72.82
4	278.59	75.84
5	406.09	72.58
6	691.95	63.27
7	705.57	77.92
8	719.29	92.47
9	730.31	109.15
10	739.22	127.06
11	749.27	144.35
12	763.35	158.55
13	769.80	177.49
14	771.33	197.43
15	785.16	211.88
16	796.32	228.47
17	800.73	237.07

*** 1.421 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.76	77.17
2	144.39	76.69
3	154.90	73.01
4	278.59	75.29
5	406.09	73.01

6	691.95	64.15
7	698.42	83.07
8	707.07	101.10
9	715.08	119.43
10	721.66	138.32
11	735.66	152.60
12	749.43	167.10
13	763.40	181.42
14	777.28	195.81
15	787.36	213.09
16	796.47	230.90
17	802.65	237.10

*** 1.439 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.54	77.14
2	144.39	76.34
3	154.90	73.53
4	278.59	75.86
5	406.09	72.33
6	691.95	63.39
7	701.17	81.14
8	714.82	95.76
9	727.48	111.24
10	738.30	128.06
11	751.60	143.00
12	765.64	157.24
13	766.72	177.21
14	775.50	195.19
15	781.58	214.24
16	790.29	232.25
17	791.60	236.93

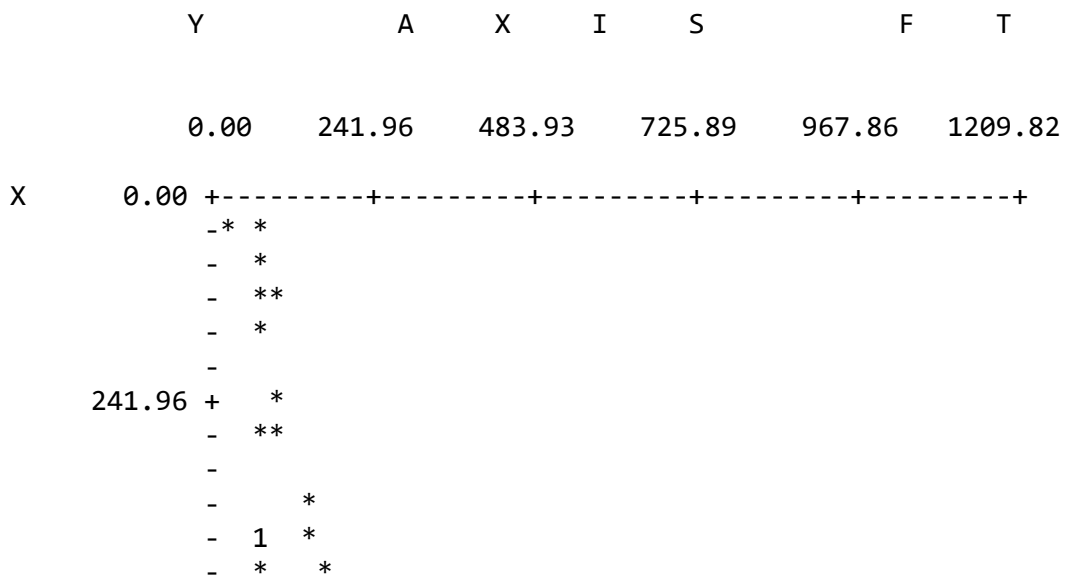
*** 1.440 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	142.96	77.05
2	144.39	76.45
3	154.90	73.18
4	278.59	75.07
5	406.09	72.73
6	691.95	63.26
7	696.44	82.75
8	710.41	97.07
9	722.19	113.22
10	736.31	127.39
11	748.85	142.97
12	759.07	160.17
13	763.70	179.62
14	774.68	196.34
15	779.81	215.67
16	791.13	232.16
17	795.96	237.00

*** 1.451 ***

1



A	483.93	+		*
		-	*	
		-	*	*
		-		
		-		
		-	*	*
X	725.89	+	*118..*	
		-	1127*	
		-	112	
		-	11	
		-		
		-		*
I	967.86	+		
		-	**	
		-	*	*
		-		
		-		
		-		*
S	1209.82	+	*	*
		-		
		-		
		-		
		-	*	
		-		
	1451.78	+		
		-		
		-	*	*
		-		
		-	*	
		-	*	
F	1693.75	+	*	
		-		
		-	**	
		-	*	
		-	*	*
		-		
T	1935.71	+	*	

ATTACHMENT 24-A-2

Veneer Stability Calculations

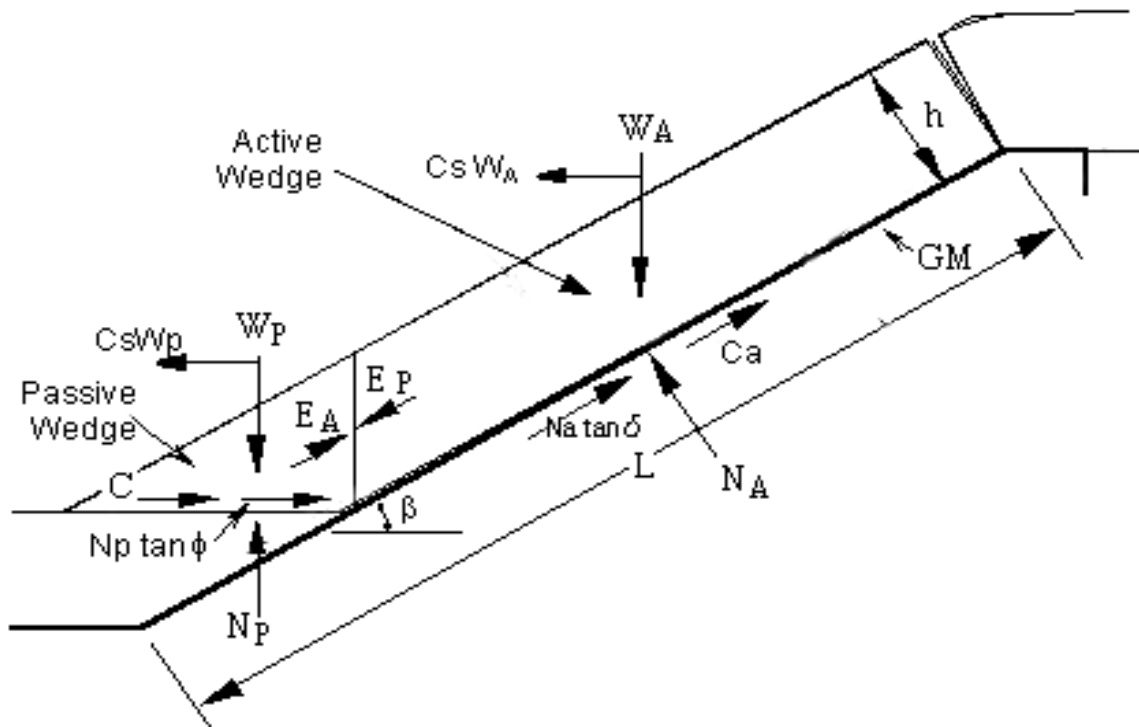
Veneer Stability – Static

COVER STABILITY CALCULATION (STATIC)

Project: Greater Lebanon Refuse Authority
Location: Lebanon, PA
Prepared by: SCS ENGINEERS
Date: December 2017

Calc'd by: APM Date: 12/27/2017
 Chk'd by: RHI Date: 1/5/2018

Consideration: To determine the factor of safety (FS) under static condition and residual strength, using analysis as described by Koerner and Soong (1998) referenced below.



Ref.: R.M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceeding of 6th International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

Parameters:

L	=	length of slope measured along the geomembrane
β	=	soil slope angle beneath the geomembrane
FS	=	factor of safety against instability
W_A	=	total weight of the active wedge
W_P	=	total weight of the passive wedge
N_A	=	effective force normal to the failure plane of the active wedge
h	=	thickness of the cover soil
γ	=	unit weight of the cover soil
ϕ	=	cover soil friction angle
δ	=	interface friction angle between cover soil and geomembrane
C_a	=	adhesive force between cover soil of the active wedge and the geomembrane
c_a	=	adhesion between cover soil of the active wedge and the geomembrane
C	=	cohesive force along the failure plane of the passive wedge
c	=	cohesion of the cover soil

COVER STABILITY CALCULATION (STATIC)

Calculate Factor of Safety (FS):

$$FS = \frac{-b + (b^2 - 4ac)^{1/2}}{2a}, \text{ where}$$

$$a = (C_s W_A + N_A \sin \beta)(\cos \beta) + C_s W_P(\cos \beta)$$

$$b = -[(C_s W_A + N_A \sin \beta) \sin \beta (\tan \phi) + (N_A \tan \delta + C_a)(\cos^2 \beta) + (C + W_P \tan \phi) \cos \beta]$$

$$c = (N_A \tan \delta + C_a) \cos \beta \sin \beta \tan \phi, \text{ where}$$

$$W_A = \gamma h^2 [(L/h) - (1/\sin \beta) - (\tan \beta / 2)]$$

$$N_A = W_A (\cos \beta)$$

$$W_P = \gamma h^2 / \sin 2\beta$$

$$C_a = c_a (L - (h/\sin \beta))$$

$$C = (ch)/(\sin \beta)$$

$\gamma =$	18.07	kN/m ³	
$h =$	610.00	mm	= 0.61 m
$L =$	48.00	m	
$\beta =$	18.40	°	= 0.32 rad
$C_s =$	0.00	g	
$\phi =$	30.00	°	= 0.52 rad
$\delta =$	19.00	°	= 0.33 rad
$c =$	0.00	kN/m ²	
$c_a =$	2.40	kN/m ²	

$W_A =$	506.67	kN
$N_A =$	480.77	kN
$W_P =$	11.22	kN
$C_a =$	110.56	kN
$C =$	0.00	kN
$a =$	144.00	
$b =$	-282.40	
$c =$	47.74	

$$FS = 1.77$$

Summary:

At the residual interface friction angle of 19 degrees for the soil-geosynthetic interface and under static condition and no seepage force applied, the factor of safety is calculated as 1.77 indicating the final cover system is stable under the slope conditions analyzed (slope length between benches = 160').

Veneer Stability – Seismic

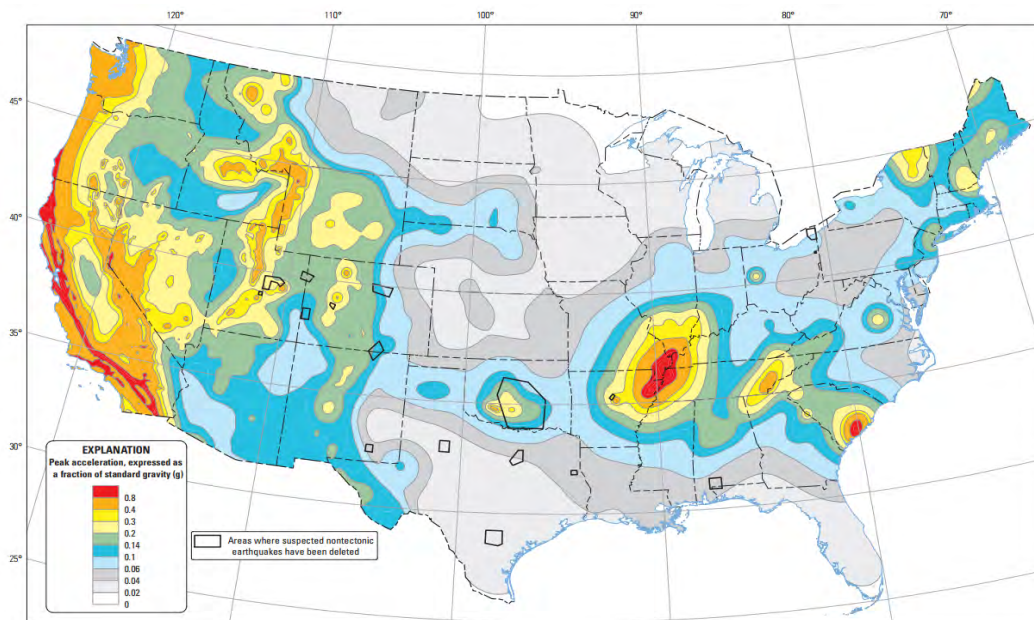
COVER STABILITY CALCULATION (SEISMIC)

Project: Greater Lebanon Refuse Authority
Location: Lebanon, PA
Prepared by: SCS ENGINEERS
Date: December 2017

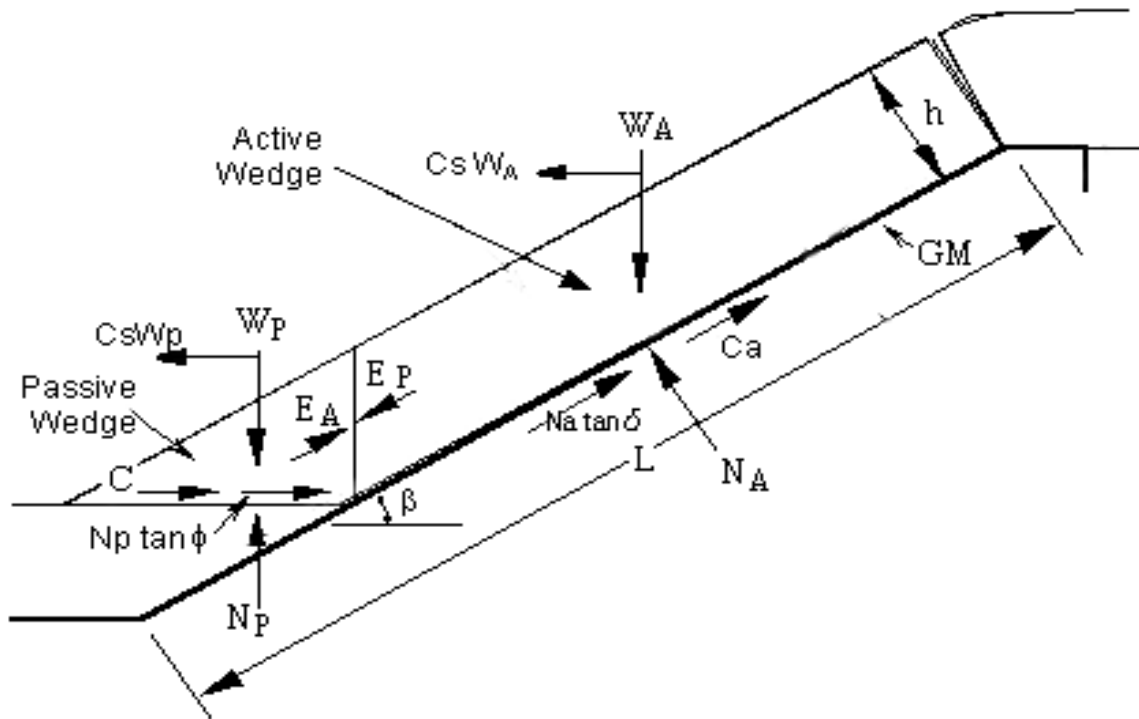
Calc'd by: APM Date: 12/27/2017
Chk'd by: RHI Date: 1/5/2018

Consideration: To determine the factor of safety (FS) of a geosynthetic lined slope using a pseudo-static analysis as described by Koerner and Soong (1998) referenced below, using an interface shear strength of 19 degrees, no cohesion.

Seismic Coefficient: Subtitle "D" of the U.S. EPA regulations requires a seismic analysis if the site has experienced a 0.1g horizontal acceleration, or more, in the past 250 years. The map below shows the seismic coefficients for various zones in the USA. Based on the site using 2014 USGS Seismic Hazard Map from website, the seismic coefficient of 0.08g was used in the analysis.



COVER STABILITY CALCULATION (SEISMIC)



Ref.: R.M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceeding of 6th International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

Parameters:

L	=	length of slope measured along the geomembrane
β	=	soil slope angle beneath the geomembrane
FS	=	factor of safety against instability
W_A	=	total weight of the active wedge
W_P	=	total weight of the passive wedge
N_A	=	effective force normal to the failure plane of the active wedge
h	=	thickness of the cover soil
γ	=	unit weight of the cover soil
ϕ	=	cover soil friction angle
δ	=	interface friction angle between cover soil and geomembrane
C_a	=	adhesive force between cover soil of the active wedge and the geomembrane
c_a	=	adhesion between cover soil of the active wedge and the geomembrane
C	=	cohesive force along the failure plane of the passive wedge
c	=	cohesion of the cover soil

COVER STABILITY CALCULATION (SEISMIC)

Calculate Factor of Safety (FS):

$$FS = \frac{-b + (b^2 - 4ac)^{1/2}}{2a}, \text{ where}$$

$$a = (C_s W_A + N_A \sin \beta)(\cos \beta) + C_s W_P(\cos \beta)$$

$$b = -[(C_s W_A + N_A \sin \beta) \sin \beta (\tan \phi) + (N_A \tan \delta + C_a)(\cos^2 \beta) + (C + W_P \tan \phi) \cos \beta]$$

$$c = (N_A \tan \delta + C_a) \cos \beta \sin \beta \tan \phi, \text{ where}$$

$$W_A = \gamma h^2 [(L/h) - (1/\sin \beta) - (\tan \beta/2)]$$

$$N_A = W_A(\cos \beta)$$

$$W_P = \gamma h^2 / \sin 2\beta$$

$$C_a = c_a(L - (h/\sin \beta))$$

$$C = (ch)/(\sin \beta)$$

$\gamma =$	18.07	kN/m ³	
$h =$	610.00	mm	= 0.61 m
$L =$	48.00	m	
$\beta =$	18.40	°	= 0.32 rad
$C_s =$	0.08	g	
$\phi =$	30.00	°	= 0.52 rad
$\delta =$	19.00	°	= 0.33 rad
$c =$	0.00	kN/m ²	
$c_a =$	2.40	kN/m ²	

$W_A =$	506.67	kN
$N_A =$	480.77	kN
$W_P =$	11.22	kN
$C_a =$	110.56	kN
$C =$	0.00	kN
$a =$	183.31	
$b =$	-289.79	
$c =$	47.74	

$$FS = 1.39$$

Summary:

At an interface friction angle of 19 degrees (and no cohesion) for the critical geosynthetic-soil interface, the factor of safety under seepage forces is calculated as 1.39.

The cover system is stable under the slope conditions analyzed (longest slope length = 160' between benches).

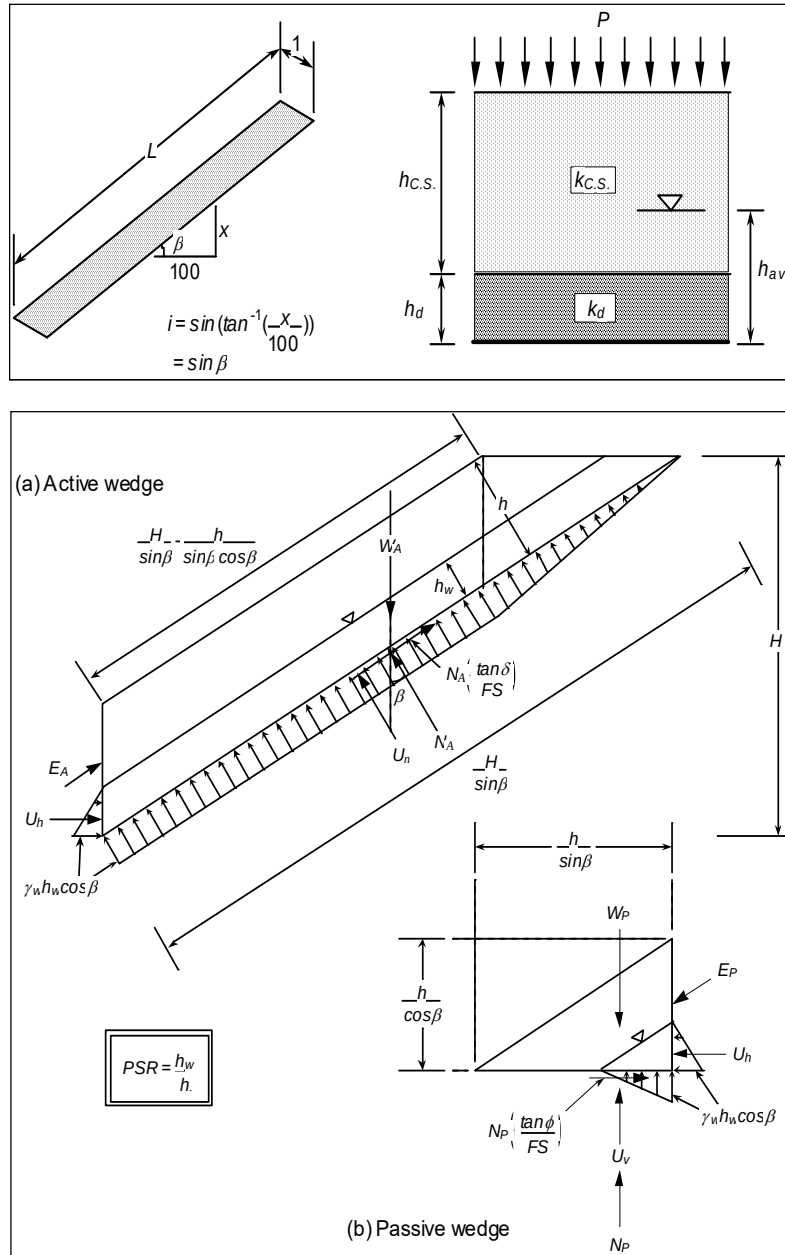
Veneer Stability – Static Seepage

COVER STABILITY (STATIC) CALCULATION WITH SEEPAGE FORCES

Project: Greater Lebanon Refuse Authority
 Location: Lebanon, PA
 Prepared by: SCS ENGINEERS
 Date: December 2017

Calc'd by: APM Date: 12/27/2017
 Chk'd by: RHI Date: 1/5/2018

Consideration: To evaluate the stability of the cover system with seepage forces applied using the method described by Koerner and Soong (1998) referenced below, using a minimum interface friction angle of 22 degrees



Ref.: R.M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceeding of 6th International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

COVER STABILITY (STATIC) CALCULATION WITH SEEPAGE FORCES

Parameters:

DLC	=	drainage layer capacity
$FLUX_{allow}$	=	allowable flow rate of the drainage layer per unit width of slope
k_d	=	permeability of drainage soil or geosynthetic
h_d	=	thickness of the drainage soil or geosynthetic
i	=	$\sin \beta$ = slope gradient
$FLUX_{req'd}$	=	actual flow rate per unit width of slope
PERC	=	the rate of percolation
P	=	probable maximum (hourly) precipitation (24-hr 25-year storm event)
RC	=	runoff coefficient
L	=	length of drainage slope
k_{cs}	=	permeability of cover soil
β	=	slope angle
w	=	1.0 m = unit width of drainage slope
PSR	=	parallel submergence ratio
h_{avg}	=	average head buildup above the geomembrane
h_{cs}	=	thickness of cover soil
FS	=	factor of safety against instability
W_A	=	total weight of the active wedge
W_P	=	total weight of the passive wedge
U_h	=	resultant of the pore pressures acting on the interwedge surfaces
U_n	=	resultant of the pore pressures acting perpendicular to the slope
U_v	=	resultant of the vertical pore pressures acting on the passive wedge
N_A	=	effective force normal to the failure plane of the active wedge
h	=	thickness of the cover soil
H	=	vertical height of the slope measured from the toe
h_w	=	$(PSR)(h)$ = height of the free water surface measured from the geomembrane
γ_{dry}	=	dry unit weight of the cover soil
$\gamma_{sat'd}$	=	saturated unit weight of the cover soil
γ_w	=	unit weight of water
ϕ	=	cover soil friction angle
δ	=	interface friction angle between cover soil and geomembrane

COVER STABILITY (STATIC) CALCULATION WITH SEEPAGE FORCES

Calculate Drainage Layer Capacity (DLC):

$$\begin{aligned} \text{PERC} &= P(1-RC), \text{ for } P(1-RC) \leq k_{cs} \\ \text{PERC} &= k_{cs}, \text{ for } P(1-RC) > k_{cs} \end{aligned}$$

$$\begin{aligned} k_{cs} &= 1.00\text{E-}06 \text{ cm/s} &= 3.60\text{E-}02 \text{ mm/hr} \\ P &= 6.70 \text{ mm/hr} \\ RC &= 0.60 \end{aligned}$$

$$P(1-RC) = 2.68 \text{ mm/hr}$$

$$\text{PERC} = 0.04 \text{ mm/hr}$$

$$\text{FLUX}_{\text{req'd}} = \frac{\text{PERC} \times L(\cos\beta) \times w}{1000}$$

$$\begin{aligned} L &= 48.00 \text{ m} \\ \beta &= 18.40^\circ &= 0.32 \text{ rad} \end{aligned}$$

$$L(\cos\beta) = 45.55 \text{ m}$$

$$\text{FLUX}_{\text{req'd}} = 0.002 \text{ m}^3/\text{hr}$$

$$\text{FLUX}_{\text{allow}} = k_d \times i \times h_d$$

$$\begin{aligned} k_d &= 4.00\text{E+}00 \text{ cm/s} &= 4.00\text{E-}02 \text{ m/s} \\ h_d &= 7.62 \text{ mm} &= 0.01 \text{ m} \\ i &= 0.32 \end{aligned}$$

$$\text{FLUX}_{\text{allow}} = 0.35 \text{ m}^3/\text{hr}$$

$$\text{DLC} = \frac{\text{FLUX}_{\text{allow}}}{\text{FLUX}_{\text{req'd}}}$$

$$\text{DLC} = 211.24$$

Notes:

- 1) If only one soil layer above geomembrane, treat it as a drainage layer.
- 2) DLC needs to be greater than one to avoid saturation of the drainage layer.

COVER STABILITY (STATIC) CALCULATION WITH SEEPAGE FORCES

Calculate Parallel Submergence Ratio (PSR):

$$h_{avg} = \frac{FLUX_{req'd}}{k_d \times i}, \text{ for } DLC \geq 1.0$$

$$h_{avg} = \frac{[FLUX_{req'd}/(3600 \times i)] - [h_d \times (k_d - k_{cs})]}{k_{cs}}, \text{ for } DLC < 1.0$$

$$h_{avg} \text{ for } DLC \geq 1.0 = 0.00 \text{ m}$$

$$h_{avg} \text{ for } DLC < 1.0 = -30335.70 \text{ m}$$

$$h_{avg} = 0.00 \text{ m}$$

$$PSR = \frac{h_{avg}}{h_{cs} + h_d}$$

if $PSR \geq 1$, set $PSR = 1$

$$h_{cs} = 610.00 \text{ mm} = 0.61 \text{ m}$$

$$PSR = 0.00$$

$$PSR = 0.00$$

Calculate Factor of Safety (FS):

$$W_A = \frac{\gamma_{dry}(h - h_w)[2H\cos\beta - (h + h_w)] + \gamma_{sat'd}(h_w)(2H\cos\beta - h_w)}{\sin 2\beta}$$

$$\gamma_{dry} = 18.07 \text{ kN/m}^3$$

$$\gamma_{sat'd} = 18.07 \text{ kN/m}^3$$

$$h = h_d + h_{cs} = 617.62 \text{ mm} = 0.62 \text{ m}$$

$$h_w = 0.04 \text{ mm} = 0.00 \text{ m}$$

$$H = L \times \sin\beta = 15.15 \text{ m}$$

$$W_A = 524.19 \text{ kN}$$

$$U_h = \frac{\gamma_w(h_w)^2}{2}$$

$$\gamma_w = 9.81 \text{ kN/m}^3$$

$$U_h = 0.00 \text{ kN}$$

$$U_n = \frac{\gamma_w(h_w)(\cos\beta)(2H\cos\beta - h_w)}{\sin 2\beta}$$

$$U_n = 0.02 \text{ kN}$$

COVER STABILITY (STATIC) CALCULATION WITH SEEPAGE FORCES

$$N_A = W_A(\cos\beta) + U_h(\sin\beta) - U_n$$

$$N_A = 497.38 \text{ kN}$$

$$W_P = \frac{\gamma_{dry}(h^2 - h_w^2) + \gamma_{sat'd}(h_w)^2}{\sin 2\beta}$$

$$W_P = 11.51 \text{ kN}$$

$$U_V = U_h(\cot\beta)$$

$$U_V = 0.00 \text{ kN}$$

$$FS = \frac{-b + (b^2 - 4ac)^{1/2}}{2a}$$

$$a = W_A(\sin\beta)(\cos\beta) - U_h(\cos^2\beta) + U_h$$

$$a = 157.00$$

$$b = -W_A(\sin^2\beta)(\tan\phi) + U_h(\sin\beta)(\cos\beta)(\tan\phi) - N_A(\cos\beta)(\tan\delta) - (W_P - U_V)(\tan\phi)$$

$$\begin{aligned} \phi &= 30.00^\circ = 0.52 \text{ rad} \\ \delta &= 19.00^\circ = 0.33 \text{ rad} \end{aligned}$$

$$b = -199.30$$

$$c = N_A(\sin\beta)(\tan\delta)(\tan\phi)$$

$$c = 31.21$$

$$FS = 1.09$$

Summary:

DLC	211.24
PSR	0.00
FS	1.09

At an interface friction angle of 19 degrees (and no cohesion) for the geosynthetic-soil interface, the factor of safety under seepage forces is calculated as 1.09, indicating that there is adequate shear strength available to prevent the cover system from sliding. Therefore the cover system is stable under the seepage forces and static slope conditions analyzed.

The resulting drainage layer capacity (DLC) of greater than 1.0, indicating the saturation of the cover soil above the liner would not occur. Therefore the anticipated flow capacity within the drainage layer is sufficient to handle a 25-year, 24-hour storm event (6 inches).

FORM 24 – ATTACHMENT B

Calculations

SOIL BEARING CAPACITY CALCULATION

Project: Greater Lebanon Refuse Authority
Location: Lebanon, PA
Prepared by: SCS ENGINEERS
Date: December 2017

Calc'd by: APM Date: Dec-17
Chk'd by: RHI Date: Dec-17

Consideration: To determine the allowable bearing capacity of the foundation soil due to landfill structure, using Terzaghi's Bearing Capacity Equations

Table 10.2
 N_c Bearing Capacity Factor Multipliers
for Various Values of B/L
(See figure 10.3)

B/L	multiplier
1 (square)	1.25
0.5	1.12
0.2	1.05
0.0	1.00
1 (circular)	1.20

Table 4-2 Bearing-capacity factors for the Terzaghi equations

Values of N_γ for ϕ of 34 and 48° are original Terzaghi values and used to back-compute K_{pr} for forward computations of N_γ by author

ϕ , deg	N_c	N_q	N_γ	K_{pr}
0	5.7	1.0	0.0	10.8
5	7.3	1.6	0.5	12.2
10	9.6	2.7	1.2	14.7
15	12.9	4.4	2.5	18.6
20	17.7	7.4	5.0	25.0
25	25.1	12.7	9.7	35.0
30	37.2	22.5	19.7	52.0
34	52.6	36.5	36.0	
35	57.8	41.4	42.4	82.0
40	95.7	81.3	100.4	141.0
45	172.3	173.3	297.5	298.0
48	258.3	287.9	780.1	
50	347.5	415.1	1153.2	800.0

Table 10.3
Terzaghi Bearing Capacity Factors
for General Shear³

ϕ	N_c	N_q	N_γ
0	5.7	1.0	0.0
5	7.3	1.6	0.5
10	9.6	2.7	1.2
15	12.9	4.4	2.5
20	17.7	7.4	5.0
25	25.1	12.7	9.7
30	37.2	22.5	19.7
34	52.6	36.5	35.0
35	57.8	41.4	42.4
40	95.7	81.3	100.4
45	172.3	173.3	297.5
48	258.3	287.9	780.1
50	347.5	415.1	1153.2

Table 10.4
 N_γ Multipliers for Various Values of B/L
(See figure 10.3)

B/L	multiplier
1.0 (square)	0.85
1.0 (circular)	0.70
0.5	0.90
0.2	0.95
0.0	1.0

Ref.: Michael R. Lindeburg, PE, 4th edition, 1986. Civil Engineering Reference Manual. Professional Publication, Inc., pp. 10-3 & 10-4. (Tables 10-2, 10-3, & 10-4)
Joseph E. Bowles. Third Edition, 1982. Foundation Analysis and Design. McGraw-Hill Book Company, pp.131-136. (Table 4-2)

Parameters:

L	=	longest lateral base dimension of the landfill footprint (ft.)	
B	=	least lateral base dimension of the landfill footprint (ft.)	
p_g	=	gross (or ultimate) bearing capacity or gross pressure (psf)	
p_{net}	=	net soil pressure (psf)	
FS	=	factor of safety, FS = 3 (average conditions)	
p_a	=	allowable soil pressure (psf)	
ρ	=	unit weight of the foundation soil (pcf)	
p_q	=	surface surcharge (psf)	
N_γ	=	bearing capacity factor	
N_c	=	bearing capacity factor	
N_q	=	bearing capacity factor	
S_γ	=	N_γ multiplier	
S_c	=	N_c multiplier	
ϕ	=	internal friction angle of foundation soil (degrees)	
D_f	=	depth of overburden soil (ft.)	
c	=	cohesion of the foundation soil (psf)	
H_w	=	maximum waste height (ft.)	
γ_w	=	unit weight of wet waste (pcf) (2025 pcy=)	75 pcf
Q_r	=	Maximum total waste overburden pressure required (psf)	
DR	=	design ratio	
K_{py}	=	from Table 4-2	

SOIL BEARING CAPACITY CALCULATION

Calculate Allowable Bearing Capacity (p_a):

$$p_g = 1/2 (\rho B N_\gamma) S_\gamma + c N_c S_c + (p_q + \rho D_f) N_q$$

, where

$$N_\gamma = 0.5 \tan \phi [(K_{p\gamma}/\cos^2 \phi) - 1]$$

$$N_c = (N_q - 1) \cot \phi = (N_q - 1)/\tan \phi$$

$$N_q = a^2/[2 \cos^2(45 + \phi/2)] (K_{p\gamma}/\cos^2 \phi - 1)$$

$$a = e^{(0.75\pi - \phi/2) \tan \phi}$$

$$p_{net} = p_g - \rho D_f$$

$$p_a = p_{net}/FS$$

$$Q_r = H_w \gamma_w$$

$$DR = p_a/Q_r$$

Input Data:

ρ =	120.00	pcf
B =	1750.00	ft
L =	1850.00	ft
D_f =	5.00	ft
ϕ =	30.00	°
$K_{p\gamma}$ =	52.00	
S_γ =	0.85	
S_c =	1.20	
FS =	3.00	
p_q =	0.00	psf
c =	0.00	psf
H_w =	220.00	ft
γ_w =	60.00	pcf

at $\phi = 30^\circ$

$$= 0.5236 \text{ rad}$$

Calculations:

$$\begin{aligned} a &= 3.351 \\ N_\gamma &= 19.73 \\ N_q &= 22.46 \\ N_c &= 37.16 \end{aligned}$$

$$\begin{aligned} p_g &= 1,774,031 \text{ psf} \\ p_{net} &= 1,773,431 \text{ psf} \\ p_a &= 591,144 \text{ psf} \end{aligned}$$

$$\begin{aligned} Q_r &= 13,200 \text{ psf} \\ DR &= 45 \quad \text{OK} \end{aligned}$$

Results: The design ratio (DR) equals 45 indicating that the bearing capacity of the foundation soil/rock is more than adequate to support the weight of the landfill at a maximum waste height equal to 220 feet and more. Note that the bearing capacity of the foundation soil layer is also indirectly computed in the global slope stability analysis using PCSTABL5M computer program, which gives a factor of safety of more than 1.5.

TABLE 1, GREATER LEBANON REFUSE AUTHORITY - SETTLEMENT ANALYSIS FOR EXPANSION

Station	Existing Grade	Base Grade	Cut/Fill	ΔP from Stress Change from Earthwork. Note 2	Top Final Cover Elevation	ΔP from Waste + Base + Final Cover Loading Note 2	P_i = Initial Loading at 25 feet below grade (soil). Note 2 and 4	P_i = Initial Loading at (Piggyback Waste Depth/2) feet below grade (waste). Note 2 and 4	Base Settlement. Notes 5, 6, 7, 8, 9, 10, 11 and 12		Piggyback Waste Depth	Expansion Waste Depth	Total Waste Depth	Long Term Settlement at 4% of Waste Depth (lower bound-heavy compaction). Note 12	Long Term Settlement at 15% of Waste Depth (upper bound-light compaction). Note 12
	(feet)	(feet)	(feet)	(psf)	(feet)	(psf)	(psf)	(psf)	(feet)	(inches)	(feet)	(feet)	(feet)	(feet)	(feet)
CS-1	2+00	486.18	487.95	1.77	221	487.95	0	3000	0	0.17	2.1	0.0	0	0.0	0.0
	4+00	499.06	490.97	-8.09	-1011	531.22	2415	3000	0	0.93	11.1	0.0	40.25	40.25	1.6
	6+00	499.24	496.24	-3.00	-375	589.21	5578	3000	0	2.43	29.2	0.0	92.97	92.97	3.7
	8+00	497.15	501.06	3.91	235	644.29	8594	3000	185	3.60	43.3	6.18	143.23	149.41	6.0
	10+00	504.91	509.07	4.16	250	705.09	11761	3000	558	4.89	58.7	18.61	196.02	214.63	8.6
	12+00	526.23	531.45	5.22	313	708.79	10640	3000	1157	5.52	66.3	38.55	177.34	215.89	8.6
	14+00	553.72	541.91	-11.81	-709	664.99	7385	3000	1415	4.33	51.9	47.17	123.08	170.25	6.8
	16+00	567.30	546.81	-20.49	-1229	612.8	3959	3000	1520	2.30	27.6	50.67	65.99	116.66	4.7
	18+00	551.40	555.3	3.90	234	555.3	0	3000	1703	0.25	3.0	56.76	0	56.76	2.3
CS-2	2+00	502.85	489.66	-13.19	-1649	529.52	2392	3000	0	0.53	6.4	0.0	39.86	39.86	1.6
	4+00	510.2	488.8	-21.40	-2675	584.74	5756	3000	0	1.71	20.5	0.0	95.94	95.94	3.8
	6+00	516.8	497.38	-19.42	-2427	640.29	8575	3000	0	2.69	32.3	0.0	142.91	142.91	5.7
	8+00	513.44	503.98	-9.46	-568	689.86	11153	3000	317	4.19	50.3	10.6	185.88	196.45	7.9
	10+00	514.02	524.01	9.99	599	710	11159	3000	966	5.47	65.7	32.2	185.99	218.19	8.7
	12+00	525.85	529.03	3.18	191	671.35	8539	3000	1080	4.76	57.1	36.0	142.32	178.33	7.1
	14+00	552.17	545.05	-7.12	-427	624.37	4759	3000	1471	3.24	38.9	49.0	79.32	128.34	5.1
	16+00	545.16	550.59	5.43	326	563.58	779	3000	1550	1.07	12.8	51.7	12.99	64.66	2.6
CS-3	2+00	546.01	545.08	-0.93	-56	565.2	1207	3000	1087	1.03	12.4	36.2	20.12	56.35	2.3
	4+00	550.86	543.16	-7.70	-462	620.39	4634	3000	991	2.87	34.5	33.1	77.23	110.28	4.4
	6+00	545.47	538.46	-7.01	-421	675.5	8222	3000	1199	4.57	54.8	40.0	137.04	176.99	7.1
	8+00	522.24	527.39	5.15	309	710	10957	3000	1030	5.44	65.2	34.3	182.61	216.93	8.7
	10+00	502.83	514.19	11.36	682	709.12	11696	3000	701	5.21	62.5	23.4	194.93	218.29	8.7
	12+00	506.75	509.88	3.13	188	681.96	10325	3000	510	4.49	53.8	17.0	172.08	189.08	7.6
	14+00	527.13	528.32	1.19	71	640.63	6739	3000	993	4.00	48.0	33.1	112.31	145.40	5.8
	16+00	550.6	546.72	-3.88	-233	592.58	2752	3000	1448	2.13	25.6	48.3	45.86	94.11	3.8
	18+00	550.17	548.76	-1.41	-85	548.76	0	3000	1385	-0.09	-1.1	46.2	0	46.15	1.8

Notes:

- 1 Assume final cover soil density = 120 pcf
- 2 Assume density of waste is = 60.0 pcf
- 3 Assume 2.0 feet bottom liner, 3.5 final cover
- 4 Assume existing soil density = 125 pcf
- 5 Assume existing soil void ratio $e = 0.35$ $G \sim 2.7$ 2.7
- 6 Compression Index for existing soil $C_c = 0.150$ (Basic Soil Engineering, B.K.Hough, 1969)
- 7 Assume existing waste void ratio $e = 1.25$ $G \sim 2.0$ 2.0
- 8 Compression Index for existing waste $C_c = 0.188$
- 9 Estimate settlement for 50 feet of shale and greywacke below landfill base (assumed to be average thickness of compressible layer)
- 10 Base Settlement Equation: $S = [C_c/(1+e)] \log((1+\Delta P)/P_i)$ where ΔP equals sum of "stress change from earthwork" + "waste+base+final cover loading"
- 11 Initial load at middle of compressible layer = $P_i = (40/2) \times 125 = 2500$ psf
- 12 Long Term Settlement: 4% Lower Bound = $0.04 \times \text{Waste Depth}$; 15% Upper Bound = $0.15 \times \text{Waste Depth}$

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Attachment 24-B: Stone Protusions into liner due to max. waste height - leachate collection trench (stone w/1-inch max size)	By DW	Date 4/19/2018
	Checked	Date
Sheet 1 of 1	MG	4/20/2018

PURPOSE:

Based on pressure over liner due to max waste, establish the maximum stone size allowable over liner in leachate collection trench that will not create a puncture hazard.

GIVEN:

- Double-layer geotextile (non-woven) will be placed above the liner, which is a 16 oz/sy geotextile cushion.
- Calculations based on those presented in Geomembrane Protection Design Manual, GSE, 1st Ed.
See Calculations section for factors involved.

- Maximum height of waste = 196 ft
- Maximum height of stone = 1.5 ft

ASSUMPTIONS:

- Geotextile mass per unit area used in calculations = 32 oz/yd²
- Provide a factor of safety, FS (based on Table 3.7, GPDM, 1st Ed.) = 3
- Maximum stone diameter allowable = 1 inches
- Unit weight of waste (average) = 55.5 lb/ft³
- Unit weight of stone = 110 lb/ft³

CALCULATIONS:

- Calculate allowable pressure, Pallow
Effective stone size, H' = MFpd * H
H, max protrusion size (max stone diameter) = 25.40 mm
MFpd, factor for packing density (packed stone) = 0.50
H' = 12.70 mm
Assume 10.0 mm for estimating related values (per recommendations of reference)
M, mass per unit area of geotextile (per assumed geotextile) = 1084.98 g/m²
FScr, factor of safety for creep (approx. from H' at 10 mm per reference) = 1.20
FScbd, factor of safety for chemical and bio. Degradation (recommended in reference) = 1.50
MFps, factor for protrusion shape (recommended in reference Table 3.5 for angular stone) = 1.00

Estimate allowable pressure on the geomembrane using reference equation (for 60 mil HDPE)

$$P_{allow} = [1 / (MFps * FScr * FScbd)] * [450 * (M / H'^2)] = 1681.73 \text{ kPa}$$
 (450 constant for conversion to kPa)

- Calculate pressure on liner system from waste, Pact
 Hw, height of waste = 59.74 m
 Yw, waste unit weight = 8.72 kN/m³
 Hs, height of stone = 0.46 m
 Ys, stone unit weight = 17.28 kN/m³

$$P_{act} = Hw * Yw + Hs * Ys = 528.73 \text{ kPa}$$

$$FS = P_{allow} / P_{act} = 3.18$$

CONCLUSIONS:

FS provided is greater than 3. The double geotextile layer thickness is adequate to protect the liner from 1-inch stone and waste loadings in leachate collection trench.

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Attachment 24-B: Stone Protusions into liner due to max. waste height (landfill floor)	By DW	Date 4/19/2018
	Checked	Date
Sheet 1 of 1	MG	4/20/2018

PURPOSE:

Based on pressure over liner due to max waste, establish the maximum stone size allowable over liner with protective cushion that will not create a puncture hazard.

GIVEN:

1. Geotextile (non-woven) layer will be placed above the liner, which is a 16 oz/sy geotextile cushion.
2. Calculations based on those presented in Geomembrane Protection Design Manual, GSE, 1st Ed. See Calculations section for factors involved.
3. Maximum height of waste = 196 ft
4. Maximum height of stone = 1.5 ft

ASSUMPTIONS:

1. Geotextile mass per unit area used in calculations = 16 oz/yd²
2. Provide a factor of safety, FS (based on Table 3.7, GPDm, 1st Ed.) = 3
3. Maximum stone diameter allowable = 0.5 inches
4. Unit weight of waste (average) = 55.5 lb/ft³
5. Unit weight of stone = 110 lb/ft³

CALCULATIONS:

1. Calculate allowable pressure, Pallow
Effective stone size, H' = MFpd * H
H, max protrusion size (max stone diameter) = 12.70 mm
MFpd, factor for packing density (packed stone) = 0.50
H' = 6.35 mm
Assume 10.0 mm for estimating related values (per recommendations of reference)
M, mass per unit area of geotextile (per assumed geotextile) = 542.49 g/m²
FScr, factor of safety for creep (approx. from H' at 10 mm per reference) = 1.50
FScbd, factor of safety for chemical and bio. Degradation (recommended in reference) = 1.50
MFps, factor for protrusion shape (recommended in reference Table 3.5 for angular stone) = 1.00

Estimate allowable pressure on the geomembrane using reference equation (for 60 mil HDPE)
$$Pallow = [1 / (MFps * FScr * FScbd)] * [450 * (M / H'^2)] = 2690.77 \text{ kPa}$$

(450 constant for conversion to kPa)

2. Calculate pressure on liner system from waste, Pact
Hw, height of waste = 59.74 m
Yw, waste unit weight = 8.72 kN/m³
Hs, height of stone = 0.46 m
Ys, stone unit weight = 17.28 kN/m³
$$Pact = Hw * Yw + Hs * Ys = 528.73 \text{ kPa}$$

$$FS = Pallow / Pact = 5.09$$

CONCLUSIONS:

FS provided is greater than 3. The geotextile layer thickness is adequate to protect the liner from 0.5-inch stone and waste loadings.

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject	By	Date
Attachment 24-B: Stone Protrusions into liner due to equipment loading/movement	DW	4/19/2018
	Checked	
Sheet 1 of 1	MG	4/20/2018

PURPOSE:

Based on equipment pressure over liner during installation, establish the maximum stone size allowable over liner with protective cushion that will not create a puncture hazard.

GIVEN:

- Geotextile (non-woven) layer will be placed above the liner, which is a 16 oz/sy geotextile cushion.
- Calculations based on those presented in Geomembrane Protection Design Manual, GSE, 1st Ed.
See Calculations section for factors involved.
- Pressure from bulldozer (per Caterpillar D3 literature) = 7.2 psi
D3 or smaller allowed on liner per specifications
- Maximum height of stone = 1.5 ft
- Dynamic braking pressure from dozer (assume half of static loading) = 3.6 psi

ASSUMPTIONS:

- Geotextile mass per unit area used in calculations (one layer, assuming no GDN)= 16 oz/yd²
- Provide a factor of safety, FS (based on Table 3.7, GPDM, 1st Ed.) = 3
- Maximum stone diameter allowable = 0.5 inches
- Unit weight of stone = 110 lb/ft³
- Neglect dozer pressure dissipation in stone.

CALCULATIONS:

- Calculate allowable pressure, Pallow
Effective stone size, H' = MFpd * H
H, max protrusion size (max stone diameter) = 12.70 mm
MFpd, factor for packing density (packed stone) = 0.50
H' = 6.35 mm
Assume 10.0 mm for estimating related values (per recommendations of reference)
M, mass per unit area of geotextile (per assumed geotextile) = 542.49 g/m²
FScr, factor of safety for creep (approx. from H' at 10 mm per reference) = 1.50
FScbd, factor of safety for chemical and bio. Degradation (recommended in reference) = 1.50
MFps, factor for protrusion shape (recommended in reference Table 3.5 for angular stone) = 1.00

Estimate allowable pressure on the geomembrane using reference equation (for 60 mil HDPE)

$$Pallow = [1 / (MFps * FScr * FScbd)] * [450 * (M / H'^2)] = 2690.77 \text{ kPa}$$

(450 constant for conversion to kPa)

- Calculate pressure on liner system from stone and equipment, Pact
Hs, height of stone = 0.46 m
Ys, stone unit weight = 17.28 kN/m³
Pdo, pressure from dozer = 49.64 kPa
Pb, dynamic braking pressure = 24.82 kPa
Pact = Hs * Ys + Pdo + Pb = 82.36 kPa

$$FS = Pallow / Pact = 32.67$$

CONCLUSIONS:

FS provided is greater than 3. The geotextile layer thickness is adequate to protect the liner from 0.75-inch stone and equipment loadings.

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Attachment 24-B: Stone Protrusions into liner due to vehicle loading/movement	By DW	Date 4/19/2018
Sheet 1 of 1	Checked MG	Date 4/20/2018

PURPOSE:

Based on vehicle pressure over liner during waste placement, establish the maximum stone size allowable over liner with protective cushion that will not create a puncture hazard.

GIVEN:

- Geotextile (non-woven) layer will be placed above the liner, which is a 16 oz/sy geotextile cushion.
- Calculations based on those presented in Geomembrane Protection Design Manual, GSE, 1st Ed.
See Calculations section for factors involved.
- Pressure from vehicle = 37.0 psi
(assuming 80,000 lbs, 3 axles, 10-wheel truck, contact area 1'x1.5' ea.)
- Initial waste height = 4.0 ft
- Maximum height of stone = 1.5 ft
- Dynamic braking pressure from vehicle (assume half of static loading) = 18.5 psi

ASSUMPTIONS:

- Geotextile mass per unit area used in calculations (one layer) = 16 oz/yd²
- Provide a factor of safety, FS (based on Table 3.7, GPDM, 1st Ed.) = 3
- Maximum stone diameter allowable = 0.5 inches
- Unit weight of stone = 110 lb/ft³
- Unit weight of initial waste = 48 lb/ft³
- Neglect vehicle pressure dissipation in stone.

CALCULATIONS:

- Calculate allowable pressure, Pallow
Effective stone size, H' = MFpd * H
H, max protrusion size (max stone diameter) = 12.70 mm
MFpd, factor for packing density (packed stone) = 0.50
H' = 6.35 mm
Assume 10.0 mm for estimating related values (per recommendations of reference)
M, mass per unit area of geotextile (per assumed geotextile) = 542.49 g/m²
FScr, factor of safety for creep (approx. from H' at 10 mm per reference) = 1.50
FScbd, factor of safety for chemical and bio. Degradation (recommended in reference) = 1.50
MFps, factor for protrusion shape (recommended in reference Table 3.5 for angular stone) = 1.00

Estimate allowable pressure on the geomembrane using reference equation (for 60 mil HDPE)

$$P_{allow} = [1 / (MFps * FScr * FScbd)] * [450 * (M / H'^2)] = 2690.77 \text{ kPa}$$
(450 constant for conversion to kPa)

- Calculate pressure on liner system from stone waste and vehicle, Pact
Hs, height of stone = 0.46 m
Ys, stone unit weight = 17.28 kN/m³
Hw, height of waste = 1.22 m
Yw, waste unit weight = 7.54 kN/m³
Pv, pressure from vehicle = 255.36 kPa
Pb, dynamic braking pressure = 127.68 kPa

$$P_{act} = Hs * Ys + Hw * Yw + Pv + Pb = 400.14 \text{ kPa}$$

$$FS = P_{allow} / P_{act} = 6.72$$

CONCLUSIONS:

FS provided is greater than 3. The geotextile layer thickness is adequate to protect the liner from 0.55-inch stone and vehicle loadings.

FORM 24 – ATTACHMENT C

Settlement Accommodation Plan



SETTLEMENT ACCOMMODATION PLAN
Greater Lebanon
Refuse Authority Landfill
Permit No. 101544

Submitted to:

**PENNSYLVANIA DEPARTMENT OF
ENVIRONMENTAL PROTECTION**

Waste Management Program
909 Elmerton Avenue
Harrisburg, PA 17110

On behalf of:

GREATER LEBANON REFUSE AUTHORITY

1610 Russell Road
Lebanon, PA 17046
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July 13, 2018

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SETTLEMENT ACCOMMODATION PLAN
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July 13, 2018

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Appendices

- A Site Plan & Cross Sections AA to RR
- B Settlement Calculations Cross Sections AA to RR

1 INTRODUCTION

This Settlement Accommodation Plan (SAP) is submitted as part of the Major Permit Modification for the Greater Lebanon Refuse Authority (GLRA) Landfill (Permit No. 101544) for the Heilmandale Expansion. This document provides the required narrative, calculations, cross sections, drawings, and analyses as required in the Standard Operating Procedures for Settlement Accommodation Plan, published by the Pennsylvania Department of Environmental Protection, 2014.

2 SITE HISTORY

The current disposal area (Shilling Farms) of the GLRA Landfill accepted waste starting in 1991. The Landfill has been developed in pads, Pads 1 through 7 comprising the current waste area. According to documentation provided by the facility, the waste composition in the Landfill is approximately 84 percent municipal solid waste (MSW), 15 percent construction and demolition (C&D) waste, and 1 percent sewage sludge.

3 EXPANSION SITE PLAN

The Heilmandale Expansion is depicted on the attached site plans and is subdivided into 6 separate pads, covering a total of 46.69 acres and as indicated below:

Pad# Heilmandale Expansion	Area (acres)
8	9.57
9	7.30
10	8.91
11	7.02
12	6.54
13	7.35

The pads will be constructed and filled in numerical order, with each pad taking 4 to 6 years, more or less, to be filled.

A plan view of the expansion area is shown on Drawings 1 in Appendix A, which depicts final permitted grades and indicates the area of existing waste, overall expansion boundary, and provides cross sections spaced at 100-foot intervals Drawings 2 through 6.

As required for the SAP, cross sections (Appendix A) show the top and bottom of existing waste elevations, top and bottom of proposed expansion waste elevations, and show the additional waste that will be placed and allowed to settle before capping commences. The thickness of additional waste is based on settlement computations, completed as described in the next section.

4 EXPANSION FILL SETTLEMENT CALCULATIONS

The thickness of additional waste that can be placed over permitted grades and allowed to settle over a 5-year time period are based on calculations of waste settlement performed at 100- foot intervals along Cross-Sections AA through RR, as shown on Drawing No. 1 in Appendix A. The cross-sections are spaced at 100- foot intervals within the waste limits as required for the SAP. The actual settlement calculations are included in Appendix B, which indicate existing and proposed waste thickness data at 100 foot intervals along each cross-section.

The estimated settlements were calculated following empirical methods developed by Sowers (1973), “Settlement of Waste Disposal Fills,” as well as published information on waste settlement measurements presented in “Prediction of Attenuation of Landfill Settlement Rates With Time”, by Courmoulus and Koryalos, 1997. The latter data was useful in checking the Sowers’ calculations which provides secondary compression coefficient values for waste materials consistent with waste from the early 1970s. Waste material composition, placement and compaction procedures have changed over the recent decades, which justifies use of settlement measurements from other sites.

Based on Sowers’ approach, long-term settlement (secondary compression) for a waste fill of this type occurs primarily due to decomposition of organic components over time (and which generate methane gas). Sowers’ methods are widely accepted in the waste industry, and dependent on the waste thickness, waste types, age, compaction and density. For this model, we assumed that the waste types, daily cover, and density are generally similar throughout the life of the landfill, which is conservative and will estimate less settlement than is likely to occur.

Sowers’ relationship for secondary waste compression is:

$$S = H * (C_s / (1 + e_0)) * \log(t_2 / t_1) \quad \text{Equation 1}$$

Where, S is the settlement over time, H is the initial waste thickness, e_0 is the initial waste void ratio, C_s is the secondary compression factor, and t_1 and t_2 are time factors.

For this analysis, the difference between t_1 and t_2 is 5 years, which represents the time between end of active filling and beginning of final closure cap construction. However, Sowers is not specific regarding how the time factors are to be calculated, and it is sometimes assumed (Yen and Scanlon, 1975)¹ that the time factors are based on the median age of the fill, which is taken from midpoint of construction (active filling) history. However, the Ohio EPA GeoRG Manual (2004) indicates that t_1 is the time to complete “primary consolidation.” Other interpretations of the time factors are presented in the literature. But, based on our experience with settlement monitoring of new waste fills, and comparison with actual measurements at other sites, we believe it is appropriate to assume $t_1 = 1$ year and $t_2 = 1 + 5 = 6$ years for the calculations with the expansion waste. For the existing waste, which has been in place since 1971 to 1991, time factors using median ages, as presented by Yen & Scanlon, are appropriate.

¹ Yen, B. C., and B. S. Scanlon. 1975. — Sanitary Landfill Settlement Rates.

Regarding the secondary compression factor C_s , Sowers defined this value as a function of the initial waste void e_0 , and was estimated to range from $0.03 \cdot e_0$ to $0.09 \cdot e_0$. The lowerbound C_s value relates to “conditions unfavorable to decomposition”, while the upperbound C_s value relates to “conditions favorable to decay.” However, as noted above, waste composition has changed significantly since 1973, including more organic matter in many cases, we have found that the upper bound C_s are more reliable for estimating long-term settlement and propose using $0.08e_0$ for this SAP.

Assuming an initial waste void ratio, e_0 of approximately 2.50, which is consistent with a wet waste density of about 1250 pounds per cubic yard, the secondary compression coefficient is $C_s = 0.08 \times 2.50 = 0.20$.

Using the parameters described above, we estimated waste settlement that is likely to occur five years beyond end of active filling. Estimates are provided for cross sections AA to RR and include the contribution of both existing (old) waste and expansion (new) waste. Since waste filling is essentially continuous, with waste placed over waste from the previous day, the influence of the physical loading (weight) from each lift of waste is not necessary to consider.

In addition to estimating settlement using empirical modeling, we also compared the results to published information on waste settlement presented in “Prediction of Attenuation of Landfill Settlement Rates With Time”, by Courmoulus and Koryalos, 1997. Based on settlement measurements from closed sites in the US and internationally, they identified a range of C_a values (where $C_a = C_s / (1 + e_0)$) from 0.26 to 0.02. For this analysis, $C_a = 0.20 / (1 + 2.5) = 0.057$. Using the figure below, settlement of new waste will range from 4.68 percent of waste thickness per year (0.39 percent per month) in the first year to 0.24 percent per year (0.20 percent per month) in year five. As summarized below, this method predicts an average settlement rate of 7.92 percent of thickness over a 5 year period.

Conservatively, for this SAP, we estimated settlements would be 7.5 percent of the new waste thickness. To be conservative, we did not include settlement contributions from the existing waste, which is relatively old and highly decomposed and the potential for future settlement is negligible.

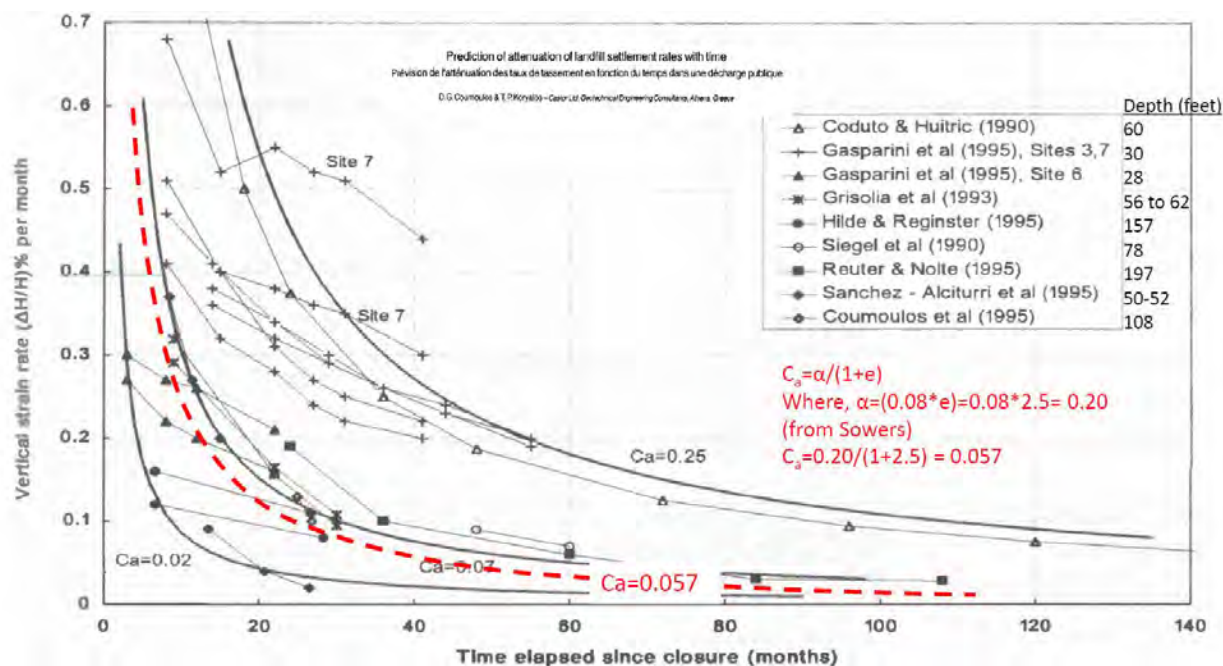


Figure 4. Published settlement data plotted in terms of vertical strain rates vs. elapsed time since closure.

Estimated settlements rates over each of the five years is summarized below, which is based on the thickness of new waste. In the first year after filling ends for each pad, settlement will be approximately 4.68 percent of the new waste thickness, which corresponds to 59.1 percent of the total overfill thickness. Each succeeding year, the rate of settlement will decrease in magnitude and percentage of waste thickness.

Year	Vertical Strain Per Month at Mid-year for $C_a=0.057$ (% of expansion waste thickness)	Vertical Strain Per Year at Mid-year for $C_a=0.057$ (% of expansion waste thickness)	Overfill Settlement per Year (% of Total Settlement)
1	0.39	4.68	59.1
2	0.13	1.56	19.7
3	0.08	0.96	12.1
4	0.04	0.48	6.1
5	0.02	0.24	3.0
Total	0.66	7.92	

As an example, where the thickness of the expansion waste is 40 feet, the waste surface would be expected to settle at least 3.2 feet total over five years, with the settlement of 1.9 feet the first year, and 0.6 feet the second year. Settlement rates for the final three years will continue to decrease.

5 SETTLEMENT MONITORING PROGRAM

As required, settlement of filled areas will be monitored by survey with surface settlement plates, survey hubs, or similar devices placed on the waste surface at approximately 200 foot spacing. An off-site bench-mark (off of the waste footprint) will be used for the baseline elevation values.

The actual locations of settlement monitoring points will be field-determined, so they are accessible by a surveyor, and kept away from areas where disturbance from equipment or vibrations are likely to occur, and well away from drainage ways and similar features. However, the settlement plate locations will be at approximate 200 foot spacing in most areas, or roughly 2 per acre.

To avoid impact of frost heave during cold weather periods, the settlement devices will need to be embedded below frost penetration depth applies to this area or as needed to be unaffected by frost heave.

Monitoring frequency will initially be on a quarterly basis for the first year, when settlement rates are more pronounced, but reducing to semi-annual for the final four years of the five-year period. Monitoring frequency may need to be amended based on the actual results.

Settlement measurements will be provided to the facility operator and engineer for review and comparison to predictions. Should settlement measurements be significantly higher or lower than predicted, the SAP will be amended to reflect actual values.

6 SAP GRADING PLAN & VOLUME

Reference is made to cross sections AA to RR in Appendix A, which cover the expansion area at 100-foot intervals, and depict (1) base grades, (2) thickness of existing waste, (3) thickness of expansion waste, (4) final (permitted) grades, and (5) proposed SAP grades. The proposed SAP grades extend above the permit grades and represent the elevation that waste can be placed before filling is terminated. Once filling is terminated, the waste column will be allowed to settle under its own weight for a period of up to five years at which time the grades should be at or below permit level, and final capping may commence.

The SAP grades were based on settlement computations taken along the sections at 100-foot intervals and calculations presented in Appendix B. The overall range of settlement values is from 0 feet to a maximum of 14.7 feet (Section JJ, 11+00), which is based on a maximum overfill equal to 7.5 percent of the new waste thickness. This is slightly less than the 7.92 percent value estimated from the work by Courmoulus and Koryalos, Prediction of Attenuation of Landfill Settlement Rates With Time, 1997. The 7.5 percent value is considered more realistic than simply applying Sowers' calculations and in each case is less than the allowable 10 percent value.

Based on our modeling, the average settlement over the entire footprint is estimated to be 7 feet, which corresponds to a total overfill volume of 527,285 cubic yards.

Due to the relatively small changes in elevations predicted across many areas of the site (e.g. 3 feet or less), and difficulty in showing the information clearly at the graphical scales necessary, separate grading plan(s) were not developed for this SAP. However, the SAP grades are easily transferred to operations division to incorporate into the final model.

It is expressly stated that proposed final grades will be complied with before placement of a final cover system, and that grades will be adjusted prior to capping. If modifications to the SAP are necessary, they will be submitted in conjunction with the Annual Operations Report (AOR).

7 SLOPE STABILITY

No significant changes to the previous slope stability computation are needed as the waste slopes will change very little with the added waste. The slope stability computations can be found in Attachment 24-A.

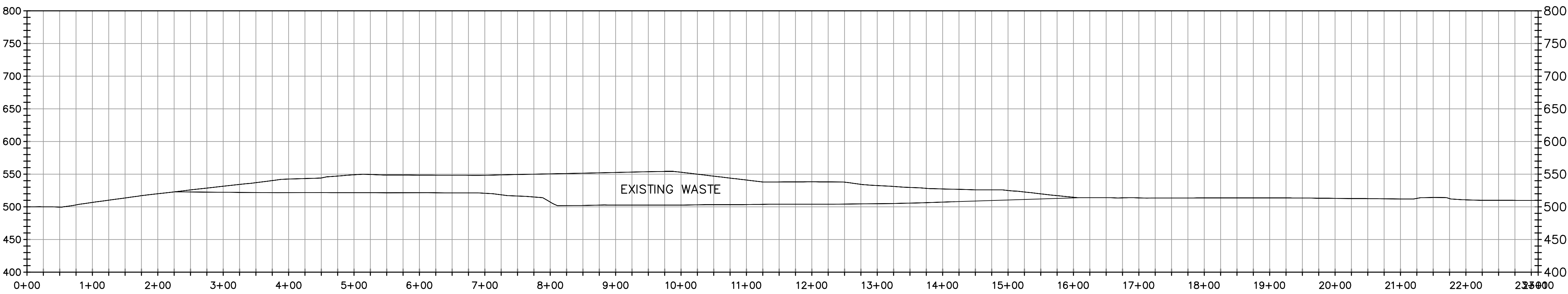
8 VENEER STABILITY

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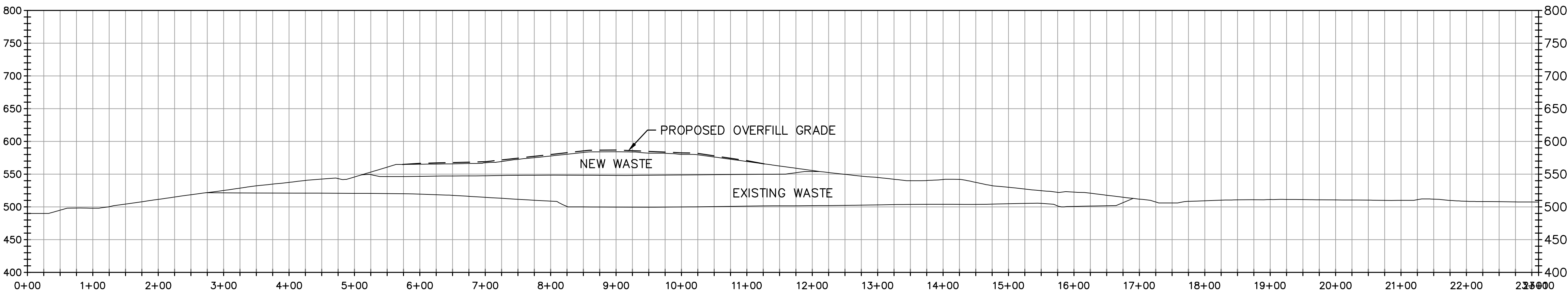
9 STORMWATER MANAGEMENT

No significant changes to the Stormwater Management Plan included in Form I, Section F, are needed as the waste slopes will change very little with the added waste.

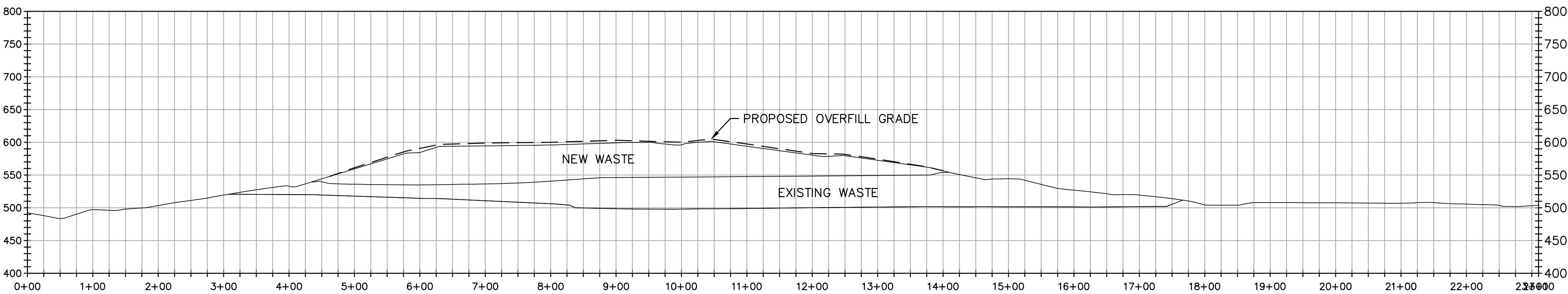
APPENDIX A
SITE PLAN & CROSS SECTIONS AA TO RR



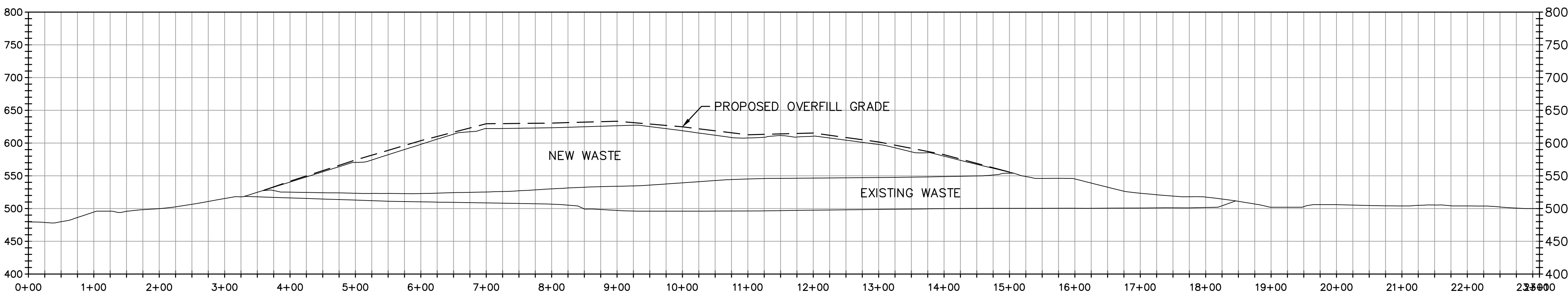
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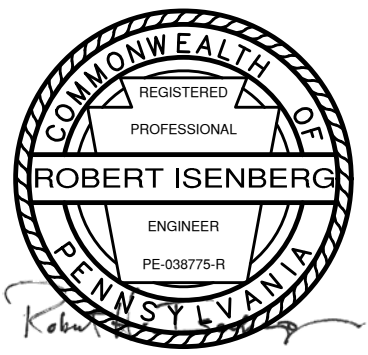
SECTION B-B PROFILE



SECTION C-C PROFILE



SECTION D-D PROFILE



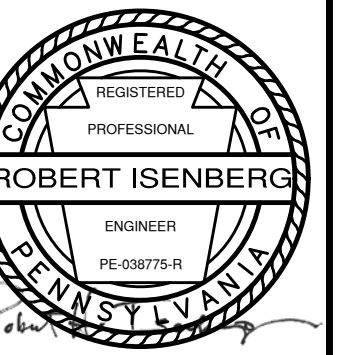
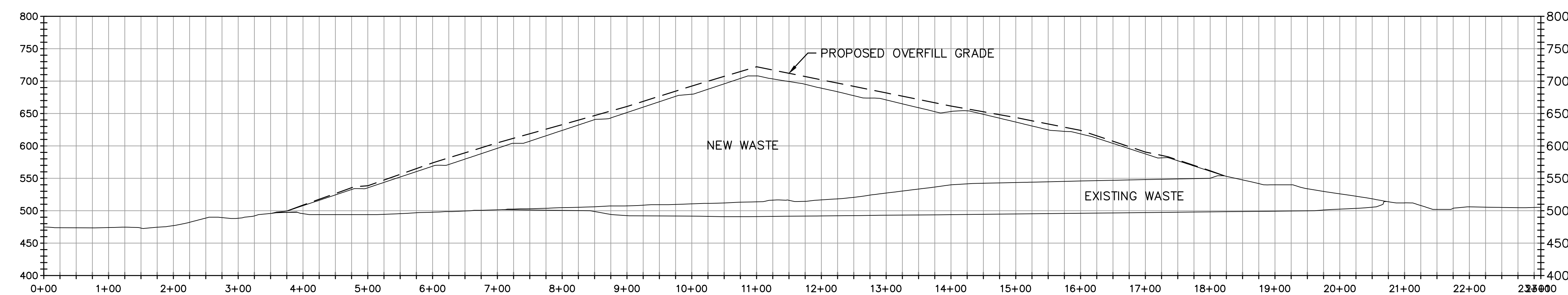
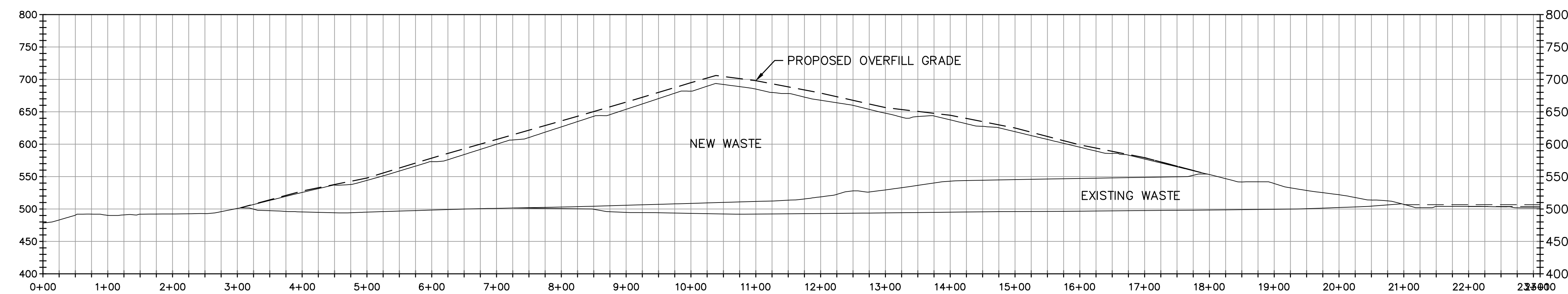
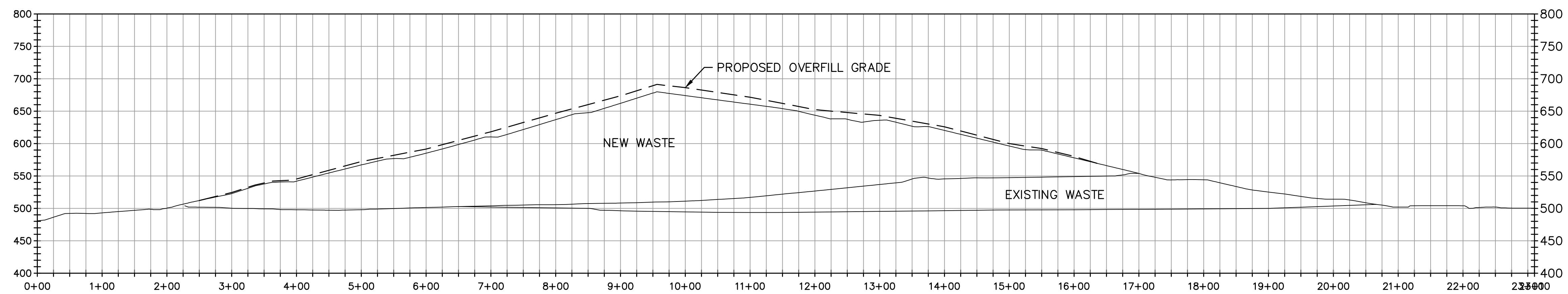
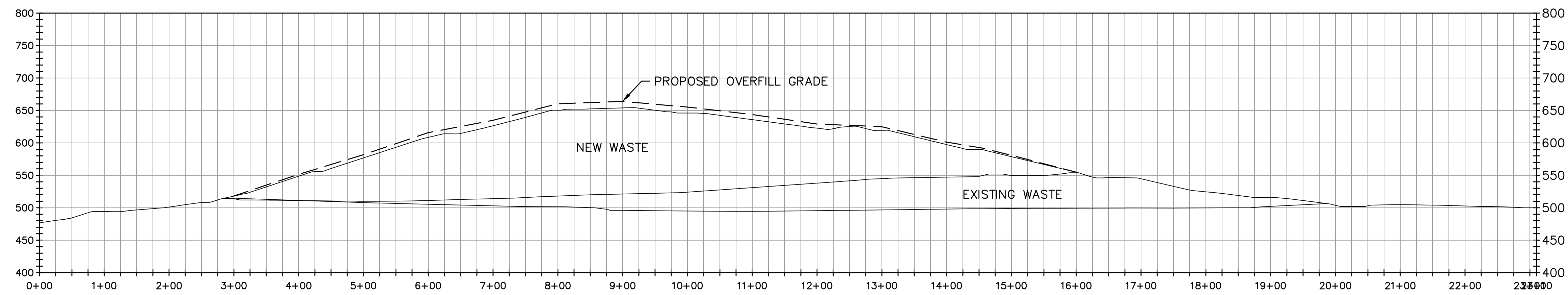
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PROJECT TITLE	XS - AA THROUGH DD
PROJECT TITLE	HEILMANDALE EXPANSION PHASE II PERMIT MODIFICATION

CLIENT	GREATER LEBANON REFUSE AUTHORITY 1610 RUSSELL ROAD LEBANON, PENNSYLVANIA 17046

SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS, INC. 11260 ROGER BACON DRIVE - RESTON, VA 20190 PH. (703) 471-6150 FAX. (703) 471-6876	Q/A BY: DW
	APP. BY: DW
PROJ. NO. 02215800.05	DWG. BY: APM
CHK. BY: RHI	APP. BY: DW

CADD FILE:
DATE: JULY 2018
SCALE:
DRAWING NO. 2 of 6

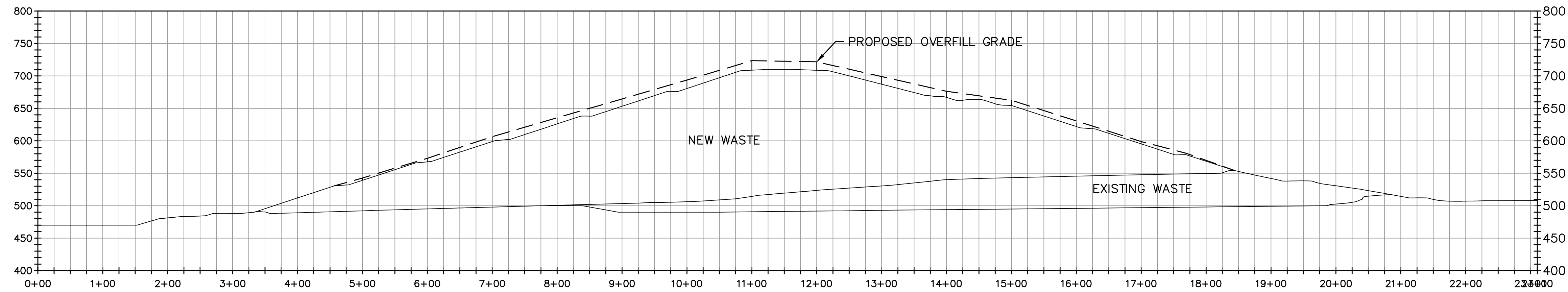
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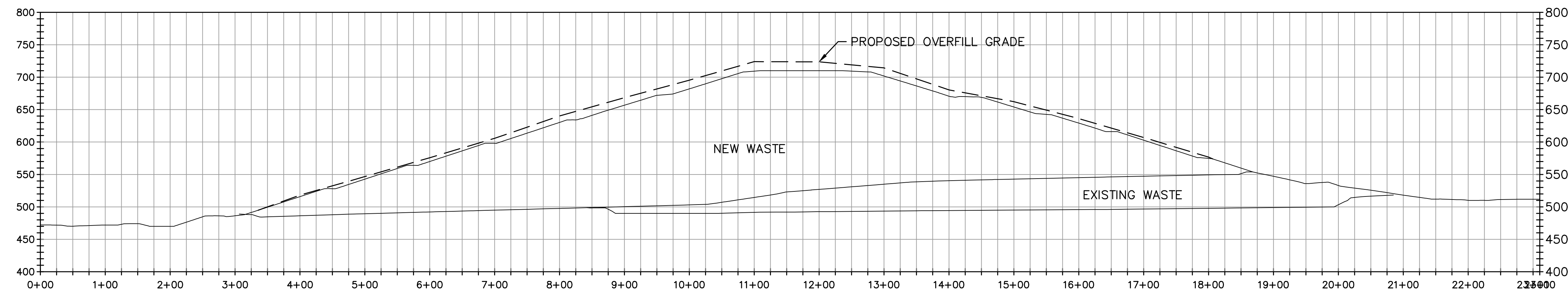
**GREATER LEBANON
REFUSE AUTHORITY**
1610 RUSSELL ROAD
LEBANON, PENNSYLVANIA 17046

PROJ. NO.	02215800.05	DWN. BY:	APM	Q/A R/W BY:	DW
DSN. BY:	RHI	CHK. BY:	DW	APP. BY:	DW

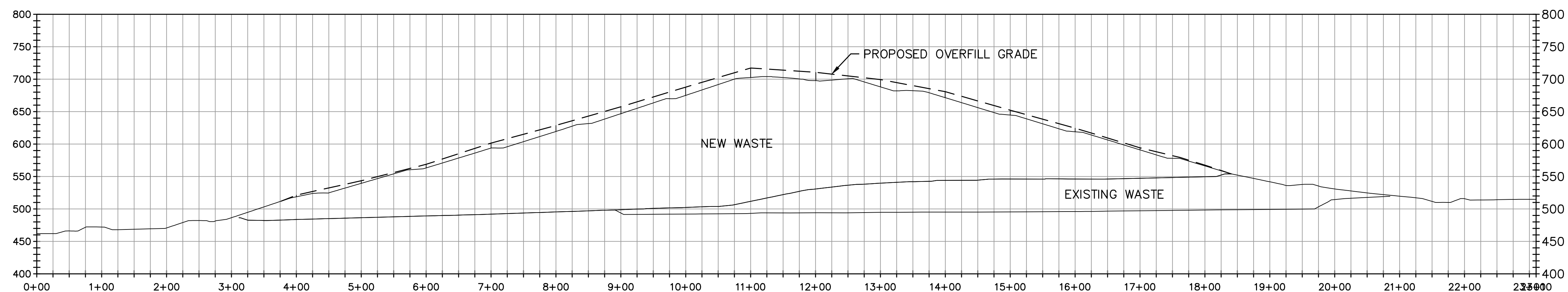
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AWING NO.



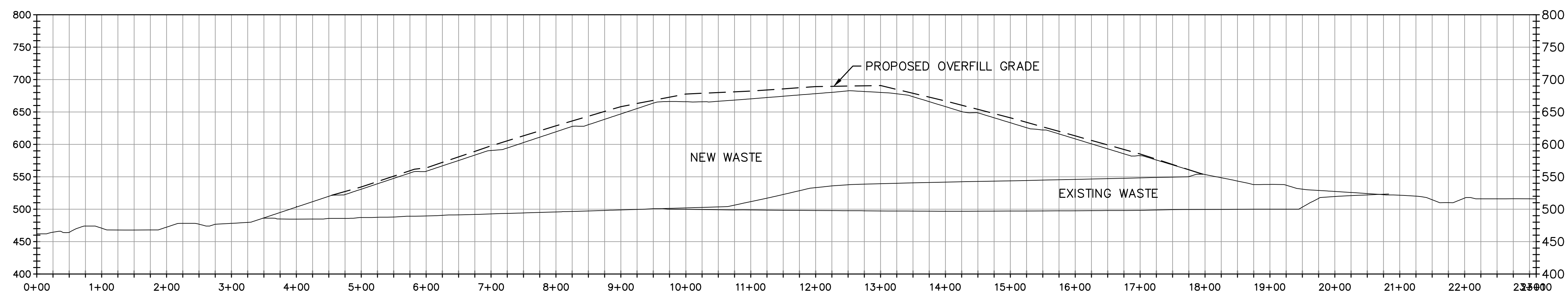
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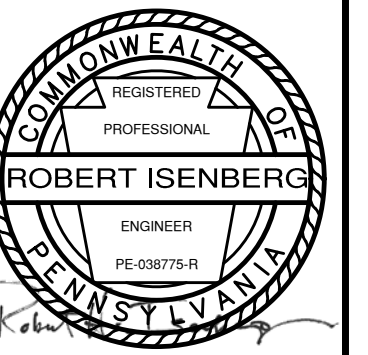
SECTION J-J PROFILE



SECTION K-K PROFILE



SECTION L-L PROFILE



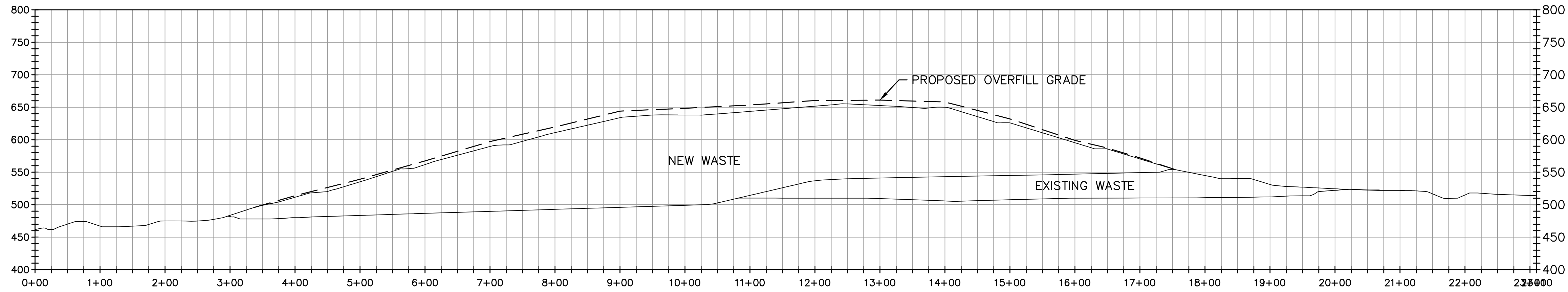
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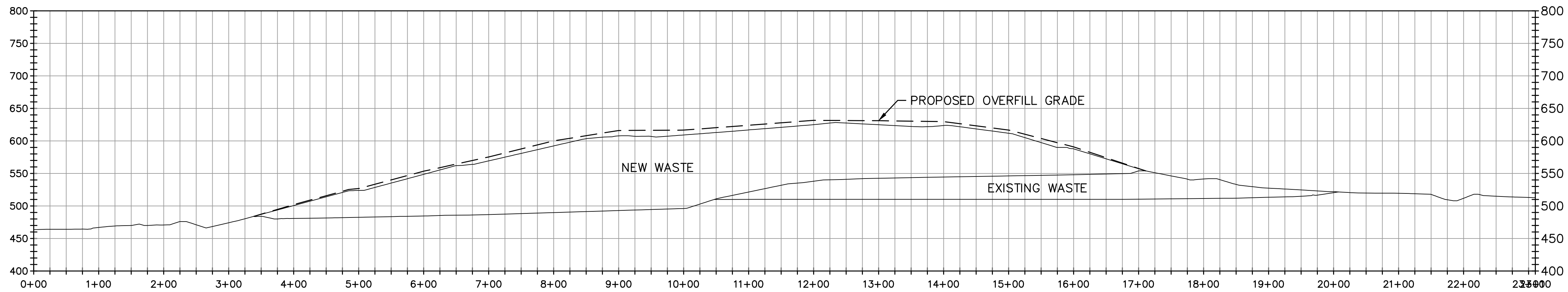
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GREATER LEBANON REFUSE AUTHORITY 1610 RUSSELL ROAD LEBANON, PENNSYLVANIA 17046

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STEARN, CONRAD AND SCHMIDT CONSULTING ENGINEERS, INC. 11260 ROGER BACON DRIVE - RESTON, VA 20190 PH. (703) 471-6150 FAX. (703) 471-6876	02215800.05	JULY 2018	APM	DW		
	BSK	RHL				

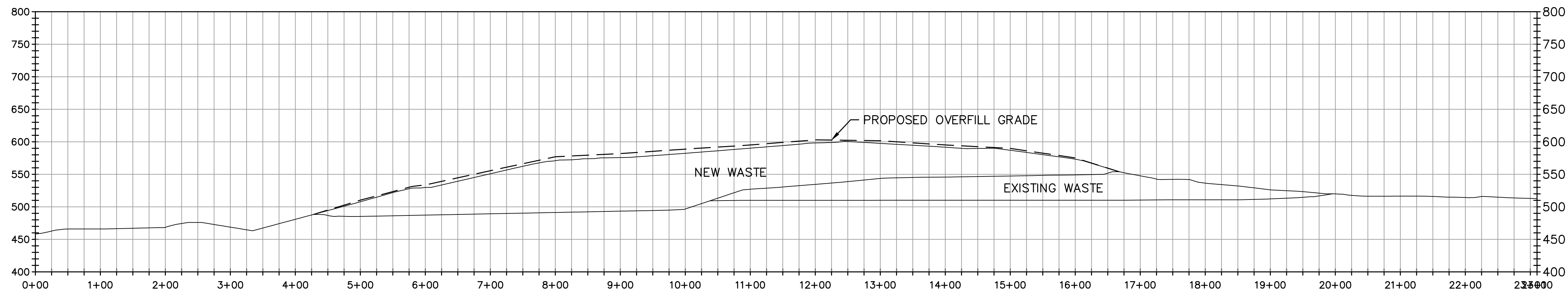
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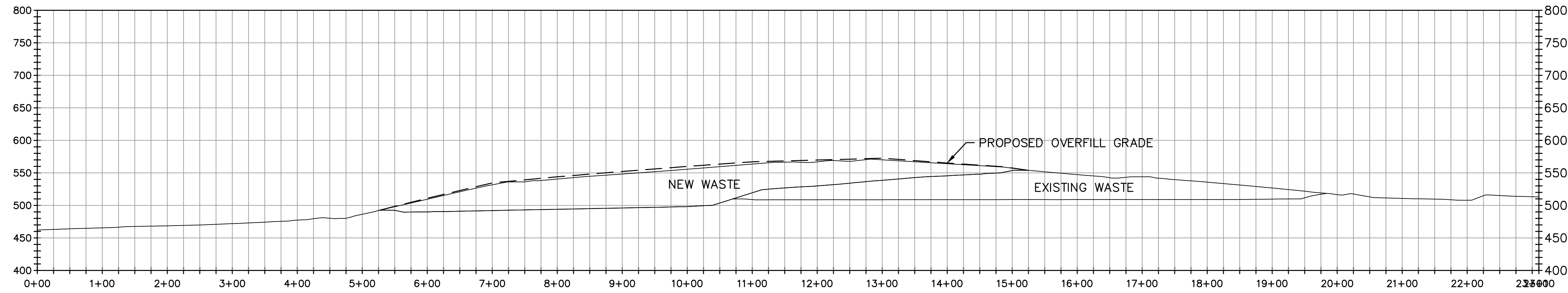
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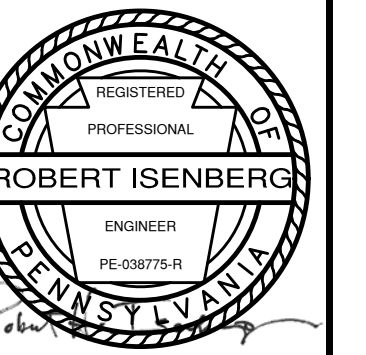
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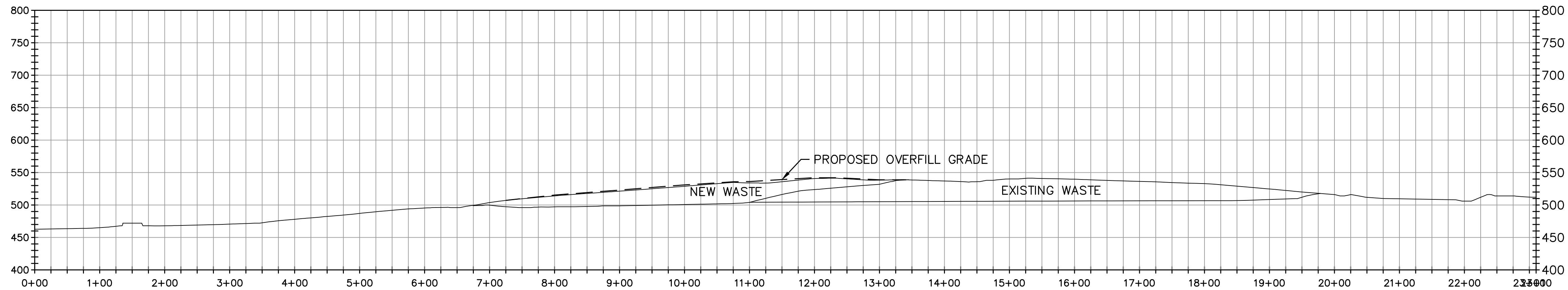
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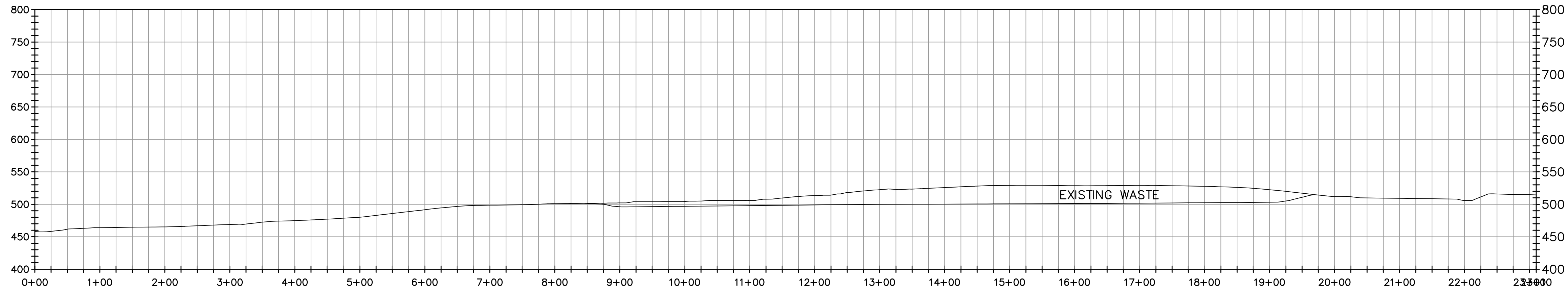
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GREATER LEBANON REFUSE AUTHORITY 1610 RUSSELL ROAD LEBANON, PENNSYLVANIA 17046

SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS, INC. 11260 ROGER BACON DRIVE - RESTON, VA 20190 PH. (703) 471-6150 FAX. (703) 471-6876	DESIGNED BY: APM	CHECKED BY: DW	IN CHARGE BY: RHL
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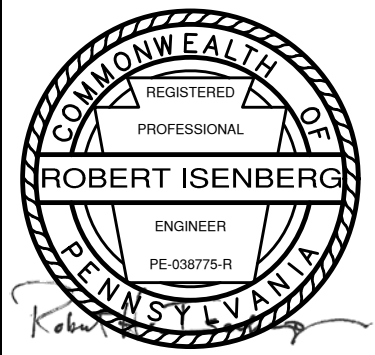
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SECTION Q-Q PROFILE



SECTION R-R PROFILE



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PROJECT TITLE	XS - QQ THROUGH PP
	HEILMANDALE EXPANSION
	PHASE II PERMIT MODIFICATION

CLIENT	GREATER LEBANON REFUSE AUTHORITY 1610 RUSSELL ROAD LEBANON, PENNSYLVANIA 17046

SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS, INC. 11260 ROGER BACON DRIVE - RESTON, VA 20190 PH. (703) 471-6150 FAX. (703) 471-6576	DESIGNER	CHECKER	APPROVER	DATE
	BY: [Signature]	BY: [Signature]	BY: [Signature]	2018

CADD FILE:
DATE: JULY 2018
SCALE:
DRAWING NO. 6 of 6

APPENDIX B

SETTLEMENT CALCULATIONS
CROSS SECTIONS AA TO RR

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION A-A	1+00	506	506	-	-	-	0.00	N/A	0.00	N/A	N/A
	2+00	520	520	-	-	-	0.00	N/A	0.00	N/A	N/A
	3+00	522	532	-	-	10	0.03	N/A	0.03	0.31	N/A
	4+00	522	542	-	-	20	0.06	N/A	0.06	0.31	N/A
	5+00	522	549	-	-	27	0.08	N/A	0.08	0.31	N/A
	6+00	522	549	-	-	27	0.08	N/A	0.08	0.31	N/A
	7+00	521	549	-	-	28	0.09	N/A	0.09	0.31	N/A
	8+00	507	550	-	-	43	0.13	N/A	0.13	0.31	N/A
	9+00	503	553	-	-	50	0.15	N/A	0.15	0.31	N/A
	10+00	503	553	-	-	50	0.15	N/A	0.15	0.31	N/A
	11+00	504	538	-	-	34	0.10	N/A	0.10	0.31	N/A
	12+00	504	538	-	-	34	0.10	N/A	0.10	0.31	N/A
	13+00	505	532	-	-	27	0.08	N/A	0.08	0.31	N/A
	14+00	507	527	-	-	20	0.06	N/A	0.06	0.31	N/A
	15+00	510	525	-	-	15	0.05	N/A	0.05	0.31	N/A
	16+00	514	515	-	-	1	0.00	N/A	0.00	0.31	N/A
	17+00	514	514	-	-	-	0.00	N/A	0.00	N/A	N/A
	18+00	514	514	-	-	-	0.00	N/A	0.00	N/A	N/A
	19+00	514	514	-	-	-	0.00	N/A	0.00	N/A	N/A
	20+00	513	513	-	-	-	0.00	N/A	0.00	N/A	N/A
	21+00	512	512	-	-	-	0.00	N/A	0.00	N/A	N/A
	22+00	511	511	-	-	-	0.00	N/A	0.00	N/A	N/A
	23+00	510	510	-	-	-	0.00	N/A	0.00	N/A	N/A

Sower's 1973 Formula

$$S = H \left(\frac{C_\alpha}{1 + e} \right) \left[\log \left(\frac{t_2}{t_1} \right) \right]$$

Where:

S = Settlement at 5 years after end of filling (before closure capping)

H = Depth of Waste (existing plus new waste)

C = Secondary Compression Index 0.2 (based on Sowers, 1973)

e = Initial Void Ratio 2.50 (assuming wet density = 45 pcf @ 25% moisture content; dry density = 36 pcf)

t2=time to end of filling plus 5 years

t1=time to end of filling

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION B-B	1+00	498	498	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	511	511	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	521	525	-	-	4	0.01	0.00	0.01	0.29	0.00
	4+00	521	537	-	-	16	0.05	0.00	0.05	0.29	0.00
	5+00	521	545	-	-	24	0.07	0.00	0.07	0.29	0.00
	6+00	519	547	565	18	46	0.08	0.80	0.88	1.91	1.35
	7+00	514	547	568	21	54	0.09	0.93	1.03	1.90	1.58
	8+00	509	548	578	30	69	0.11	1.33	1.45	2.09	2.25
	9+00	500	548	584	36	84	0.14	1.60	1.74	2.07	2.70
	10+00	500	549	580	31	80	0.14	1.38	1.52	1.90	2.33
	11+00	501	550	569	19	68	0.14	0.84	0.98	1.45	1.43
	12+00	502	554	555	1	53	0.15	0.04	0.19	0.36	0.08
	13+00	503	544	-	-	41	0.12	0.00	0.12	0.29	0.00
	14+00	504	542	-	-	38	0.11	0.00	0.11	0.29	0.00
	15+00	505	530	-	-	25	0.07	0.00	0.07	0.29	0.00
	16+00	500	522	-	-	22	0.06	0.00	0.06	0.29	0.00
	17+00	512	512	-	-	-	0.00	0.00	0.00	N/A	0.00
	18+00	511	511	-	-	-	0.00	0.00	0.00	N/A	0.00
	19+00	511	511	-	-	-	0.00	0.00	0.00	N/A	0.00
	20+00	510	510	-	-	-	0.00	0.00	0.00	N/A	0.00
	21+00	510	510	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	508	508	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	508	508	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION C-C	1+00	497	497	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	503	503	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	520	520	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	520	532	-	-	12	0.03	0.00	0.03	0.27	0.00
	5+00	518	536	560	24	42	0.05	1.07	1.12	2.66	1.80
	6+00	515	535	584	49	69	0.05	2.18	2.23	3.24	3.68
	7+00	510	537	595	58	85	0.07	2.58	2.65	3.12	4.35
	8+00	506	541	596	55	90	0.10	2.45	2.54	2.82	4.13
	9+00	499	546	599	53	100	0.13	2.36	2.48	2.48	3.98
	10+00	498	547	597	50	99	0.13	2.22	2.36	2.38	3.75
	11+00	499	548	594	46	95	0.13	2.05	2.18	2.29	3.45
	12+00	500	549	581	32	81	0.13	1.42	1.56	1.92	2.40
	13+00	501	550	572	22	71	0.13	0.98	1.11	1.57	1.65
	14+00	502	553	556	3	54	0.14	0.13	0.27	0.50	0.23
	15+00	502	544	-	-	42	0.11	0.00	0.11	0.27	0.00
	16+00	502	526	-	-	24	0.07	0.00	0.07	0.27	0.00
	17+00	501	517	-	-	16	0.04	0.00	0.04	0.27	0.00
	18+00	504	504	-	-	-	0.00	0.00	0.00	N/A	0.00
	19+00	508	508	-	-	-	0.00	0.00	0.00	N/A	0.00
	20+00	508	508	-	-	-	0.00	0.00	0.00	N/A	0.00
	21+00	507	507	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	506	506	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	502	502	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION D-D	1+00	495	495	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	500	500	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	515	515	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	516	525	541	16	25	0.02	0.71	0.73	2.94	1.20
	5+00	513	523	571	48	58	0.03	2.13	2.16	3.72	3.60
	6+00	510	523	598	75	88	0.03	3.33	3.37	3.83	5.63
	7+00	509	525	622	97	113	0.04	4.31	4.35	3.85	7.28
	8+00	507	530	624	94	117	0.06	4.18	4.24	3.62	7.05
	9+00	497	534	626	92	129	0.09	4.09	4.18	3.24	6.90
	10+00	495	539	619	80	124	0.11	3.56	3.67	2.96	6.00
	11+00	496	545	609	64	113	0.12	2.85	2.97	2.63	4.80
	12+00	498	547	611	64	113	0.12	2.85	2.97	2.63	4.80
	13+00	499	547	598	51	99	0.12	2.27	2.39	2.41	3.83
	14+00	500	549	579	30	79	0.12	1.33	1.46	1.84	2.25
	15+00	500	554	555	1	55	0.14	0.04	0.18	0.33	0.08
	16+00	500	545	-	-	45	0.11	0.00	0.11	0.25	0.00
	17+00	501	523	-	-	22	0.06	0.00	0.06	0.25	0.00
	18+00	502	518	-	-	16	0.04	0.00	0.04	0.25	0.00
	19+00	502	502	-	-	-	0.00	0.00	0.00	N/A	0.00
	20+00	506	506	-	-	-	0.00	0.00	0.00	N/A	0.00
	21+00	504	504	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	504	504	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	500	500	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION E-E	1+00	493	493	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	501	501	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	514	514	518	4	4	0.00	0.18	0.18	N/A	0.30
	4+00	511	511	549	38	38	0.00	1.69	1.69	4.45	2.85
	5+00	508	510	576	66	68	0.00	2.93	2.94	4.32	4.95
	6+00	505	511	608	97	103	0.01	4.31	4.33	4.20	7.28
	7+00	503	514	626	112	123	0.03	4.98	5.01	4.07	8.40
	8+00	502	518	650	132	148	0.04	5.87	5.91	3.99	9.90
	9+00	496	521	654	133	158	0.06	5.91	5.97	3.78	9.98
	10+00	495	524	647	123	152	0.07	5.47	5.54	3.64	9.23
	11+00	495	531	636	105	141	0.08	4.67	4.75	3.37	7.88
	12+00	496	538	622	84	126	0.10	3.74	3.83	3.04	6.30
	13+00	497	545	620	75	123	0.11	3.33	3.45	2.80	5.63
	14+00	498	548	597	49	99	0.12	2.18	2.29	2.32	3.68
	15+00	499	550	578	28	79	0.12	1.25	1.36	1.73	2.10
	16+00	500	554	555	1	55	0.13	0.04	0.17	0.31	0.08
	17+00	500	545	-	-	45	0.10	0.00	0.10	0.23	0.00
	18+00	500	545	-	-	45	0.10	0.00	0.10	0.23	0.00
	19+00	502	525	-	-	23	0.05	0.00	0.05	0.23	0.00
	20+00	502	502	-	-	-	0.00	0.00	0.00	N/A	0.00
	21+00	505	505	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	502	502	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	500	500	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION F-F	1+00	493	493	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	500	500	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	500	500	522	22	22	0.00	0.98	0.98	N/A	1.65
	4+00	497	497	542	45	45	0.00	2.00	2.00	4.45	3.38
	5+00	498	498	567	69	69	0.00	3.07	3.07	4.45	5.18
	6+00	501	501	586	85	85	0.00	3.78	3.78	4.45	6.38
	7+00	502	504	610	106	108	0.00	4.71	4.72	4.37	7.95
	8+00	500	506	637	131	137	0.01	5.83	5.84	4.26	9.83
	9+00	495	508	662	154	167	0.03	6.85	6.88	4.12	11.55
	10+00	494	511	674	163	180	0.04	7.25	7.28	4.05	12.23
	11+00	494	517	661	144	167	0.05	6.40	6.45	3.86	10.80
	12+00	494	527	643	116	149	0.07	5.16	5.23	3.51	8.70
	13+00	495	537	635	98	140	0.09	4.36	4.45	3.18	7.35
	14+00	496	546	620	74	124	0.11	3.29	3.40	2.74	5.55
	15+00	498	547	596	49	98	0.11	2.18	2.28	2.33	3.68
	16+00	498	549	578	29	80	0.11	1.29	1.40	1.75	2.18
	17+00	498	554	-	-	56	0.12	0.00	0.12	0.22	0.00
	18+00	499	544	-	-	45	0.10	0.00	0.10	0.22	0.00
	19+00	500	525	-	-	25	0.05	0.00	0.05	0.22	0.00
	20+00	504	514	-	-	10	0.02	0.00	0.02	0.22	0.00
	21+00	502	502	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	504	504	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	500	500	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION G-G	1+00	490	490	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	493	493	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	501	501	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	495	495	525	30	30	0.00	1.33	1.33	4.45	2.25
	5+00	495	495	544	49	49	0.00	2.18	2.18	4.45	3.68
	6+00	498	498	573	75	75	0.00	3.33	3.33	4.45	5.63
	7+00	501	501	600	99	99	0.00	4.40	4.40	4.45	7.43
	8+00	500	503	626	123	126	0.01	5.47	5.48	4.35	9.23
	9+00	495	506	654	148	159	0.02	6.58	6.60	4.15	11.10
	10+00	493	509	682	173	189	0.03	7.69	7.72	4.09	12.98
	11+00	492	511	684	173	192	0.04	7.69	7.73	4.03	12.98
	12+00	492	519	667	148	175	0.05	6.58	6.64	3.79	11.10
	13+00	493	533	648	115	155	0.08	5.11	5.19	3.35	8.63
	14+00	495	542	637	95	142	0.09	4.22	4.32	3.04	7.13
	15+00	495	545	620	75	125	0.10	3.33	3.44	2.75	5.63
	16+00	497	547	595	48	98	0.10	2.13	2.24	2.28	3.60
	17+00	498	549	577	28	79	0.10	1.25	1.35	1.71	2.10
	18+00	498	553	-	-	55	0.11	0.00	0.11	0.20	0.00
	19+00	500	539	-	-	39	0.08	0.00	0.08	0.20	0.00
	20+00	502	522	-	-	20	0.04	0.00	0.04	0.20	0.00
	21+00	506	506	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	504	504	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	502	502	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION H-H	1+00	474	474	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	475	475	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	488	488	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	495	495	508	13	13	0.00	0.58	0.58	4.45	0.98
	5+00	493	493	535	42	42	0.00	1.87	1.87	4.45	3.15
	6+00	498	498	568	70	70	0.00	3.11	3.11	4.45	5.25
	7+00	502	502	596	94	94	0.00	4.18	4.18	4.45	7.05
	8+00	500	505	624	119	124	0.01	5.29	5.30	4.28	8.93
	9+00	492	507	652	145	160	0.03	6.45	6.48	4.05	10.88
	10+00	492	511	680	169	188	0.04	7.51	7.55	4.02	12.68
	11+00	490	516	708	192	218	0.05	8.54	8.59	3.94	14.40
	12+00	491	517	688	171	197	0.05	7.60	7.65	3.89	12.83
	13+00	493	527	671	144	178	0.07	6.40	6.47	3.63	10.80
	14+00	494	540	653	113	159	0.09	5.02	5.11	3.22	8.48
	15+00	495	543	636	93	141	0.09	4.14	4.23	3.00	6.98
	16+00	496	546	618	72	122	0.10	3.20	3.30	2.70	5.40
	17+00	497	548	587	39	90	0.10	1.73	1.83	2.04	2.93
	18+00	498	550	561	11	63	0.10	0.49	0.59	0.94	0.83
	19+00	499	540	-	-	41	0.08	0.00	0.08	0.19	0.00
	20+00	503	525	-	-	22	0.04	0.00	0.04	0.19	0.00
	21+00	512	512	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	506	506	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	505	505	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION I-I	1+00	470	470	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	481	481	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	488	488	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	490	490	512	22	22	0.00	0.98	0.98	4.45	1.65
	5+00	492	492	539	47	47	0.00	2.09	2.09	4.45	3.53
	6+00	495	495	568	73	73	0.00	3.25	3.25	4.45	5.48
	7+00	498	498	599	101	101	0.00	4.49	4.49	4.45	7.58
	8+00	500	500	626	126	126	0.00	5.60	5.60	4.45	9.45
	9+00	490	503	653	150	163	0.03	6.67	6.69	4.11	11.25
	10+00	490	506	680	174	190	0.03	7.74	7.77	4.09	13.05
	11+00	491	514	709	195	218	0.04	8.67	8.72	4.00	14.63
	12+00	492	523	709	186	217	0.06	8.27	8.33	3.84	13.95
	13+00	493	530	686	156	193	0.07	6.94	7.01	3.63	11.70
	14+00	494	540	665	125	171	0.09	5.56	5.65	3.30	9.38
	15+00	494	543	654	111	160	0.09	4.94	5.03	3.14	8.33
	16+00	496	545	621	76	125	0.09	3.38	3.47	2.78	5.70
	17+00	497	548	595	47	98	0.10	2.09	2.19	2.23	3.53
	18+00	498	550	568	18	70	0.10	0.80	0.90	1.29	1.35
	19+00	499	542	-	-	43	0.08	0.00	0.08	0.19	0.00
	20+00	503	531	-	-	28	0.05	0.00	0.05	0.19	0.00
	21+00	514	514	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	507	507	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	508	508	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION J-J	1+00	471	471	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	470	470	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	486	486	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	486	486	516	30	30	0.00	1.33	1.33	4.45	2.25
	5+00	490	490	542	52	52	0.00	2.31	2.31	4.45	3.90
	6+00	492	492	570	78	78	0.00	3.47	3.47	4.45	5.85
	7+00	495	495	598	103	103	0.00	4.58	4.58	4.45	7.73
	8+00	497	497	630	133	133	0.00	5.91	5.91	4.45	9.98
	9+00	490	500	656	156	166	0.02	6.94	6.96	4.19	11.70
	10+00	490	503	682	179	192	0.03	7.96	7.98	4.16	13.43
	11+00	492	514	710	196	218	0.04	8.72	8.76	4.02	14.70
	12+00	493	527	710	183	217	0.07	8.14	8.20	3.78	13.73
	13+00	494	535	702	167	208	0.08	7.43	7.50	3.61	12.53
	14+00	495	540	670	130	175	0.09	5.78	5.87	3.35	9.75
	15+00	495	543	653	110	158	0.09	4.89	4.98	3.15	8.25
	16+00	495	545	639	94	144	0.10	4.18	4.28	2.97	7.05
	17+00	496	547	603	56	107	0.10	2.49	2.59	2.42	4.20
	18+00	498	549	575	26	77	0.10	1.16	1.25	1.63	1.95
	19+00	499	547	-	-	48	0.09	0.00	0.09	0.19	0.00
	20+00	503	532	-	-	29	0.06	0.00	0.06	0.19	0.00
	21+00	518	518	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	510	510	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	512	512	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION K-K	1+00	472	472	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	470	470	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	486	486	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	484	484	519	35	35	0.00	1.56	1.56	4.45	2.63
	5+00	486	486	539	53	53	0.00	2.36	2.36	4.45	3.98
	6+00	489	489	563	74	74	0.00	3.29	3.29	4.45	5.55
	7+00	491	491	593	102	102	0.00	4.54	4.54	4.45	7.65
	8+00	495	495	619	124	124	0.00	5.51	5.51	4.45	9.30
	9+00	494	499	647	148	153	0.01	6.58	6.59	4.31	11.10
	10+00	491	502	675	173	184	0.02	7.69	7.71	4.19	12.98
	11+00	492	512	703	191	211	0.04	8.49	8.53	4.04	14.33
	12+00	493	531	698	167	205	0.07	7.43	7.50	3.66	12.53
	13+00	495	540	688	148	193	0.09	6.58	6.67	3.45	11.10
	14+00	495	544	671	127	176	0.09	5.65	5.74	3.26	9.53
	15+00	495	546	644	98	149	0.10	4.36	4.46	2.99	7.35
	16+00	495	546	619	73	124	0.10	3.25	3.34	2.70	5.48
	17+00	497	547	590	43	93	0.10	1.91	2.01	2.16	3.23
	18+00	498	550	567	17	69	0.10	0.76	0.86	1.24	1.28
	19+00	499	542	-	-	43	0.08	0.00	0.08	0.19	0.00
	20+00	514	531	-	-	17	0.03	0.00	0.03	0.19	0.00
	21+00	520	520	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	515	515	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	514	514	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION L-L	1+00	470	470	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	472	472	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	478	478	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	484	484	503	19	19	0.00	0.84	0.84	4.45	1.43
	5+00	486	486	531	45	45	0.00	2.00	2.00	4.45	3.38
	6+00	489	489	559	70	70	0.00	3.11	3.11	4.45	5.25
	7+00	493	493	590	97	97	0.00	4.31	4.31	4.45	7.28
	8+00	496	496	619	123	123	0.00	5.47	5.47	4.45	9.23
	9+00	498	498	647	149	149	0.00	6.63	6.63	4.45	11.18
	10+00	500	502	660	158	160	0.00	7.03	7.03	4.39	11.85
	11+00	499	511	670	159	171	0.03	7.07	7.10	4.15	11.93
	12+00	498	533	678	145	180	0.08	6.45	6.52	3.62	10.88
	13+00	497	539	680	141	183	0.09	6.27	6.36	3.48	10.58
	14+00	497	542	658	116	161	0.10	5.16	5.26	3.26	8.70
	15+00	497	544	632	88	135	0.10	3.91	4.01	2.97	6.60
	16+00	498	547	608	61	110	0.11	2.71	2.82	2.56	4.58
	17+00	498	548	583	35	85	0.11	1.56	1.66	1.96	2.63
	18+00	499	553	-	-	54	0.12	0.00	0.12	0.22	0.00
	19+00	500	538	-	-	38	0.08	0.00	0.08	0.22	0.00
	20+00	520	527	-	-	7	0.02	0.00	0.02	0.22	0.00
	21+00	521	521	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	517	517	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	516	516	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION M-M	1+00	467	467	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	475	475	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	481	481	483	2	2	0.00	0.09	0.09	N/A	0.15
	4+00	480	480	512	32	32	0.00	1.42	1.42	4.45	2.40
	5+00	483	483	535	52	52	0.00	2.31	2.31	4.45	3.90
	6+00	487	487	562	75	75	0.00	3.33	3.33	4.45	5.63
	7+00	490	490	590	100	100	0.00	4.45	4.45	4.45	7.50
	8+00	492	496	612	116	120	0.01	5.16	5.17	4.31	8.70
	9+00	496	499	634	135	138	0.01	6.00	6.01	4.35	10.13
	10+00	499	499	638	139	139	0.00	6.18	6.18	4.45	10.43
	11+00	510	514	644	130	134	0.01	5.78	5.79	4.32	9.75
	12+00	510	536	652	116	142	0.06	5.16	5.22	3.67	8.70
	13+00	509	541	652	111	143	0.07	4.94	5.01	3.50	8.33
	14+00	506	543	650	107	144	0.09	4.76	4.84	3.36	8.03
	15+00	508	545	625	80	117	0.09	3.56	3.64	3.11	6.00
	16+00	510	547	595	48	85	0.09	2.13	2.22	2.61	3.60
	17+00	510	549	571	22	61	0.09	0.98	1.07	1.75	1.65
	18+00	511	544	-	-	33	0.08	0.00	0.08	N/A	0.00
	19+00	512	539	-	-	27	0.06	0.00	0.06	N/A	0.00
	20+00	522	525	-	-	3	0.01	0.00	0.01	N/A	0.00
	21+00	522	522	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	515	515	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	514	514	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION N-N	1+00	466	466	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	471	471	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	474	474	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	481	481	500	19	19	0.00	0.84	0.84	4.45	1.43
	5+00	483	483	524	41	41	0.00	1.82	1.82	4.45	3.08
	6+00	485	485	549	64	64	0.00	2.85	2.85	4.45	4.80
	7+00	489	489	569	80	80	0.00	3.56	3.56	4.45	6.00
	8+00	493	493	592	99	99	0.00	4.40	4.40	4.45	7.43
	9+00	495	495	607	112	112	0.00	4.98	4.98	4.45	8.40
	10+00	496	496	609	113	113	0.00	5.02	5.02	4.45	8.48
	11+00	510	521	617	96	107	0.03	4.27	4.30	4.02	7.20
	12+00	510	538	626	88	116	0.07	3.91	3.98	3.43	6.60
	13+00	510	542	625	83	115	0.08	3.69	3.77	3.28	6.23
	14+00	510	544	623	79	113	0.09	3.51	3.60	3.18	5.93
	15+00	510	546	612	66	102	0.09	2.93	3.03	2.97	4.95
	16+00	510	548	587	39	77	0.10	1.73	1.83	2.38	2.93
	17+00	511	554	557	3	46	0.11	0.13	0.24	0.52	0.23
	18+00	511	541	-	-	30	0.08	0.00	0.08	0.25	0.00
	19+00	513	527	-	-	14	0.04	0.00	0.04	0.25	0.00
	20+00	520	521	-	-	1	0.00	0.00	0.00	0.25	0.00
	21+00	519	519	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	512	512	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	513	513	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION O-O	1+00	466	466	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	468	468	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	468	468	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	471	471	-	-	-	0.00	0.00	0.00	N/A	0.00
	5+00	474	474	507	33	33	0.00	1.47	1.47	4.45	2.48
	6+00	477	477	530	53	53	0.00	2.36	2.36	4.45	3.98
	7+00	489	489	551	62	62	0.00	2.76	2.76	4.45	4.65
	8+00	491	491	571	80	80	0.00	3.56	3.56	4.45	6.00
	9+00	493	493	575	82	82	0.00	3.65	3.65	4.45	6.15
	10+00	497	497	582	85	85	0.00	3.78	3.78	4.45	6.38
	11+00	510	526	591	65	81	0.04	2.89	2.93	3.62	4.88
	12+00	510	534	598	64	88	0.07	2.85	2.91	3.31	4.80
	13+00	510	543	598	55	88	0.09	2.45	2.54	2.88	4.13
	14+00	510	546	592	46	82	0.10	2.05	2.14	2.61	3.45
	15+00	510	547	586	39	76	0.10	1.73	1.84	2.41	2.93
	16+00	510	549	573	24	63	0.11	1.07	1.17	1.86	1.80
	17+00	510	548	-	-	38	0.10	0.00	0.10	0.27	0.00
	18+00	510	537	-	-	27	0.07	0.00	0.07	0.27	0.00
	19+00	512	526	-	-	14	0.04	0.00	0.04	0.27	0.00
	20+00	520	520	-	-	-	0.00	0.00	0.00	N/A	0.00
	21+00	516	516	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	514	514	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	513	513	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION P-P	1+00	466	466	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	468	468	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	472	472	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	478	478	-	-	-	0.00	0.00	0.00	N/A	0.00
	5+00	487	487	-	-	-	0.00	0.00	0.00	N/A	0.00
	6+00	490	490	509	19	19	0.00	0.84	0.84	4.45	1.43
	7+00	492	492	531	39	39	0.00	1.73	1.73	4.45	2.93
	8+00	494	494	540	46	46	0.00	2.05	2.05	4.45	3.45
	9+00	496	496	549	53	53	0.00	2.36	2.36	4.45	3.98
	10+00	498	498	555	57	57	0.00	2.53	2.53	4.45	4.28
	11+00	508	519	564	45	56	0.03	2.00	2.03	3.63	3.38
	12+00	508	530	567	37	59	0.06	1.65	1.71	2.90	2.78
	13+00	508	538	570	32	62	0.09	1.42	1.51	2.43	2.40
	14+00	508	549	564	15	56	0.12	0.67	0.78	1.40	1.13
	15+00	508	553	557	4	49	0.13	0.18	0.31	0.63	0.30
	16+00	508	548	-	-	40	0.11	0.00	0.11	0.29	0.00
	17+00	508	543	-	-	35	0.10	0.00	0.10	0.29	0.00
	18+00	508	536	-	-	28	0.08	0.00	0.08	0.29	0.00
	19+00	510	527	-	-	17	0.05	0.00	0.05	0.29	0.00
	20+00	516	516	-	-	-	0.00	0.00	0.00	N/A	0.00
	21+00	511	511	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	508	508	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	513	513	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement Existing Waste (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION Q-Q	1+00	465	465	-	-	-	0.00	0.00	0.00	N/A	0.00
	2+00	468	468	-	-	-	0.00	0.00	0.00	N/A	0.00
	3+00	470	470	-	-	-	0.00	0.00	0.00	N/A	0.00
	4+00	478	478	-	-	-	0.00	0.00	0.00	N/A	0.00
	5+00	487	487	-	-	-	0.00	0.00	0.00	N/A	0.00
	6+00	495	495	-	-	-	0.00	0.00	0.00	N/A	0.00
	7+00	500	500	504	4	4	0.00	0.18	0.18	4.45	0.30
	8+00	497	497	514	17	17	0.00	0.76	0.76	4.45	1.28
	9+00	499	499	522	23	23	0.00	1.02	1.02	4.45	1.73
	10+00	501	501	529	28	28	0.00	1.25	1.25	4.45	2.10
	11+00	504	504	534	30	30	0.00	1.33	1.33	4.45	2.25
	12+00	504	524	541	17	37	0.06	0.76	0.81	2.20	1.28
	13+00	505	532	538	6	33	0.08	0.27	0.34	1.04	0.45
	14+00	505	538	-	-	33	0.09	0.00	0.09	0.29	0.00
	15+00	505	540	-	-	35	0.10	0.00	0.10	0.29	0.00
	16+00	505	540	-	-	35	0.10	0.00	0.10	0.29	0.00
	17+00	506	536	-	-	30	0.09	0.00	0.09	0.29	0.00
	18+00	506	533	-	-	27	0.08	0.00	0.08	0.29	0.00
	19+00	509	525	-	-	16	0.05	0.00	0.05	0.29	0.00
	20+00	516	516	-	-	-	0.00	0.00	0.00	N/A	0.00
	21+00	510	510	-	-	-	0.00	0.00	0.00	N/A	0.00
	22+00	506	506	-	-	-	0.00	0.00	0.00	N/A	0.00
	23+00	512	512	-	-	-	0.00	0.00	0.00	N/A	0.00

	Station	Existing Base Grade	Existing Grade	Proposed Grade	Proposed Expansion Waste Depth	Total Waste Depth	Settlement (Sowers 1973)	Settlement Proposed Waste (Sowers 1973)	Total Settlement	Settlement Percentage	Settlement @ 7.5% New Waste Thickness
		feet	feet	feet	feet	feet	feet	feet	feet	%	feet
SECTION R-R	1+00	465	465	-	-	-	0.00	N/A	0.00	N/A	N/A
	2+00	465	465	-	-	-	0.00	N/A	0.00	N/A	N/A
	3+00	469	469	-	-	-	0.00	N/A	0.00	N/A	N/A
	4+00	475	475	-	-	-	0.00	N/A	0.00	N/A	N/A
	5+00	480	480	-	-	-	0.00	N/A	0.00	N/A	N/A
	6+00	492	492	-	-	-	0.00	N/A	0.00	N/A	N/A
	7+00	498	498	-	-	-	0.00	N/A	0.00	N/A	N/A
	8+00	501	501	-	-	-	0.00	N/A	0.00	N/A	N/A
	9+00	496	502	-	-	6	0.02	N/A	0.02	0.31	N/A
	10+00	497	504	-	-	7	0.02	N/A	0.02	0.31	N/A
	11+00	498	506	-	-	8	0.02	N/A	0.02	0.31	N/A
	12+00	499	513	-	-	14	0.04	N/A	0.04	0.31	N/A
	13+00	500	523	-	-	23	0.07	N/A	0.07	0.31	N/A
	14+00	500	525	-	-	25	0.08	N/A	0.08	0.31	N/A
	15+00	501	529	-	-	28	0.09	N/A	0.09	0.31	N/A
	16+00	501	529	-	-	28	0.09	N/A	0.09	0.31	N/A
	17+00	502	529	-	-	27	0.08	N/A	0.08	0.31	N/A
	18+00	503	528	-	-	25	0.08	N/A	0.08	0.31	N/A
	19+00	503	523	-	-	20	0.06	N/A	0.06	0.31	N/A
	20+00	512	512	-	-	-	0.00	N/A	0.00	N/A	N/A
	21+00	509	509	-	-	-	0.00	N/A	0.00	N/A	N/A
	22+00	506	506	-	-	-	0.00	N/A	0.00	N/A	N/A
	23+00	515	515	-	-	-	0.00	N/A	0.00	N/A	N/A

Form 25
Leachate Management



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

Date Prepared/Revised
July 2018

DEP USE ONLY

Date Received

FORM 25

LEACHATE MANAGEMENT - PHASE II

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 25, reference the item number and identify the date prepared. The "date prepared/revised" on any attached sheets should match the "date prepared/revised" on this page.

General References: 273.162, 273.163, 273.271 to 273.275/277.162, 277.163, 277.271 to 277.275, 285.122, 285.123

SECTION A. SITE IDENTIFIER

Applicant/permittee: Greater Lebanon Refuse Authority

Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

SECTION B. BASIC TREATMENT METHODS

- ☒ 1. Discharge to permitted POTW, following pretreatment, if required, by federal, state or local law or by discharge into another permitted treatment facility.
- ☐ 2. On-site treatment and discharge to stream.
- ☐ 3. Spray irrigation following treatment.
- ☐ 4. Other: _____

For Proposed Site: Will permanent leachate pre-treatment method be in-place before placement of waste? _____

SECTION C. COMPONENTS OF LEACHATE TREATMENT PLAN

Check and/or Describe

1. Estimate of annual leachate quantity and quality and supporting calculations. Attachment A - HELP Model
- ☒ 2. Plans, designs, and cross sections for the proposed collection and handling system. See permit drawings
- ☐ 3. Plans, designs, and cross-sections for on-site leachate treatment or disposal systems. N/A
- ☐ 4. Description of on-site treatment system already in operation, including NPDES number, capability to treat leachate, and compliance status under The Clean Streams Law. N/A
5. If interim vehicular transportation to an off-site treatment facility is proposed, provide:
 - ☐ a. Copy of signed contractual agreement with operator of off -site facility, or N/A
 - ☐ b. Signed letter of intent from operator of the off-site facility to enter a contractual agreement for leachate treatment. N/A
 - ☐ c. Copy of signed contractual agreement with the operator of a 2nd off-site facility as backup, or N/A
 - ☐ d. Signed letter of intent from operator of the 2nd off-site facility to enter a contractual agreement f or leachate treatment. N/A
 - ☐ e. Additional bond in amount sufficient to pay for the cost of vehicular transportation and off-site leachate treatment until final closure; if off-site treatment is negligent. N/A
 - ☐ f. Submit plans, designs, and cross-sections for an on site pretreatment facility. N/A
6. If recirculation of raw or pretreated leachate is proposed in conjunction with another method, describe:
 - ☐ a. Designs and cross-sections of leachate distribution method. N/A
 - ☐ b. Methods to prevent leachate seeps and breakouts. N/A
 - ☐ c. Methods to prevent odors, runoff, and ponding. N/A
 - ☐ 7. Schedule and method for cleaning sludges from the leachate storage and treatment system, and a plan for disposing of such sludges. N/A
 - ☐ 8. Method for measuring average flow rate of leachate from landfill to leachate storage/treatment system. N/A
 - ☐ 9. Identify if leachate pumping occurs. N/A
 - ☐ 10. Plans and designs for secondary containment of underground pipes used for the transport of leachate from the liner system. N/A

SECTION D. ADDITIONAL INFORMATION

Location in Application

1. Interim Leachate Transportation

N/A

Check appropriate items:

- ☐ 1. A permitted and fully operating system for fully pre-treating leachate will be installed before disposal of waste.
- ☒ 2. Direct discharge into a POTW or other permitted treatment facility is attainable within 3 years.
- ☐ 3. Discharge of treated leachate into a receiving stream in a manner consistent with The Clean Stream Law is attainable within 3 years.
- ☐ 4. A leachate recirculation system will be constructed and operated.

2. Leachate Recirculation: (Prohibited, except for landfills with composite liners)

N/A

Describe design of system. Show that there is sufficient municipal waste capacity to absorb leachate and that the area subject to leachate recirculation is underlain by a composite liner. Describe system used to recirculate leachate:

3. Leachate Collection and Storage (for storage impoundments, submit Form 24):

Design leachate volume (gal./year)

See attached narrative

Tanks or Impoundments:

	#1	#2	#3
1. Volume (gallons)	<u> </u>	<u> </u>	<u> </u>
2. Dimensions (feet)	<u> </u>	<u> </u>	<u> </u>
3. Freeboard (feet)	<u> </u>	<u> </u>	<u> </u>
4. Function (equalization, storage, etc.)	<u> </u>	<u> </u>	<u> </u>
5. Aeration Capacity	<u> </u>	<u> </u>	<u> </u>
6. Detention Time	<u> </u>	<u> </u>	<u> </u>
7. Secondary containment or liner	<u> </u>	<u> </u>	<u> </u>



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Form 25 – Leachate Management – Phase II
Form 2540-PM-BWM0152, Rev. 6/2005
Greater Lebanon Refuse Authority (Permit No. 101544)
Heilmandale Expansion

C. COMPONENTS OF LEACHATE TREATMENT PLAN

1. Estimate of annual leachate quantity and quality and supporting calculations

The estimates of annual leachate quality and quantity are included in **Attachment 25-A**.

2. Plans, designs, and cross sections for the proposed collection and handling system.

The leachate management facilities for the Heilmandale Expansion will be similar to the Schilling Farms Expansion area. The leachate from the Heilmandale Expansion area will be gravity drained to leachate sumps as shown in the Permit Drawings. The leachate will be pumped out through sideslope risers into a new leachate main which connects into the existing leachate main from Pump Station 7 where it will be combined with leachate from the Schilling Farms Expansion area. From there, leachate will be transmitted to Valve Vault 3 before entering the 1,000,000 gallon storage tank. Leachate is stored in the 1,000,000 gallon storage tank until it is discharged via a force main to the City of Lebanon Authority (COLA) for treatment. Leachate hauling is used as a backup to reduce leachate levels in the leachate storage tank or if there is a spill or leachate outbreak to one of the stormwater basins.

The Leachate Detection Zone (LDZ), which is located between the primary liner and the secondary liner, is intended to show any leakage or flow through the primary liner. Liquid in the LDZ sump can be observed and tested to determine if it is construction water condensate, or possible leachate.

3. Plans, designs, and cross sections for on-site leachate treatment or disposal systems.

Not applicable.

4. Description of on-site treatment system already in operation, including NPDES number, capability to treat leachate, and compliance status under The Clean Streams Law.

Active Disposal Area (Permit No. 101544)

There is no on-site leachate treatment system for leachate from the lined areas of the landfill as this leachate is direct-discharged, after flow equalization, to the Lebanon sanitary sewer system. As mentioned above, leachate from the Heilmandale Expansion area will be combined with leachate from Pads 1-7 and discharged to the City of Lebanon sanitary sewer system.

NALTS Background

There is a Natural Aquatic Life Treatment System (NALTS) in place, consisting of wetlands and wastewater treatment ponds, to naturally treat leachate and stormwater runoff from GLRA's unlined landfill areas. Twelve of the fourteen original NALTS treatment ponds were constructed on top of the existing creek bed (an unnamed tributary to Union Canal and Swatara Creek). Ponds 1 and 2 were originally farm ponds on Site 100825 located east of Pond 5 and are now filled and capped. The leachate and stormwater was intended to reach the NALTS ponds via the existing groundwater table, a porous concrete landfill underdrain system with catch basins, and overland topography. The ponds were established as settling, treatment and/or aeration ponds (see NALTS description with accompanying maps in **Attachment 25-B**). Discharge from the NALTS (south of Pond 14) is regulated under NPDES Permit No. 0080322.

In the late 1980's, PADEP instructed GLRA to install a groundwater interceptor system around sections of Site 100825 to separate contaminated groundwater from the NALTS. At the time, the treatment capabilities of the pond system were inhibited primarily due to vegetative destruction by muskrats. The interceptor system components were specified by PADEP and include the Russell Road Interceptor, Southwest Interceptor, Northwest Interceptor, a series of manholes, and a connection (via manhole MH4) to the conduit that crosses Russell Road. The Southwest Interceptor was installed when Ponds 1 and 2 were capped as part of final closure activities on Site 100825.

A final cap was installed over approximately 36 acres of the unlined landfill site in 1994. As part of the capping project, a six-inch Leachate Perimeter Drain and a series of French drains were installed to collect and convey leachate from beneath the capped areas to the existing catch basins (No. 1, No. 2, and No. 3) along the east side of the landfill.

Current Status

Water quality analysis results show that the NALTS ponds currently serve the intended purpose as a natural treatment system for the unlined landfill sites. The muskrat population has been kept in check since the 1990's and a pond maintenance system is in place to maintain vegetative cover and sediment levels. The landfill underdrain system, interceptors, and leachate perimeter drain are still collecting and transporting groundwater and leachate from the closed landfill site. All three Interceptors (Northwest, Southwest, and Russell Road) are currently configured to flow through the system of manholes to manhole 4 (MH4) where they discharge into Pond 8 of the Natural Aquatic Life Treatment System (NALTS) treatment ponds.

Stormwater is also conveyed into the NALTS. Stormwater flows into Pond 3 at the northern end of the NALTS via a culvert under Heilmandale Road and from the closed site (Permit No. 100825) at Pond 6 via a culvert under the existing landfill perimeter road. Stormwater from the active landfill area (Permit No. 101544) enters the NALTS from stormwater basins at Pond 10 via three culverts under the existing haul road.

Composite water samples are collected from the discharge at Pond 14 and analyzed weekly. Results are in compliance.

Interceptor Status

GLRA submitted an application to PADEP for a minor permit modification to alter the closed landfill's groundwater interceptor system. The proposed modification involves the Northwest (NW) and Southwest (SW) Interceptors. GLRA recommends the system modifications to:

1. separate the discharge points of the Interceptors
2. discharge further upstream in the NALTS ponds to gain additional treatment and aeration
3. investigate the possibility of removing a section of the NW interceptor
4. facilitate construction of the proposed piggyback expansion project

The following were proposed for the NW Interceptor:

1. Cut the NW Interceptor to separate the east-to-west and north-to-south sections of pipe.
2. Extend the east-to-west section of the interceptor pipe under the perimeter road to discharge into Pond 3.
3. Remove the existing discharge pipe that extends from MH3 to MH3A and reconfigure to discharge towards Pond 5.
4. Install a new culvert under the perimeter road to temporarily discharge from MH3 west into Pond 5.
5. Raise MH3 to correspond to the proposed roadway elevation.
6. Continue to monitor water quality and estimated flow to MH3 to investigate the possibility of removal of this section of piping to allow groundwater to enter the pond system naturally.

The following are proposed for the SW Interceptor and connecting manholes:

1. Replace MH3A with a new manhole located at the bottom of the western slope of the proposed perimeter road between Ponds 5 and 6. This will provide easier access for maintenance and sample collection.
2. Install a culvert to convey discharge from MH 3D to the new manhole.
3. Remove MH3C and all pipe connections.
4. Abandon and seal access to MH 3D. Access to the pipes will remain on the west side of the perimeter road via the new manhole.
5. Install a discharge pipe from the new manhole into Pond 6.

5. If interim vehicular transportation to an off-site leachate treatment facility is proposed, provide:

Interim vehicular transportation to an off-site leachate treatment facility is not proposed; therefore this section is not applicable.

6. If recirculation of raw or pretreated leachate is proposed in conjunction with another method, describe:

Recirculation of raw or pretreated leachate is not proposed; therefore this section is not applicable.

7. Schedule and method for cleaning sludges from the leachate storage and treatment system, and a plan for disposing of such sludges:

The leachate storage and treatment system has been previously permitted, as has the method for cleaning and disposal of residual sludges. GLRA will continue to implement the maintenance and disposal programs previously approved by PADEP.

8. Method for measuring average flow rate of leachate from landfill to leachate storage/treatment system.

GLRA will continue to measure the flow rates using the existing metering system at the leachate storage tank. The flow monitoring will be completed using the same continuous automatic flow recording devices installed on the collection and detection piping in the Schilling Farms Expansion area. Additional measuring devices will be installed at the two new leachate pump houses.

9. Identify if leachate pumping occurs.

As is the case with the Schilling Farms Expansion area, leachate will flow by gravity to leachate sumps as shown in the Permit Drawings. The leachate will be pumped out through sideslope risers through proposed Pump Stations 8 and 10 into a new leachate force main. The force main will connect into the existing leachate main from Pump Station 7 where it will be combined with leachate from the Schilling Farms Expansion area. From there, leachate will be transmitted to Valve Vault 3 before being pumped into the 1,000,000 gallon storage tank. Leachate is stored in the 1,000,000 gallon storage tank until it is pumped out to the City of Lebanon sanitary sewer line.

10. Plans and designs for secondary containment of underground pipes used for the transport of leachate from the liner system.

The leachate from the lined disposal areas will be transported to the leachate storage tank in new and existing underground piping. The existing leachate piping is dual-contained. The new underground piping will also provide secondary containment as shown in the Permit Drawings.

D. ADDITIONAL INFORMATION

1. Interim leachate transportation:

Interim vehicular transportation to an off-site leachate treatment facility is not proposed; therefore this section is not applicable.

2. Leachate Recirculation

Recirculation of raw or pretreated leachate is not proposed; therefore this section is not applicable.

3. Leachate Collection and Storage

GLRA will continue to use the existing 1,000,000 gallon storage tank currently serving the Schilling Farms Expansion area. Refer to the HELP Model analysis in **Attachment 25-A** for discussion on the peak leachate production associated with the Heilmandale Expansion and Schilling Farms Expansion areas combined, and discussion of leachate storage capacity.

FORM 25 – ATTACHMENT A

HELP Model

**Form 25 – Attachment A – HELP Modeling
Greater Lebanon Refuse Authority (Permit No. 101544)
Heilmandale Expansion**

A GENERAL

In accordance with 25 PA 273.162, an estimate of the quality and quantity of leachate to be produced annually by the facility, shall be based on the water balance method set forth in “Use of Water Balance Method for Predicting Leachate Generation from Solid Waste Disposal Sites” U. S. EPA SW-168 (1975), or another method of accurately projecting leachate flows that is approved by the Department in writing. The estimate shall include the 30-day leachate volume and average flow rate for each month of the year. A separate estimate shall be submitted for anticipated leachate generation at the end of 5 year increments of operation for 20 years, or until closure, whichever date is earlier. For existing facilities, current leachate generation shall be included with this separate estimate.

In addition, 25 PA 273.275 requires an onsite leachate storage system that shall be part of each leachate treatment method used by the operator. The storage system shall contain impoundments or tanks for storage of leachate. The tanks or impoundments shall have sufficient storage capacity at least equal to the maximum expected production of leachate for any 30-day period for the life of the facility estimated under §273.162 (relating to leachate treatment plan), or 250,000 gallons, whichever is greater. No more than 25 percent of the total leachate storage capacity may be used for flow equalization on a regular basis.

This report provides a detailed description of the bottom liner and leachate collection and removal system (LCRS) design features in support of a Heilmandale Expansion of the Greater Lebanon Refuse Authority Landfill. HELP modeling results for each scenario considered and the leachate quantity estimation and storage capability are included in this attachment.

The liner and leachate collection systems for the Heilmandale Expansion are as follow:

Bottom Liner and LCRS Systems

The bottom liner system consists of the following (top to bottom):

- 18-inches drainage stone layer
- Cushion Geotextile
- 60 mil textured geomembrane (HDPE)
- Geocomposite drainage net
- 60 mil textured geomembrane (HDPE)
- Geosynthetic Clay Liner (GCL)
- 6-inches of prepared subbase

The final cover system consists of the following (top to bottom):

- 24-inches vegetative support layer
- Geocomposite drainage net*

- 40 mil textured geomembrane (LLDPE)*
- Cushion geotextile
- 12-inches of intermediate/daily cover over waste

*50 mil LLDPE Super Gripnet® by Agru America, with an overlying non-woven geotextile, is a proposed equivalent alternative to these components.

B LEACHATE ESTIMATE

The EPA Hydrologic Evaluation of Landfill Performance (HELP) computer model version 3.07 was used to perform water balance analysis for the landfill. The HELP model performs a sequential daily water balance on a liner system profile to determine runoff, evapotranspiration, infiltration of leachate into the LCRS, lateral drainage within the LCRS and percolation through the liner. Results from the HELP model were used to:

- Estimate leachate generation including:
 - Average monthly information
 - Flow rate at the end of five-year increments of operation for 20-years, or until closure, whichever date is earlier (per 25 PA 273.162). For GLRA expansion landfill, 15-years is earlier.
- Estimate the peak daily leachate generation rate during the life of the landfill. The peak daily generation rate forms the basis for sizing leachate collection pipes, and pumps.
- Leachate storage capacity based on average monthly data.
- Estimate the required permeability of the leachate collection layer material and the maximum horizontal distance for leachate to be collected in laterals to maintain less than 12 inches of leachate head on top of the liner.

The HELP model requires climatological data of the project site location and soil type characteristics for the liner system profile to perform the water balance analysis. The soil type characteristics in the HELP model similar to the on-site soils and construction materials were used. The following parameters and/or assumptions were used in the water balance analysis:

- The Pittsburgh, Pennsylvania climatological stations were selected and used in the model set up. However, the main climatological data required for the HELP model include using site-specific monthly average precipitation and temperature (from Station USC00364896, Lebanon 2 W, PA) and solar radiation's latitude (40.374 degrees). The annual rainfall used in the model is approximately 45 inches for 5-year simulation and 43 inches for 20-year simulation.
- The permeability of waste used in the HELP modeling was 1×10^{-3} centimeters per second.

- It was assumed that 100 percent of the runoff within the disposal area can be diverted as stormwater during the initial operations, the intermediate landfill operations, as well as the final condition prior to capping scenario. Standard operational practices will be used during the initial operations to divert stormwater away from the leachate collection system to minimize leachate generation. These practices include the use of temporary stormwater diversion berms placed such that the landfill cell is divided into subcells, or the use of temporary poly sheeting (rain cap or equivalent) over the drainage layer. The rain cap limits infiltration into the drainage layer. The runoff flows on the poly sheeting, and along the temporary diversion berms to the edge of the cell, where it exits the cell through a temporary culvert or weir or by portable pump.
- The grading of the bottom liner system of the landfill varies from 2 percent to 33 percent. The drainage length used in the model is assumed to be 200 feet on 2 percent cell floor.
- Surface grades were generally modeled with a slope of two percent and a drainage length of 200 feet. A slope of 33 percent was also used for higher waste height scenario due to the anticipated steep slopes as the landfill reaches this height. A 20-year simulation period was used for all scenarios higher than 100 feet of waste.
- The initial moisture content of the layers was calculated by the program as nearly steady state.
- A geomembrane pinhole density of one defect (hole diameter = one mm) per acre, a geomembrane installation defect density of two defects (hole area = two cm²) per acre, and excellent (2) geomembrane placement quality was assumed for the analysis. This assumption is reasonable as the primary geomembrane will be sandwiched between geotextile and a geocomposite drainage net (GDN) and the secondary geomembrane between a GDN and a geocomposite clay liner (GCL).
- The permeability of the leachate collection stone/aggregate drainage layer was modeled with a permeability of 0.3 centimeters per second and 3 cm/sec for the leak detection zone GDN which has a thickness of 0.23 inches.
- The permeability of the lateral drainage layer within the cap system was modeled with a permeability of 4 cm/sec for the GDN which has a thickness of 0.29 inches.
- For waste height of 70 feet or under, the daily cover soil thickness was assumed to be 6 inches and 12 inches if it is over 70 feet.

Leachate generated within cell floor of the landfill will flow in a stone drainage layer to a series of perforated HDPE lateral pipes located at an appropriate spacing to limit the maximum peak daily leachate head to less than 12-inches over the liner. The perforated lateral collection pipes convey leachate to the HDPE header pipe that slope toward the sump locations. The collection pipes are surrounded with a layer of inert coarse aggregate to provide filter protection and bedding support. The coarse aggregate is sized large enough to minimize clogging of the

perforations in the collection pipes and fine enough to minimize migration of the primary granular drainage layer into the coarse aggregate layer. Cleanouts will be provided at the top of the side slopes for periodic cleaning of the header (primary collection) pipes.

B.1 SCENARIOS CONSIDERED

Table 1 shows the scenarios considered for HELP modeling. There were various waste heights and bottom slope configurations for each HELP modeling scenario.

Table 1. Scenarios Considered in Help Modeling

Scenario	Cell Floor Slope & Drainage Length (% & ft.)	Liner/Leachate Collection System	Waste Height (ft.)
Initial Operations	2 & 200	Floor: 18" stone/FML/GDN/FML/GCL Daily Soil Cover: 6"	8 30 70
Intermediate Landfill Operations & Prior to Capping	2 & 200	Floor: 18" stone/FML/GDN/FML/GCL Intermediate Soil Cover: 12"	100 130 190
Landfill After Capping	2 & 200	Floor: 18" stone/FML/GDN/FML/GCL; Cap: 24 Soil/GDN/FML/12" Intermediate Soil	70 100 130 190

B.2 RESULTS OF HELP MODELING

A summary of the results of the HELP water balance analysis are provided in **Table A**, as well as the computer printouts which contain the detailed material properties of the various layers and results of the runs.

The maximum daily head on the liner was estimated to be approximately 1.2 inches, which is below the 12-inch head allowed. The maximum build-up of leachate head occurs during the "Initial Operations" scenario with 8 feet of waste. The peak daily leachate generation rate was calculated to be 2,977 gal/day/acre. The peak generation occurred during the "Initial Operations" scenario with the first lift of waste placed.

Maximum average monthly leachate data is provided in **Table A**. The maximum average monthly flow rates are provided in volumetric monthly averages, which are equal to 17,783 gallons per acre and 24,444 gallons per acre for scenarios with 8 feet and 130 feet of waste height, respectively. A daily flow rate based on the maximum average monthly leachate generation data divided by 30-days is also provided in **Table A**.

The annual average leachate generation calculated by HELP Model with 8 feet and 130 feet of waste heights are 115,230 gallons per acre and 118,746 gallons per acre, respectively. Its corresponding average annual head on liner is 1.2 and 0.9 inches, respectively.

The 30-day leachate volume and average flow rate for each month of the year is provided in **Table B**. A separate estimate is also provided for anticipated leachate generation at the end of 5 year increments of operation for 20 years, or until closure, whichever date is earlier. The maximum 30-day leachate volume for any given month of any of the scenarios shown in **Table B** indicates a maximum volumetric monthly average value of 24,443 gallons per acre.

Leachate flow information at the end of 5-year increments over 20-years is provided in **Tables C-1** through **C-4**. The 5-year leachate estimates provide a snapshot of potential leachate generation during the life of the landfill.

Given the total expansion landfill footprint of 47.69 acres, the maximum 30-day monthly average leachate volume would be 1,165,687 gallons.

For GLRA Landfill, the volume of leachate that was pumped from the Shilling Farms Expansion areas for years 2016 through September 2017:

<u>Year</u>	<u>Volume (gallons)</u>
2016 (12 months)	8,041,904
2017 (9 months)	10,959,000

This gives a total leachate volume of 19,000,904 gallons in 21 months, or an average of 904,805 gallons per month.

The combined maximum leachate volume collected from both the Heilmandale Expansion operations and the Shilling Farms Expansion will equal to $1,165,687 + 904,805 = 2,070,492$ gallons per month, or 69,016 gallons per day, assuming that the Shilling Farms Expansion areas is not capped.

Assuming an average leachate pumped volume of 45,000 gallons per day to the sewage treatment facility, a total of 1,350,000 ($45,000 \times 30 = 1,350,000$) gallons will be subtracted from the monthly total of 2,070,492 gallons. Therefore, the remaining leachate that requires storage is $2,070,492 - 1,350,000 = 720,492$ gallons per month. The existing storage capacity is a 1,000,000 gallon storage tank. According to 25 PA 273.275(b) no more than 25 percent of the total leachate storage capacity tank may be used for flow equalization on a regular basis. Therefore, 75 percent of the leachate storage capacity is available for storage, or 750,000 gallons. Since the available storage tank capacity is greater than the required storage volume, a comparison of the required 30 day storage capacity versus the available storage capacity indicates that sufficient storage will be available within the existing lined impoundments.

GLRA will continue to use the existing 1,000,000 gallon storage tank currently serving the Shilling Farms Expansion area. As noted in the HELP Model analysis, the peak leachate production associated with the Heilmandale Expansion and Shilling Farms Expansion areas combined is approximately 69,016 gallons per day. The peak daily flow projected to a monthly estimate yields approximately 2,070,492 gallons of leachate per month.

SITE-SPECIFIC WEATHER INFORMATION

(Station: USC00364896; Name: Lebanon 2 W, PA US; Latitude: 40.374 degrees)

SITE-SPECIFIC WEATHER DATA (YEAR 2010)

STATION	NAME	LATITUDE	LONGITUDE	ELEVATION	DATE	MLY-PRCP-NORMAL	MLY-TAVG-NORMAL	MLY-TMAX-NORMAL	MLY-TMIN-NORMAL
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	1	2.96	28.2	36.2	20.2
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	2	2.67	31.2	39.9	22.5
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	3	3.34	39.4	49.3	29.4
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	4	3.68	50.1	61.5	38.6
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	5	4.1	59.8	71.2	48.3
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	6	4.15	68.8	79.8	57.8
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	7	4.56	73	83.8	62.2
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	8	3.64	71.4	82.1	60.7
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	9	3.93	63.9	74.6	53.2
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	10	3.49	52.5	63.6	41.5
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	11	3.49	42.6	52.2	33
USC00364896	LEBANON 2 W, PA US	40.3333	-76.4667	137.2	12	3.34	32.5	40.3	24.7

HELP MODEL RESULTS SUMMARY TABLE

TABLE A. HELP MODEL DATA SUMMARY

HELP MODEL SCENARIOS	SOIL COVER/CAP SYSTEM DESCRIPTION	BOTTOM LINER SYSTEM DESCRIPTION	WASTE HEIGHT (FT)	FINAL COVER	AVERAGE ANNUAL LEACHATE FLOW		MONTHLY-RELATED LEACHATE INFORMATION				PEAK DAILY VALUES			
					CUBIC FEET (CF/ACRE)	GALLONS (GAL/ACRE)	MAX AVG MONTHLY FLOW (IN/ACRE)	MAX AVG MONTHLY FLOW (CF/ACRE)	MAX AVG MONTHLY FLOW (GAL/ACRE)	DAILY FLOW BASED ON MAX AVG MONTHLY (GAL/ACRE)*	LEACHATE FLOW (CF/ACRE)	LEACHATE FLOW (GAL/ACRE)	MAXIMUM HEAD ON LINER (IN)	
GL2M8	6" daily cover, surface 2%, 200', bare	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	8	NO	15,404	115,230	0.655	2377	17,783	593	398	2,977	1.195	
GL2M30	6" daily cover, surface 2%, 200', bare	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	30	NO	15,037	112,485	0.782	2840	21,246	708	290	2,169	0.883	
GL12M70	12" daily cover, surface 2%, 200', bare	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	70	NO	15,182	113,569	0.827	3003	22,462	749	281	2,102	0.856	
GL12M100	12" daily cover, surface 2%, 200', bare	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	100	NO	15,160	113,405	0.827	3002	22,459	749	276	2,065	0.844	
GL12M130	12" daily cover, surface 33%, 150', fair	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	130	NO	15,874	118,746	0.900	3268	24,444	815	284	2,124	0.866	
GL12M190	12" daily cover, surface 33%, 150', fair	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	190	NO	15,844	118,521	0.889	3228	24,148	805	279	2,087	0.852	
GL24N70	24" soil cover/GDN/40mil FML/12" Intermediate soil cover, surface 33%, 150', good	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	70	YES	0.002	0.015	0.0000	0.0000	0.0000	0.0000	0.0003	0.002	0.004	
GL24N100	24" soil cover/GDN/40mil FML/12" Intermediate soil cover, surface 33%, 150', good	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	100	YES	0.002	0.015	0.0000	0.0000	0.0000	0.0000	0.0003	0.002	0.004	
GL24N130	24" soil cover/GDN/40mil FML/12" Intermediate soil cover, surface 33%, 150', good	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	130	YES	0.002	0.015	0.0000	0.0000	0.0000	0.0000	0.0003	0.002	0.004	
GL24N190	24" soil cover/GDN/40mil FML/12" Intermediate soil cover, surface 33%, 150', good	18" Drainage stone/60mil FML/GDN/60mil FML/GCL/6" compacted soil subgrade, cell floor 2%, 200'	190	YES	0.002	0.015	0.0000	0.0000	0.0000	0.0000	0.0003	0.002	0.004	

* Maximum average monthly flow rate divided by 30-days

LEACHATE QUANTITY ESTIMATION

(Maximum Monthly Average)

TABLE B. MAXIMUM MONTHLY AVERAGE LEACHATE GENERATION

HELP MODEL SCENARIOS	WASTE HEIGHT (FT.)	MAXIMUM MONTHLY AVERAGE (GAL/MO/AC.)												ANNUAL TOTAL (GAL/YR/AC.)
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
GL6M8	8	10,902	749	14,589	17,782	250	3,340	1,686	5,292	11,130	17,293	16,731	15,480	115,232
GL6M30	30	10,655	1,178	10,283	21,244	255	3,321	1,678	4,811	9,677	11,097	19,267	19,012	112,478
GL12M70	70	10,603	2,259	8,844	20,302	880	4,418	2,623	4,841	8,884	10,307	17,149	22,460	113,570
GL12M100	100	10,975	2,357	8,729	20,367	885	4,415	2,623	4,830	8,811	10,112	16,837	22,458	113,399
GL12M130	130	18,665	10,402	5,485	24,443	18,371	9,053	2,664	5	1,268	3,989	8,499	16,492	119,336
GL12M190	190	18,360	10,722	5,496	24,147	18,317	9,096	2,479	5	1,268	3,948	8,404	16,272	118,514
MAX VALUE (GAL/AC.)		18,665	10,722	14,589	24,443	18,371	9,096	2,664	5,292	11,130	17,293	19,267	22,460	173,992

TABLE C-1. LEACHATE GENERATION ESTIMATE: 5-YEARS (2017-2022)

PAD	STATUS	CAPPED AREA (AC)	UNCAPPED AREA (AC)	CAPPED ANNUAL FLOW (GPYR/AC)	UNCAPPED ANNUAL FLOW (GPYR/AC)	TOTAL MAX LEACHATE FLOW (GPYR)
8	Uncapped, 70' waste, 2% plateau, 2% bottom floor	0.0	10.07	0	113,569	1,143,640
9	Uncapped, 30' waste, 2% plateau, 2% bottom floor	0.0	6.63	0	112,485	745,776
10	Uncapped, 8' waste, 2% plateau, 2% bottom floor	0.0	7.47	0	115,230	860,768
Anticipated Annual Leachate Generation at 5-years (gallons per year)						2,750,183

TABLE C-2. LEACHATE GENERATION ESTIMATE: 10-YEARS (2022-2027)

PAD	STATUS	CAPPED AREA (AC)	UNCAPPED AREA (AC)	CAPPED ANNUAL FLOW (GPYR/AC)	UNCAPPED ANNUAL FLOW (GPYR/AC)	TOTAL MAX LEACHATE FLOW (GPYR)
8	Uncapped, 130' waste, 2% plateau, 2% bottom floor	0.0	10.07	0	118,746	1,195,772
9	Uncapped, 70' waste, 2% plateau, 2% bottom floor	0.0	7.37	0	113,569	837,004
10	Uncapped, 70' waste, 2% plateau, 2% bottom floor	0.0	8.98	0	113,569	1,019,850
11	Uncapped, 30' waste, 2% plateau, 2% bottom floor	0.0	7.17	0	112,485	806,517
12	Uncapped, 8' waste, 2% plateau, 2% bottom floor	0.0	6.63	0	115,230	763,975
Anticipated Annual Leachate Generation at 10-years (gallons per year)						4,623,118

TABLE C-3. LEACHATE GENERATION ESTIMATE: 15-YEARS (2027-2032)

PAD	STATUS	CAPPED AREA (AC)	UNCAPPED AREA (AC)	CAPPED ANNUAL FLOW (GPYR/AC)	UNCAPPED ANNUAL FLOW (GPYR/AC)	TOTAL MAX LEACHATE FLOW (GPYR)
8	Uncapped, 130' waste, 33% slope, 2% bottom floor	0.0	10.07	0	118,746	1,195,772
9	Uncapped, 130' waste, 33% slope, 2% bottom floor	0.0	7.37	0	118,746	875,158
10	Uncapped, 70' waste, 2% plateau, 2% bottom floor	0.0	8.98	0	113,569	1,019,850
11	Uncapped, 70' waste, 2% plateau, 2% bottom floor	0.0	7.17	0	113,569	814,290
12	Uncapped, 30' waste, 2% plateau, 2% bottom floor	0.0	6.63	0	112,485	745,776
13	Uncapped, 8' waste, 2% plateau, 2% bottom floor	0.0	7.47	0	115,230	860,768
Anticipated Annual Leachate Generation at 15-years (gallons per year)						5,511,613

TABLE C-4. LEACHATE GENERATION ESTIMATE: 20-YEARS (2032-2037)

PAD	STATUS	CAPPED AREA (AC)	UNCAPPED AREA (AC)	CAPPED ANNUAL FLOW (GPYR/AC)	UNCAPPED ANNUAL FLOW (GPYR/AC)	TOTAL MAX LEACHATE FLOW (GPYR)
8	Uncapped, 190' waste, 33% sideslope, 2% bottom floor	0.0	10.07	0	118,521	1,193,506
9	Uncapped, 130' waste, 33% sideslope, 2% bottom floor	0.0	7.37	0	118,746	875,158
10	Uncapped, 70' waste, 2% plateau, 2% bottom floor	0.0	8.98	0	113,569	1,019,850
11	Uncapped, 70' waste, 2% plateau, 2% bottom floor	0.0	7.17	0	113,569	814,290
12	Uncapped, 30' waste, 2% plateau, 2% bottom floor	0.0	6.63	0	112,485	745,776
13	Uncapped, 8' waste, 2% plateau, 2% bottom floor	0.0	7.47	0	115,230	860,768
Anticipated Annual Leachate Generation at 20-years (gallons per year)						5,509,347

HELP Model Scenarios & Printouts

1. Waste Height = 8 feet (Filename: GL6M8)
2. Waste Height = 30 feet (Filename: GL6M30)
3. Waste Height = 70 feet (Filename: GL12M70)
4. Waste Height = 100 feet (Filename: GL12M100)
5. Waste Height = 130 feet (Filename: GL12M130)
6. Waste Height = 190 feet (Filename: GL12M190)
7. Waste Height = 70 feet + Cap (Filename: GL24N70)
8. Waste Height = 100 feet + Cap (Filename: GL24N100)
9. Waste Height = 130 feet + Cap (Filename: GL24N130)
10. Waste Height = 190 feet + Cap (Filename: GL24N190)

Scenario 1

(Waste Height = 8 feet; Filename: GL6M8)

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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:\HELP3\GLRA2\5B.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\5B.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\5B.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\5B.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL6M8.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL6M8.OUT

```

TIME: 13:36 DATE: 10/28/2017

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TITLE: GLRA PHASE 2 - 8' WASTE, 6" CS

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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 10
THICKNESS = 6.00 INCHES
POROSITY = 0.3980 VOL/VOL
FIELD CAPACITY = 0.2440 VOL/VOL
WILTING POINT = 0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2721 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.119999997000E-03 CM/SEC

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LAYER 2

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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 96.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3038 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

```

LAYER 3

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	=	0.0337	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 4

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.22	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7313	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.200000003000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 6

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	=	2.00	HOLES/ACRE

FML PLACEMENT QUALITY = 2 - EXCELLENT

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3650	VOL/VOL
FIELD CAPACITY	=	0.3050	VOL/VOL
WILTING POINT	=	0.2020	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2637	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.270000010000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND
A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	94.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.232	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.730	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.970	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	33.325	INCHES
TOTAL INITIAL WATER	=	33.325	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE	=	40.37	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	114	
END OF GROWING SEASON (JULIAN DATE)	=	288	

EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	8.595	31201.223	18.74
EVAPOTRANSPIRATION	27.835	101041.797	60.68
DRAINAGE COLLECTED FROM LAYER 3	4.9584	17998.875	10.81
PERC./LEAKAGE THROUGH LAYER 4	4.474786	16243.475	9.76
AVG. HEAD ON TOP OF LAYER 4	0.0796		
DRAINAGE COLLECTED FROM LAYER 5	4.4729	16236.796	9.75
PERC./LEAKAGE THROUGH LAYER 7	0.000006	0.022	0.00
AVG. HEAD ON TOP OF LAYER 6	0.1075		
PERC./LEAKAGE THROUGH LAYER 8	0.049905	181.157	0.11
CHANGE IN WATER STORAGE	-0.042	-151.739	-0.09
SOIL WATER AT START OF YEAR	33.327	120977.062	

SOIL WATER AT END OF YEAR	33.285	120825.328	
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	-0.023	0.00

ANNUAL TOTALS FOR YEAR 2			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	15.087	54767.512	33.14
EVAPOTRANSPIRATION	20.612	74820.414	45.28
DRAINAGE COLLECTED FROM LAYER 3	5.9750	21689.078	13.13
PERC./LEAKAGE THROUGH LAYER 4	4.877299	17704.596	10.71
AVG. HEAD ON TOP OF LAYER 4	0.0954		
DRAINAGE COLLECTED FROM LAYER 5	4.6168	16759.086	10.14
PERC./LEAKAGE THROUGH LAYER 7	0.000006	0.023	0.00
AVG. HEAD ON TOP OF LAYER 6	0.1118		
PERC./LEAKAGE THROUGH LAYER 8	0.028690	104.143	0.06
CHANGE IN WATER STORAGE	-0.800	-2902.654	-1.76
SOIL WATER AT START OF YEAR	33.285	120825.328	
SOIL WATER AT END OF YEAR	32.486	117922.672	
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	-0.035	0.00

ANNUAL TOTALS FOR YEAR 3			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	15.083	54752.422	34.79
EVAPOTRANSPIRATION	22.020	79932.164	50.78

DRAINAGE COLLECTED FROM LAYER 3	2.8046	10180.828	6.47
PERC./LEAKAGE THROUGH LAYER 4	2.901772	10533.434	6.69
AVG. HEAD ON TOP OF LAYER 4	0.0452		
DRAINAGE COLLECTED FROM LAYER 5	3.2545	11813.730	7.51
PERC./LEAKAGE THROUGH LAYER 7	0.000005	0.017	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0782		
PERC./LEAKAGE THROUGH LAYER 8	0.020051	72.784	0.05
CHANGE IN WATER STORAGE	0.178	644.861	0.41
SOIL WATER AT START OF YEAR	32.486	117922.672	
SOIL WATER AT END OF YEAR	32.466	117850.594	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.038	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	12.715	46155.844	28.25
EVAPOTRANSPIRATION	23.661	85890.562	52.57
DRAINAGE COLLECTED FROM LAYER 3	4.4537	16167.085	9.90
PERC./LEAKAGE THROUGH LAYER 4	3.941259	14306.769	8.76
AVG. HEAD ON TOP OF LAYER 4	0.0717		
DRAINAGE COLLECTED FROM LAYER 5	3.9777	14439.162	8.84
PERC./LEAKAGE THROUGH LAYER 7	0.000005	0.020	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0958		
PERC./LEAKAGE THROUGH LAYER 8	0.015395	55.885	0.03
CHANGE IN WATER STORAGE	0.187	677.775	0.41
SOIL WATER AT START OF YEAR	32.466	117850.594	
SOIL WATER AT END OF YEAR	32.475	117885.711	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	-0.022	0.00

ANNUAL TOTALS FOR YEAR 5			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	14.604	53011.070	32.22
EVAPOTRANSPIRATION	24.908	90415.211	54.95
DRAINAGE COLLECTED FROM LAYER 3	3.0265	10986.273	6.68
PERC./LEAKAGE THROUGH LAYER 4	3.070676	11146.553	6.77
AVG. HEAD ON TOP OF LAYER 4	0.0486		
DRAINAGE COLLECTED FROM LAYER 5	2.9218	10606.250	6.45
PERC./LEAKAGE THROUGH LAYER 7	0.000004	0.016	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0704		
PERC./LEAKAGE THROUGH LAYER 8	0.012410	45.050	0.03
CHANGE IN WATER STORAGE	-0.142	-515.958	-0.31
SOIL WATER AT START OF YEAR	32.475	117885.711	
SOIL WATER AT END OF YEAR	32.708	118729.352	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.019	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	3.45 3.77	3.48 4.10	3.93 5.20	3.33 3.90	3.10 3.50	3.74 3.52
STD. DEVIATIONS	0.72 1.31	1.17 1.59	0.61 3.40	1.01 1.97	1.40 1.26	0.54 1.49
RUNOFF						
TOTALS	2.075 0.574	2.360 0.926	2.726 1.437	0.317 0.504	0.300 0.452	0.573 0.973

STD. DEVIATIONS	1.436 0.283	1.004 0.599	2.484 1.381	0.277 0.444	0.272 0.342	0.136 1.198
EVAPOTRANSPIRATION						

TOTALS	0.524 3.467	0.549 2.493	1.260 2.353	3.134 2.175	2.328 1.858	2.838 0.826
STD. DEVIATIONS	0.092 1.292	0.188 0.559	0.539 0.778	0.628 0.885	1.458 0.163	0.674 0.271
LATERAL DRAINAGE COLLECTED FROM LAYER 3						

TOTALS	0.4015 0.0621	0.0276 0.1949	0.5373 0.4099	0.6549 0.6369	0.0092 0.6162	0.1230 0.5701
STD. DEVIATIONS	0.5724 0.0886	0.0612 0.2040	0.6312 0.4069	0.3056 0.9038	0.0113 0.4623	0.1267 0.1321
PERCOLATION/LEAKAGE THROUGH LAYER 4						

TOTALS	0.3219 0.0852	0.0325 0.2053	0.4517 0.3721	0.5572 0.5296	0.0203 0.5748	0.1519 0.5506
STD. DEVIATIONS	0.4581 0.1154	0.0713 0.2020	0.4981 0.3232	0.2123 0.5457	0.0181 0.2675	0.1515 0.1089
LATERAL DRAINAGE COLLECTED FROM LAYER 5						

TOTALS	0.4031 0.1183	0.0964 0.1277	0.2921 0.3062	0.6072 0.4576	0.1423 0.5102	0.1268 0.6611
STD. DEVIATIONS	0.3491 0.0849	0.1525 0.1419	0.3621 0.1603	0.1229 0.2021	0.0884 0.2409	0.1181 0.1363
PERCOLATION/LEAKAGE THROUGH 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 8						

TOTALS	0.0027 0.0021	0.0023 0.0020	0.0024 0.0019	0.0023 0.0019	0.0022 0.0017	0.0021 0.0017
STD. DEVIATIONS	0.0019 0.0012	0.0016 0.0011	0.0016 0.0010	0.0014 0.0010	0.0014 0.0009	0.0012 0.0009

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)						

DAILY AVERAGE HEAD ON TOP OF LAYER 4						

AVERAGES	0.0762 0.0118	0.0058 0.0370	0.1019 0.0804	0.1284 0.1209	0.0017 0.1208	0.0241 0.1082
STD. DEVIATIONS	0.1086 0.0168	0.0129 0.0387	0.1198 0.0798	0.0599 0.1715	0.0022 0.0906	0.0248 0.0251
DAILY AVERAGE HEAD ON TOP OF LAYER 6						

AVERAGES	0.1147	0.0304	0.0831	0.1786	0.0405	0.0373

	0.0337	0.0363	0.0900	0.1302	0.1501	0.1882
STD. DEVIATIONS	0.0993	0.0481	0.1031	0.0361	0.0252	0.0347
	0.0242	0.0404	0.0472	0.0575	0.0709	0.0388

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS				1 THROUGH	5
				INCHES	CU. FEET
				PERCENT	
PRECIPITATION	45.02	(0.978)		163415.3	100.00
RUNOFF	13.217	(2.7621)		47977.62	29.359
EVAPOTRANSPIRATION	23.807	(2.7777)		86420.03	52.884
LATERAL DRAINAGE COLLECTED FROM LAYER 3	4.24364	(1.33272)		15404.429	9.42655
PERCOLATION/LEAKAGE THROUGH LAYER 4	3.85316	(0.86030)		13986.965	8.55915
AVERAGE HEAD ON TOP OF LAYER 4	0.068	(0.021)			
LATERAL DRAINAGE COLLECTED FROM LAYER 5	3.84876	(0.74306)		13971.005	8.54939
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)		0.019	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.093	(0.018)			
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.02529	(0.01507)		91.804	0.05618
CHANGE IN WATER STORAGE	-0.124	(0.4035)		-449.54	-0.275

PEAK DAILY VALUES FOR YEARS		1 THROUGH	5
		(INCHES)	(CU. FT.)
PRECIPITATION		2.16	7840.800
RUNOFF		3.421	12417.6436
DRAINAGE COLLECTED FROM LAYER 3		0.10958	397.79257
PERCOLATION/LEAKAGE THROUGH LAYER 4		0.059061	214.39265
AVERAGE HEAD ON TOP OF LAYER 4		0.645	
MAXIMUM HEAD ON TOP OF LAYER 4		1.195	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)		14.6 FEET	

DRAINAGE COLLECTED FROM LAYER 5	0.02539	92.15794
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00011
AVERAGE HEAD ON TOP OF LAYER 6	0.224	
MAXIMUM HEAD ON TOP OF LAYER 6	0.433	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	6.8 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000198	0.71960
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4085	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1213	

*** 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	1.6987	0.2831
2	28.5249	0.2971
3	0.6635	0.0369
4	0.0000	0.0000
5	0.1858	0.8292
6	0.0000	0.0000
7	0.1770	0.7500
8	1.4558	0.2426
SNOW WATER	0.000	

Scenario 2

(Waste Height = 30 feet; Filename: GL6M30)

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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:\HELP3\GLRA2\5B.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\5B.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\5B.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\5B.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL6M30.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL6M30.OUT

```

TIME: 13:58 DATE: 10/28/2017

```

*****
TITLE: GLRA PHASE 2 - 30' WASTE, 6" CS
*****

```

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 10
THICKNESS = 6.00 INCHES
POROSITY = 0.3980 VOL/VOL
FIELD CAPACITY = 0.2440 VOL/VOL
WILTING POINT = 0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2721 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.119999997000E-03 CM/SEC

```

LAYER 2

```

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 360.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2955 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

```

LAYER 3

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	=	0.0338	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 4

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 -	EXCELLENT

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.8500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.000000000000	CM/SEC

LAYER 6

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 -	EXCELLENT

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0			
THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24			
THICKNESS	=	6.00	INCHES
POROSITY	=	0.3650	VOL/VOL
FIELD CAPACITY	=	0.3050	VOL/VOL
WILTING POINT	=	0.2020	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2637	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.270000010000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND
A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	94.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.232	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.730	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.970	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	110.576	INCHES
TOTAL INITIAL WATER	=	110.576	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE	=	40.37	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	114	
END OF GROWING SEASON (JULIAN DATE)	=	288	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	63.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	8.595	31201.223	18.74
EVAPOTRANSPIRATION	27.835	101041.797	60.68
DRAINAGE COLLECTED FROM LAYER 3	4.8348	17550.414	10.54
PERC./LEAKAGE THROUGH LAYER 4	4.599994	16697.979	10.03
AVG. HEAD ON TOP OF LAYER 4	0.0775		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.049906	181.157	0.11
CHANGE IN WATER STORAGE	4.555	16533.516	9.93
SOIL WATER AT START OF YEAR	111.152	403483.187	
SOIL WATER AT END OF YEAR	115.707	420016.719	
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	-0.020	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	15.087	54767.512	33.14
EVAPOTRANSPIRATION	20.612	74820.414	45.28
DRAINAGE COLLECTED FROM LAYER 3	5.8291	21159.637	12.81
PERC./LEAKAGE THROUGH LAYER 4	5.153414	18706.893	11.32
AVG. HEAD ON TOP OF LAYER 4	0.0936		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.028690	104.145	0.06
CHANGE IN WATER STORAGE	3.963	14385.930	8.71
SOIL WATER AT START OF YEAR	115.707	420016.719	
SOIL WATER AT END OF YEAR	119.670	434402.656	
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	-0.094	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	15.083	54752.422	34.79
EVAPOTRANSPIRATION	22.020	79932.164	50.78
DRAINAGE COLLECTED FROM LAYER 3	2.7512	9986.842	6.35
PERC./LEAKAGE THROUGH LAYER 4	2.955211	10727.417	6.82
AVG. HEAD ON TOP OF LAYER 4	0.0444		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.020050	72.781	0.05
CHANGE IN WATER STORAGE	3.486	12652.660	8.04
SOIL WATER AT START OF YEAR	119.670	434402.656	
SOIL WATER AT END OF YEAR	122.958	446338.375	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46

ANNUAL WATER BUDGET BALANCE	0.0000	-0.041	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	12.715	46155.844	28.25
EVAPOTRANSPIRATION	23.661	85890.562	52.57
DRAINAGE COLLECTED FROM LAYER 3	4.3364	15741.244	9.63
PERC./LEAKAGE THROUGH LAYER 4	4.058571	14732.612	9.02
AVG. HEAD ON TOP OF LAYER 4	0.0699		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.015396	55.886	0.03
CHANGE IN WATER STORAGE	4.282	15542.769	9.51
SOIL WATER AT START OF YEAR	122.958	446338.375	
SOIL WATER AT END OF YEAR	127.063	461238.469	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	-0.013	0.00

ANNUAL TOTALS FOR YEAR 5			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	14.604	53011.070	32.22
EVAPOTRANSPIRATION	24.908	90415.211	54.95
DRAINAGE COLLECTED FROM LAYER 3	2.9608	10747.868	6.53
PERC./LEAKAGE THROUGH LAYER 4	3.094930	11234.595	6.83
AVG. HEAD ON TOP OF LAYER 4	0.0476		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.012410	45.048	0.03

CHANGE IN WATER STORAGE	2.845	10328.788	6.28
SOIL WATER AT START OF YEAR	127.063	461238.469	
SOIL WATER AT END OF YEAR	130.283	472926.875	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.108	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	3.45	3.48	3.93	3.33	3.10	3.74	
	3.77	4.10	5.20	3.90	3.50	3.52	
STD. DEVIATIONS	0.72	1.17	0.61	1.01	1.40	0.54	
	1.31	1.59	3.40	1.97	1.26	1.49	
RUNOFF							

TOTALS	2.075	2.360	2.726	0.317	0.300	0.573	
	0.574	0.926	1.437	0.504	0.452	0.973	
STD. DEVIATIONS	1.436	1.004	2.484	0.277	0.272	0.136	
	0.283	0.599	1.381	0.444	0.342	1.198	
EVAPOTRANSPIRATION							

TOTALS	0.524	0.549	1.260	3.134	2.328	2.838	
	3.467	2.493	2.353	2.175	1.858	0.826	
STD. DEVIATIONS	0.092	0.188	0.539	0.628	1.458	0.674	
	1.292	0.559	0.778	0.885	0.163	0.271	
LATERAL DRAINAGE COLLECTED FROM LAYER 3							

TOTALS	0.3924	0.0434	0.3787	0.7824	0.0094	0.1223	
	0.0618	0.1772	0.3564	0.4087	0.7096	0.7002	
STD. DEVIATIONS	0.5495	0.0586	0.4395	0.3102	0.0109	0.1259	
	0.0881	0.1888	0.3403	0.4150	0.4610	0.2221	
PERCOLATION/LEAKAGE THROUGH LAYER 4							

TOTALS	0.3416	0.0470	0.3685	0.6816	0.0214	0.1528	
	0.0856	0.1973	0.3416	0.4302	0.6531	0.6519	
STD. DEVIATIONS	0.4771	0.0638	0.4068	0.2357	0.0176	0.1525	
	0.1160	0.1960	0.2820	0.3262	0.3135	0.1693	
PERCOLATION/LEAKAGE THROUGH 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 8

TOTALS	0.0027 0.0021	0.0023 0.0020	0.0024 0.0019	0.0023 0.0019	0.0022 0.0017	0.0021 0.0017
STD. DEVIATIONS	0.0019 0.0012	0.0016 0.0011	0.0016 0.0010	0.0014 0.0010	0.0014 0.0009	0.0012 0.0009

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0745 0.0117	0.0091 0.0336	0.0719 0.0699	0.1534 0.0776	0.0018 0.1391	0.0240 0.1329
STD. DEVIATIONS	0.1043 0.0167	0.0123 0.0358	0.0834 0.0667	0.0608 0.0787	0.0021 0.0904	0.0247 0.0421

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.2300 0.2300	0.2300 0.2300	0.2300 0.2300	0.2300 0.2300	0.2300 0.2300	0.2300 0.2300
STD. DEVIATIONS	0.0001 0.0001	0.0001 0.0001	0.0001 0.0001	0.0001 0.0001	0.0001 0.0001	0.0001 0.0001

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.02 (0.978)	163415.3	100.00
RUNOFF	13.217 (2.7621)	47977.62	29.359
EVAPOTRANSPIRATION	23.807 (2.7777)	86420.03	52.884
LATERAL DRAINAGE COLLECTED FROM LAYER 3	4.14248 (1.29360)	15037.202	9.20183
PERCOLATION/LEAKAGE THROUGH LAYER 4	3.97242 (0.94878)	14419.900	8.82408
AVERAGE HEAD ON TOP OF LAYER 4	0.067 (0.021)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.040	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.230 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.02529 (0.01507)	91.803	0.05618
CHANGE IN WATER STORAGE	3.826 (0.6773)	13888.73	8.499

PEAK DAILY VALUES FOR YEARS	1 THROUGH	5
	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	7840.800
RUNOFF	3.421	12417.6436
DRAINAGE COLLECTED FROM LAYER 3	0.07975	289.50912
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.050146	182.02853
AVERAGE HEAD ON TOP OF LAYER 4	0.469	
MAXIMUM HEAD ON TOP OF LAYER 4	0.883	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	11.7 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00011
AVERAGE HEAD ON TOP OF LAYER 6	0.230	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000198	0.71963
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4085
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1213

*** 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	1.6987	0.2831	
2	105.6602	0.2935	
3	0.6575	0.0365	
4	0.0000	0.0000	
5	20.0576	87.2070	
6	0.0000	0.0000	
7	0.1770	0.7500	
8	1.4558	0.2426	
SNOW WATER	0.000		

Scenario 3

(Waste Height = 70 feet; Filename: GL12M70)

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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:\HELP3\GLRA2\5B.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\5B.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\5B.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\5B.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL12M70.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL12M70.OUT

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TIME: 16:42 DATE: 10/28/2017

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*****
TITLE: GLRA PHASE 2 - 70' WASTE, 12" CS
*****

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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 10
THICKNESS = 12.00 INCHES
POROSITY = 0.3980 VOL/VOL
FIELD CAPACITY = 0.2440 VOL/VOL
WILTING POINT = 0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2754 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.119999997000E-03 CM/SEC

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LAYER 2

```

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 840.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2935 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

```

LAYER 3

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	=	0.0336	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 4

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.8500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.000000000000	CM/SEC

LAYER 6

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3650	VOL/VOL
FIELD CAPACITY	=	0.3050	VOL/VOL
WILTING POINT	=	0.2020	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2654	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.270000010000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	94.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.220	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.184	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.088	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	252.387	INCHES
TOTAL INITIAL WATER	=	252.387	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE	=	40.37	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	114	
END OF GROWING SEASON (JULIAN DATE)	=	288	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20	MPH

AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
 AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 63.00 %
 AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
 AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
 AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	8.750	31760.721	19.07
EVAPOTRANSPIRATION	27.100	98373.531	59.08
DRAINAGE COLLECTED FROM LAYER 3	4.8795	17712.510	10.64
PERC./LEAKAGE THROUGH LAYER 4	5.140449	18659.828	11.21
AVG. HEAD ON TOP OF LAYER 4	0.0781		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.055146	200.181	0.12
CHANGE IN WATER STORAGE	5.086	18461.066	11.09
SOIL WATER AT START OF YEAR	252.963	918254.750	
SOIL WATER AT END OF YEAR	258.048	936715.812	
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	0.076	0.00

ANNUAL TOTALS FOR YEAR 2			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	15.254	55373.766	33.51
EVAPOTRANSPIRATION	20.244	73486.742	44.47
DRAINAGE COLLECTED FROM LAYER 3	5.6627	20555.697	12.44
PERC./LEAKAGE THROUGH LAYER 4	5.214472	18928.533	11.46
AVG. HEAD ON TOP OF LAYER 4	0.0912		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.030361	110.209	0.07
CHANGE IN WATER STORAGE	4.328	15711.315	9.51
SOIL WATER AT START OF YEAR	258.048	936715.812	
SOIL WATER AT END OF YEAR	262.377	952427.125	
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	-0.0001	-0.185	0.00

ANNUAL TOTALS FOR YEAR 3			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	15.335	55664.668	35.37
EVAPOTRANSPIRATION	21.503	78055.562	49.59
DRAINAGE COLLECTED FROM LAYER 3	2.9308	10638.778	6.76
PERC./LEAKAGE THROUGH LAYER 4	3.459539	12558.125	7.98
AVG. HEAD ON TOP OF LAYER 4	0.0471		

PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.020864	75.737	0.05
CHANGE IN WATER STORAGE	3.571	12961.982	8.24
SOIL WATER AT START OF YEAR	262.377	952427.125	
SOIL WATER AT END OF YEAR	265.750	964672.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.105	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	12.830	46572.832	28.50
EVAPOTRANSPIRATION	23.232	84331.344	51.61
DRAINAGE COLLECTED FROM LAYER 3	4.2900	15572.800	9.53
PERC./LEAKAGE THROUGH LAYER 4	4.387059	15925.023	9.75
AVG. HEAD ON TOP OF LAYER 4	0.0691		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.015877	57.632	0.04
CHANGE IN WATER STORAGE	4.642	16851.814	10.31
SOIL WATER AT START OF YEAR	265.750	964672.187	
SOIL WATER AT END OF YEAR	270.215	980881.312	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	-0.130	0.00

ANNUAL TOTALS FOR YEAR 5			
	INCHES	CU. FEET	PERCENT

PRECIPITATION	45.33	164547.875	100.00
RUNOFF	14.849	53902.332	32.76
EVAPOTRANSPIRATION	23.900	86755.430	52.72
DRAINAGE COLLECTED FROM LAYER 3	3.1494	11432.417	6.95
PERC./LEAKAGE THROUGH LAYER 4	3.685254	13377.472	8.13
AVG. HEAD ON TOP OF LAYER 4	0.0507		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.012725	46.192	0.03
CHANGE IN WATER STORAGE	3.419	12411.541	7.54
SOIL WATER AT START OF YEAR	270.215	980881.312	
SOIL WATER AT END OF YEAR	274.009	994652.437	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.032	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	3.45 3.77	3.48 4.10	3.93 5.20	3.33 3.90	3.10 3.50	3.74 3.52
STD. DEVIATIONS	0.72 1.31	1.17 1.59	0.61 3.40	1.01 1.97	1.40 1.26	0.54 1.49
RUNOFF						
TOTALS	2.105 0.582	2.412 0.923	2.766 1.449	0.321 0.515	0.302 0.462	0.578 0.989
STD. DEVIATIONS	1.454 0.285	1.019 0.591	2.505 1.400	0.277 0.454	0.271 0.349	0.138 1.204
EVAPOTRANSPIRATION						
TOTALS	0.524 3.295	0.549 2.436	1.235 2.342	3.018 2.134	2.289 1.843	2.706 0.825
STD. DEVIATIONS	0.092 1.211	0.188 0.520	0.504 0.794	0.623 0.872	1.443 0.138	0.663 0.271

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.3905	0.0832	0.3257	0.7477	0.0324	0.1627
	0.0966	0.1783	0.3272	0.3796	0.6316	0.8272
STD. DEVIATIONS	0.4526	0.1367	0.3985	0.2733	0.0423	0.1533
	0.0974	0.1979	0.2843	0.2550	0.3858	0.3374

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.3653	0.0758	0.3403	0.7084	0.0666	0.2215
	0.1727	0.2329	0.3531	0.4512	0.6236	0.7659
STD. DEVIATIONS	0.4264	0.1088	0.3942	0.2078	0.0581	0.1930
	0.1269	0.2258	0.2666	0.2219	0.2686	0.2387

PERCOLATION/LEAKAGE THROUGH 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 8

TOTALS	0.0029	0.0025	0.0026	0.0024	0.0024	0.0022
	0.0022	0.0021	0.0020	0.0020	0.0018	0.0018
STD. DEVIATIONS	0.0023	0.0018	0.0019	0.0016	0.0015	0.0014
	0.0013	0.0012	0.0011	0.0011	0.0010	0.0009

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0741	0.0175	0.0618	0.1466	0.0062	0.0319
	0.0183	0.0338	0.0641	0.0720	0.1238	0.1570
STD. DEVIATIONS	0.0859	0.0287	0.0756	0.0536	0.0080	0.0301
	0.0185	0.0376	0.0557	0.0484	0.0756	0.0640

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.02	(0.978)	163415.3	100.00
RUNOFF	13.404	(2.7944)	48654.86	29.774
EVAPOTRANSPIRATION	23.196	(2.6133)	84200.52	51.525

LATERAL DRAINAGE COLLECTED FROM LAYER 3	4.18249 (1.15352)	15182.440	9.29071
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.37735 (0.80693)	15889.796	9.72357
AVERAGE HEAD ON TOP OF LAYER 4	0.067 (0.019)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.040	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.230 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.02699 (0.01709)	97.990	0.05996
CHANGE IN WATER STORAGE	4.209 (0.7074)	15279.54	9.350

PEAK DAILY VALUES FOR YEARS	1 THROUGH	5
	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	7840.800
RUNOFF	3.427	12439.5605
DRAINAGE COLLECTED FROM LAYER 3	0.07741	280.99939
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.049387	179.27493
AVERAGE HEAD ON TOP OF LAYER 4	0.455	
MAXIMUM HEAD ON TOP OF LAYER 4	0.858	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	11.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00011
AVERAGE HEAD ON TOP OF LAYER 6	0.230	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000228	0.82630
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.3867
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1360

*** 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	3.3987	0.2832
2	245.6662	0.2925
3	0.6516	0.0362
4	0.0000	0.0000
5	22.0823	96.0099
6	0.0000	0.0000
7	0.1770	0.7500
8	1.4573	0.2429
SNOW WATER	0.000	

Scenario 4

(Waste Height = 100 feet; Filename: GL12M100)

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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:\HELP3\GLRA2\5B.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\5B.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\5B.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\5B.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL12M100.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL12M100.OUT

```

TIME: 17:51 DATE: 11/18/2017

```

*****
TITLE: GLRA PHASE 2 - 100' WASTE, 12" CS
*****

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

LAYER 1 -----

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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10
THICKNESS = 12.00 INCHES
POROSITY = 0.3980 VOL/VOL
FIELD CAPACITY = 0.2440 VOL/VOL
WILTING POINT = 0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2754 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.119999997000E-03 CM/SEC

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LAYER 2 -----

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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 1200.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2930 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

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LAYER 3

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	=	0.0335	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 4

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 -	EXCELLENT

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.8500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.000000000000	CM/SEC

LAYER 6

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 -	EXCELLENT

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08 CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 24

THICKNESS	=	6.00 INCHES
POROSITY	=	0.3650 VOL/VOL
FIELD CAPACITY	=	0.3050 VOL/VOL
WILTING POINT	=	0.2020 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2654 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.270000010000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND
A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	94.00
FRACTION OF AREA ALLOWING RUNOFF	=	100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000 ACRES
EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.220 INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.184 INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.088 INCHES
INITIAL SNOW WATER	=	0.000 INCHES
INITIAL WATER IN LAYER MATERIALS	=	357.511 INCHES
TOTAL INITIAL WATER	=	357.511 INCHES
TOTAL SUBSURFACE INFLOW	=	0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE	=	40.37 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	114
END OF GROWING SEASON (JULIAN DATE)	=	288
EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

-----	-----	-----	-----	-----	-----
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	8.750	31760.721	19.07
EVAPOTRANSPIRATION	27.100	98373.531	59.08
DRAINAGE COLLECTED FROM LAYER 3	4.8749	17696.021	10.63
PERC./LEAKAGE THROUGH LAYER 4	5.144996	18676.336	11.22
AVG. HEAD ON TOP OF LAYER 4	0.0781		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.055146	200.181	0.12
CHANGE IN WATER STORAGE	5.090	18477.684	11.10
SOIL WATER AT START OF YEAR	358.087	1299857.370	
SOIL WATER AT END OF YEAR	363.178	1318335.120	
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	-0.052	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.52	165237.547	100.00

RUNOFF	15.254	55373.766	33.51
EVAPOTRANSPIRATION	20.244	73486.742	44.47
DRAINAGE COLLECTED FROM LAYER 3	5.5620	20190.061	12.22
PERC./LEAKAGE THROUGH LAYER 4	5.164790	18748.187	11.35
AVG. HEAD ON TOP OF LAYER 4	0.0897		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.030361	110.209	0.07
CHANGE IN WATER STORAGE	4.429	16076.996	9.73
SOIL WATER AT START OF YEAR	363.178	1318335.120	
SOIL WATER AT END OF YEAR	367.607	1334412.000	
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	-0.0001	-0.230	0.00

ANNUAL TOTALS FOR YEAR 3			

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	15.335	55664.668	35.37
EVAPOTRANSPIRATION	21.503	78055.562	49.59
DRAINAGE COLLECTED FROM LAYER 3	3.0144	10942.405	6.95
PERC./LEAKAGE THROUGH LAYER 4	3.531035	12817.658	8.14
AVG. HEAD ON TOP OF LAYER 4	0.0484		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.020864	75.737	0.05
CHANGE IN WATER STORAGE	3.487	12658.338	8.04
SOIL WATER AT START OF YEAR	367.607	1334412.000	
SOIL WATER AT END OF YEAR	370.896	1346353.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.122	0.00

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	12.830	46572.832	28.50
EVAPOTRANSPIRATION	23.232	84331.344	51.61
DRAINAGE COLLECTED FROM LAYER 3	4.2829	15546.965	9.52
PERC./LEAKAGE THROUGH LAYER 4	4.394177	15950.864	9.76
AVG. HEAD ON TOP OF LAYER 4	0.0690		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.015877	57.632	0.04
CHANGE IN WATER STORAGE	4.649	16877.625	10.33
SOIL WATER AT START OF YEAR	370.896	1346353.500	
SOIL WATER AT END OF YEAR	375.369	1362588.370	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	-0.106	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	14.849	53902.332	32.76
EVAPOTRANSPIRATION	23.900	86755.430	52.72
DRAINAGE COLLECTED FROM LAYER 3	3.1473	11424.742	6.94
PERC./LEAKAGE THROUGH LAYER 4	3.686133	13380.661	8.13
AVG. HEAD ON TOP OF LAYER 4	0.0507		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.012725	46.192	0.03
CHANGE IN WATER STORAGE	3.421	12419.295	7.55
SOIL WATER AT START OF YEAR	375.369	1362588.370	

SOIL WATER AT END OF YEAR	379.165	1376367.370	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.112	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	3.45 3.77	3.48 4.10	3.93 5.20	3.33 3.90	3.10 3.50	3.74 3.52
STD. DEVIATIONS	0.72 1.31	1.17 1.59	0.61 3.40	1.01 1.97	1.40 1.26	0.54 1.49
RUNOFF						

TOTALS	2.105 0.582	2.412 0.923	2.766 1.449	0.321 0.515	0.302 0.462	0.578 0.989
STD. DEVIATIONS	1.454 0.285	1.019 0.591	2.505 1.400	0.277 0.454	0.271 0.349	0.138 1.204
EVAPOTRANSPIRATION						

TOTALS	0.524 3.295	0.549 2.436	1.235 2.342	3.018 2.134	2.289 1.843	2.706 0.825
STD. DEVIATIONS	0.092 1.211	0.188 0.520	0.504 0.794	0.623 0.872	1.443 0.138	0.663 0.271
LATERAL DRAINAGE COLLECTED FROM LAYER 3						

TOTALS	0.4042 0.0966	0.0868 0.1779	0.3215 0.3245	0.7501 0.3724	0.0326 0.6201	0.1626 0.8271
STD. DEVIATIONS	0.4403 0.0974	0.1444 0.1978	0.3938 0.2818	0.2762 0.2361	0.0424 0.3715	0.1532 0.3263
PERCOLATION/LEAKAGE THROUGH LAYER 4						

TOTALS	0.3782 0.1728	0.0785 0.2326	0.3379 0.3514	0.7120 0.4469	0.0671 0.6176	0.2215 0.7679
STD. DEVIATIONS	0.4178 0.1268	0.1141 0.2258	0.3917 0.2650	0.2114 0.2101	0.0582 0.2615	0.1930 0.2338
PERCOLATION/LEAKAGE THROUGH 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 8						

TOTALS	0.0029	0.0025	0.0026	0.0024	0.0024	0.0022

	0.0022	0.0021	0.0020	0.0020	0.0018	0.0018
STD. DEVIATIONS	0.0023	0.0018	0.0019	0.0016	0.0015	0.0014
	0.0013	0.0012	0.0011	0.0011	0.0010	0.0009

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0767	0.0182	0.0610	0.1471	0.0062	0.0319
	0.0183	0.0338	0.0636	0.0707	0.1216	0.1569
STD. DEVIATIONS	0.0836	0.0303	0.0747	0.0542	0.0080	0.0300
	0.0185	0.0375	0.0552	0.0448	0.0728	0.0619

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.02 (0.978)	163415.3	100.00
RUNOFF	13.404 (2.7944)	48654.86	29.774
EVAPOTRANSPIRATION	23.196 (2.6133)	84200.52	51.525
LATERAL DRAINAGE COLLECTED FROM LAYER 3	4.17632 (1.09868)	15160.038	9.27700
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.38423 (0.77515)	15914.741	9.73883
AVERAGE HEAD ON TOP OF LAYER 4	0.067 (0.018)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.040	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.230 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.02699 (0.01709)	97.990	0.05996
CHANGE IN WATER STORAGE	4.215 (0.7349)	15301.99	9.364

PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	7840.800
RUNOFF	3.427	12439.5605
DRAINAGE COLLECTED FROM LAYER 3	0.07611	276.26572
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.048957	177.71411
AVERAGE HEAD ON TOP OF LAYER 4	0.448	
MAXIMUM HEAD ON TOP OF LAYER 4	0.844	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	11.3 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00011
AVERAGE HEAD ON TOP OF LAYER 6	0.230	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000228	0.82630
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.3867
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1360

*** 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	3.3987	0.2832
2	350.7873	0.2923
3	0.6517	0.0362
4	0.0000	0.0000
5	22.1166	96.1593
6	0.0000	0.0000
7	0.1770	0.7500
8	1.4573	0.2429
SNOW WATER	0.000	

Scenario 5

(Waste Height = 130 feet; Filename: GL12M130)

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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:\HELP3\GLRA2\20F.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\20F.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\20F.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\20F.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL12M130.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL12M130.OUT

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TIME: 16:46 DATE: 10/28/2017

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TITLE: GLRA PHASE 2 - 130' WASTE, 12" CS

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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 10
THICKNESS = 12.00 INCHES
POROSITY = 0.3980 VOL/VOL
FIELD CAPACITY = 0.2440 VOL/VOL
WILTING POINT = 0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2728 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.119999997000E-03 CM/SEC
NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

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LAYER 2

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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 1560.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL

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INITIAL SOIL WATER CONTENT = 0.2941 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

LAYER 3

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 = 0.0365 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000012000 CM/SEC
SLOPE = 2.00 PERCENT
DRAINAGE LENGTH = 200.0 FEET

LAYER 4

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 = 2.00 HOLES/ACRE
FML PLACEMENT QUALITY = 2 - EXCELLENT

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS = 0.23 INCHES
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.8500 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 3.000000000000 CM/SEC

LAYER 6

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 = 2.00 HOLES/ACRE

FML PLACEMENT QUALITY = 2 - EXCELLENT

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3650	VOL/VOL
FIELD CAPACITY	=	0.3050	VOL/VOL
WILTING POINT	=	0.2020	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2637	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.270000010000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 33.%
AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	87.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.905	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.815	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.325	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	464.758	INCHES
TOTAL INITIAL WATER	=	464.758	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE	=	40.37	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	114	
END OF GROWING SEASON (JULIAN DATE)	=	288	

EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 AVERAGE ANNUAL WIND SPEED = 9.20 MPH
 AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
 AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 63.00 %
 AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
 AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
 AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	3.501	12706.902	7.63
EVAPOTRANSPIRATION	30.777	111721.852	67.10
DRAINAGE COLLECTED FROM LAYER 3	6.0908	22109.436	13.28
PERC./LEAKAGE THROUGH LAYER 4	5.513456	20013.846	12.02
AVG. HEAD ON TOP OF LAYER 4	0.0991		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.049906	181.157	0.11
CHANGE IN WATER STORAGE	5.451	19788.750	11.88
SOIL WATER AT START OF YEAR	465.334	1689163.000	
SOIL WATER AT END OF YEAR	470.786	1708951.750	

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	-0.011	0.00

ANNUAL TOTALS FOR YEAR 2			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	9.671	35105.512	21.25
EVAPOTRANSPIRATION	23.835	86519.555	52.36
DRAINAGE COLLECTED FROM LAYER 3	6.4598	23449.117	14.19
PERC./LEAKAGE THROUGH LAYER 4	5.716853	20752.178	12.56
AVG. HEAD ON TOP OF LAYER 4	0.1057		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.028690	104.145	0.06
CHANGE IN WATER STORAGE	5.526	20059.383	12.14
SOIL WATER AT START OF YEAR	470.786	1708951.750	
SOIL WATER AT END OF YEAR	476.312	1729011.120	
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	-0.169	0.00

ANNUAL TOTALS FOR YEAR 3			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	10.218	37090.484	23.56
EVAPOTRANSPIRATION	26.189	95066.672	60.40
DRAINAGE COLLECTED FROM LAYER 3	5.1578	18722.980	11.90
PERC./LEAKAGE THROUGH LAYER 4	4.411306	16013.040	10.17
AVG. HEAD ON TOP OF LAYER 4	0.0825		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00

AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.020050	72.781	0.05
CHANGE IN WATER STORAGE	1.775	6443.868	4.09
SOIL WATER AT START OF YEAR	476.312	1729011.120	
SOIL WATER AT END OF YEAR	477.889	1734738.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.048	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	6.833	24802.316	15.18
EVAPOTRANSPIRATION	29.650	107628.406	65.87
DRAINAGE COLLECTED FROM LAYER 3	4.3043	15624.642	9.56
PERC./LEAKAGE THROUGH LAYER 4	3.898114	14150.152	8.66
AVG. HEAD ON TOP OF LAYER 4	0.0690		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.015396	55.886	0.03
CHANGE IN WATER STORAGE	4.208	15275.100	9.35
SOIL WATER AT START OF YEAR	477.889	1734738.120	
SOIL WATER AT END OF YEAR	481.920	1749370.500	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	-0.053	0.00

ANNUAL TOTALS FOR YEAR 5			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	8.951	32492.771	19.75
EVAPOTRANSPIRATION	29.352	106546.383	64.75

DRAINAGE COLLECTED FROM LAYER 3	2.7688	10050.923	6.11
PERC./LEAKAGE THROUGH LAYER 4	2.766095	10040.926	6.10
AVG. HEAD ON TOP OF LAYER 4	0.0447		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.012410	45.048	0.03
CHANGE IN WATER STORAGE	4.246	15412.870	9.37
SOIL WATER AT START OF YEAR	481.920	1749370.500	
SOIL WATER AT END OF YEAR	486.541	1766143.000	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.121	0.00

ANNUAL TOTALS FOR YEAR 6			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	38.49	139718.734	100.00
RUNOFF	3.313	12026.587	8.61
EVAPOTRANSPIRATION	26.365	95706.164	68.50
DRAINAGE COLLECTED FROM LAYER 3	4.3837	15912.917	11.39
PERC./LEAKAGE THROUGH LAYER 4	3.984774	14464.730	10.35
AVG. HEAD ON TOP OF LAYER 4	0.0711		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.010398	37.745	0.03
CHANGE IN WATER STORAGE	4.417	16035.139	11.48
SOIL WATER AT START OF YEAR	486.541	1766143.000	
SOIL WATER AT END OF YEAR	488.562	1773478.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	2.397	8699.588	6.23
ANNUAL WATER BUDGET BALANCE	0.0001	0.185	0.00

ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.49	165128.703	100.00
RUNOFF	9.345	33921.156	20.54
EVAPOTRANSPIRATION	27.634	100310.961	60.75
DRAINAGE COLLECTED FROM LAYER 3	2.7066	9824.938	5.95
PERC./LEAKAGE THROUGH LAYER 4	2.718251	9867.252	5.98
AVG. HEAD ON TOP OF LAYER 4	0.0434		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.008936	32.437	0.02
CHANGE IN WATER STORAGE	5.796	21039.316	12.74
SOIL WATER AT START OF YEAR	488.562	1773478.500	
SOIL WATER AT END OF YEAR	496.754	1803217.500	
SNOW WATER AT START OF YEAR	2.397	8699.588	5.27
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.101	0.00

ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.30	175329.000	100.00
RUNOFF	2.758	10010.157	5.71
EVAPOTRANSPIRATION	34.535	125360.250	71.50
DRAINAGE COLLECTED FROM LAYER 3	8.2171	29828.049	17.01
PERC./LEAKAGE THROUGH LAYER 4	7.058099	25620.900	14.61
AVG. HEAD ON TOP OF LAYER 4	0.1328		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.007847	28.483	0.02
CHANGE IN WATER STORAGE	2.783	10102.092	5.76
SOIL WATER AT START OF YEAR	496.754	1803217.500	
SOIL WATER AT END OF YEAR	499.069	1811620.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.468	1699.519	0.97
ANNUAL WATER BUDGET BALANCE	0.0000	-0.034	0.00

ANNUAL TOTALS FOR YEAR 9			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.40	161172.000	100.00
RUNOFF	6.342	23020.797	14.28
EVAPOTRANSPIRATION	28.983	105207.695	65.28
DRAINAGE COLLECTED FROM LAYER 3	4.4078	16000.244	9.93
PERC./LEAKAGE THROUGH LAYER 4	3.794647	13774.570	8.55
AVG. HEAD ON TOP OF LAYER 4	0.0706		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.006954	25.244	0.02
CHANGE IN WATER STORAGE	4.661	16918.180	10.50
SOIL WATER AT START OF YEAR	499.069	1811620.000	
SOIL WATER AT END OF YEAR	503.694	1828410.620	
SNOW WATER AT START OF YEAR	0.468	1699.519	1.05
SNOW WATER AT END OF YEAR	0.503	1827.065	1.13
ANNUAL WATER BUDGET BALANCE	0.0000	-0.153	0.00

ANNUAL TOTALS FOR YEAR 10			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	36.62	132930.625	100.00
RUNOFF	3.354	12174.972	9.16
EVAPOTRANSPIRATION	26.438	95969.867	72.20
DRAINAGE COLLECTED FROM LAYER 3	4.1454	15047.770	11.32
PERC./LEAKAGE THROUGH LAYER 4	3.642313	13221.595	9.95
AVG. HEAD ON TOP OF LAYER 4	0.0661		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.006255	22.705	0.02

CHANGE IN WATER STORAGE	2.676	9715.246	7.31
SOIL WATER AT START OF YEAR	503.694	1828410.620	
SOIL WATER AT END OF YEAR	505.189	1833836.000	
SNOW WATER AT START OF YEAR	0.503	1827.065	1.37
SNOW WATER AT END OF YEAR	1.685	6117.030	4.60
ANNUAL WATER BUDGET BALANCE	0.0000	0.063	0.00

ANNUAL TOTALS FOR YEAR 11			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	40.15	145744.484	100.00
RUNOFF	7.572	27485.248	18.86
EVAPOTRANSPIRATION	24.304	88222.453	60.53
DRAINAGE COLLECTED FROM LAYER 3	3.9908	14486.489	9.94
PERC./LEAKAGE THROUGH LAYER 4	3.847683	13967.090	9.58
AVG. HEAD ON TOP OF LAYER 4	0.0636		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.005680	20.618	0.01
CHANGE IN WATER STORAGE	4.278	15529.920	10.66
SOIL WATER AT START OF YEAR	505.189	1833836.000	
SOIL WATER AT END OF YEAR	510.178	1851946.120	
SNOW WATER AT START OF YEAR	1.685	6117.030	4.20
SNOW WATER AT END OF YEAR	0.974	3536.720	2.43
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.256	0.00

ANNUAL TOTALS FOR YEAR 12			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141206.984	100.00
RUNOFF	6.361	23091.598	16.35
EVAPOTRANSPIRATION	26.550	96377.383	68.25
DRAINAGE COLLECTED FROM LAYER 3	4.0562	14724.178	10.43

PERC./LEAKAGE THROUGH LAYER 4	3.800674	13796.445	9.77
AVG. HEAD ON TOP OF LAYER 4	0.0649		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.005213	18.924	0.01
CHANGE IN WATER STORAGE	1.927	6994.911	4.95
SOIL WATER AT START OF YEAR	510.178	1851946.120	
SOIL WATER AT END OF YEAR	513.079	1862477.750	
SNOW WATER AT START OF YEAR	0.974	3536.720	2.50
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.95	126868.500	100.00
RUNOFF	3.381	12272.882	9.67
EVAPOTRANSPIRATION	26.055	94580.047	74.55
DRAINAGE COLLECTED FROM LAYER 3	2.0884	7580.994	5.98
PERC./LEAKAGE THROUGH LAYER 4	2.056201	7464.011	5.88
AVG. HEAD ON TOP OF LAYER 4	0.0335		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.004791	17.391	0.01
CHANGE IN WATER STORAGE	3.421	12417.196	9.79
SOIL WATER AT START OF YEAR	513.079	1862477.750	
SOIL WATER AT END OF YEAR	516.500	1874895.000	
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

ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT

PRECIPITATION	34.82	126396.602	100.00
RUNOFF	4.052	14709.976	11.64
EVAPOTRANSPIRATION	27.165	98610.187	78.02
DRAINAGE COLLECTED FROM LAYER 3	2.3166	8409.271	6.65
PERC./LEAKAGE THROUGH LAYER 4	2.227015	8084.065	6.40
AVG. HEAD ON TOP OF LAYER 4	0.0371		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.004441	16.123	0.01
CHANGE IN WATER STORAGE	1.281	4651.159	3.68
SOIL WATER AT START OF YEAR	516.500	1874895.000	
SOIL WATER AT END OF YEAR	517.781	1879546.120	
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	-0.115	0.00

ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	52.41	190248.281	100.00
RUNOFF	9.149	33209.160	17.46
EVAPOTRANSPIRATION	33.438	121378.164	63.80
DRAINAGE COLLECTED FROM LAYER 3	3.7131	13478.548	7.08
PERC./LEAKAGE THROUGH LAYER 4	3.477758	12624.263	6.64
AVG. HEAD ON TOP OF LAYER 4	0.0598		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.004138	15.022	0.01
CHANGE IN WATER STORAGE	6.107	22167.504	11.65
SOIL WATER AT START OF YEAR	517.781	1879546.120	
SOIL WATER AT END OF YEAR	523.888	1901713.620	
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	-0.115	0.00

ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	32.14	116668.227	100.00
RUNOFF	2.118	7687.965	6.59
EVAPOTRANSPIRATION	21.042	76383.148	65.47
DRAINAGE COLLECTED FROM LAYER 3	3.8082	13823.716	11.85
PERC./LEAKAGE THROUGH LAYER 4	3.254978	11815.570	10.13
AVG. HEAD ON TOP OF LAYER 4	0.0616		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003883	14.095	0.01
CHANGE IN WATER STORAGE	5.168	18759.596	16.08
SOIL WATER AT START OF YEAR	523.888	1901713.620	
SOIL WATER AT END OF YEAR	527.730	1915660.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.326	4812.322	4.12
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.298	0.00

ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	49.12	178305.609	100.00
RUNOFF	7.673	27852.926	15.62
EVAPOTRANSPIRATION	31.265	113493.125	63.65
DRAINAGE COLLECTED FROM LAYER 3	8.4010	30495.748	17.10
PERC./LEAKAGE THROUGH LAYER 4	7.257475	26344.635	14.77
AVG. HEAD ON TOP OF LAYER 4	0.1377		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003638	13.205	0.01
CHANGE IN WATER STORAGE	1.777	6450.724	3.62

SOIL WATER AT START OF YEAR	527.730	1915660.870	
SOIL WATER AT END OF YEAR	530.381	1925283.000	
SNOW WATER AT START OF YEAR	1.326	4812.322	2.70
SNOW WATER AT END OF YEAR	0.452	1641.020	0.92
ANNUAL WATER BUDGET BALANCE	0.0000	-0.117	0.00

ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	48.15	174784.562	100.00
RUNOFF	8.428	30594.051	17.50
EVAPOTRANSPIRATION	32.246	117053.766	66.97
DRAINAGE COLLECTED FROM LAYER 3	2.5711	9333.107	5.34
PERC./LEAKAGE THROUGH LAYER 4	2.539986	9220.148	5.28
AVG. HEAD ON TOP OF LAYER 4	0.0415		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003430	12.449	0.01
CHANGE IN WATER STORAGE	4.901	17791.133	10.18
SOIL WATER AT START OF YEAR	530.381	1925283.000	
SOIL WATER AT END OF YEAR	535.734	1944715.120	
SNOW WATER AT START OF YEAR	0.452	1641.020	0.94
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.056	0.00

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	46.11	167379.297	100.00
RUNOFF	5.592	20300.488	12.13
EVAPOTRANSPIRATION	32.018	116223.875	69.44
DRAINAGE COLLECTED FROM LAYER 3	4.8601	17642.020	10.54
PERC./LEAKAGE THROUGH LAYER 4	4.290142	15573.214	9.30
AVG. HEAD ON TOP OF LAYER 4	0.0787		

PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003243	11.773	0.01
CHANGE IN WATER STORAGE	3.637	13201.271	7.89
SOIL WATER AT START OF YEAR	535.734	1944715.120	
SOIL WATER AT END OF YEAR	538.638	1955256.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.733	2659.559	1.59
ANNUAL WATER BUDGET BALANCE	0.0000	-0.128	0.00

ANNUAL TOTALS FOR YEAR 20			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	46.85	170065.469	100.00
RUNOFF	11.944	43357.066	25.49
EVAPOTRANSPIRATION	27.228	98837.547	58.12
DRAINAGE COLLECTED FROM LAYER 3	3.0098	10925.401	6.42
PERC./LEAKAGE THROUGH LAYER 4	2.793053	10138.784	5.96
AVG. HEAD ON TOP OF LAYER 4	0.0479		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003084	11.195	0.01
CHANGE IN WATER STORAGE	4.665	16934.332	9.96
SOIL WATER AT START OF YEAR	538.638	1955256.870	
SOIL WATER AT END OF YEAR	544.036	1974850.750	
SNOW WATER AT START OF YEAR	0.733	2659.559	1.56
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.074	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20						
	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						

TOTALS	3.02 4.27	2.80 4.06	3.39 4.03	3.84 3.00	3.71 3.67	3.76 3.55
STD. DEVIATIONS	1.13 1.77	0.99 1.98	1.11 2.14	1.24 1.74	2.33 1.10	1.33 1.21
RUNOFF						

TOTALS	1.377 0.171	1.765 0.340	1.783 0.205	0.176 0.084	0.121 0.094	0.104 0.307
STD. DEVIATIONS	1.432 0.219	1.285 0.417	1.493 0.288	0.446 0.145	0.199 0.093	0.132 0.606
EVAPOTRANSPIRATION						

TOTALS	0.619 4.200	0.556 3.503	1.287 2.497	3.835 1.683	3.335 1.324	4.622 0.794
STD. DEVIATIONS	0.184 1.474	0.222 1.642	0.532 0.765	0.355 0.218	1.289 0.187	0.971 0.202
LATERAL DRAINAGE COLLECTED FROM LAYER 3						

TOTALS	0.6874 0.0760	0.3831 0.0002	0.2020 0.0467	0.9002 0.1469	0.6766 0.3130	0.3334 0.6074
STD. DEVIATIONS	0.5440 0.1576	0.5747 0.0003	0.3068 0.1292	0.3059 0.2214	0.6215 0.3561	0.5582 0.2717
PERCOLATION/LEAKAGE THROUGH LAYER 4						

TOTALS	0.5805 0.0628	0.2934 0.0012	0.2070 0.0525	0.7905 0.1673	0.5438 0.3453	0.2722 0.6360
STD. DEVIATIONS	0.4375 0.1195	0.4365 0.0019	0.2715 0.1297	0.2250 0.2361	0.4701 0.3021	0.4315 0.1948
PERCOLATION/LEAKAGE THROUGH 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 8						

TOTALS	0.0010 0.0009	0.0009 0.0008	0.0010 0.0008	0.0009 0.0008	0.0009 0.0008	0.0009 0.0008
STD. DEVIATIONS	0.0013 0.0009	0.0011 0.0009	0.0012 0.0008	0.0010 0.0008	0.0010 0.0007	0.0009 0.0007

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)						

DAILY AVERAGE HEAD ON TOP OF LAYER 4						

AVERAGES	0.1304 0.0144	0.0797 0.0000	0.0383 0.0092	0.1765 0.0279	0.1284 0.0614	0.0654 0.1152
STD. DEVIATIONS	0.1032 0.0299	0.1198 0.0001	0.0582 0.0253	0.0600 0.0420	0.1179 0.0698	0.1095 0.0516

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.10 (5.491)	156451.2	100.00
RUNOFF	6.528 (2.9002)	23695.65	15.146
EVAPOTRANSPIRATION	28.253 (3.4349)	102559.87	65.554
LATERAL DRAINAGE COLLECTED FROM LAYER 3	4.37287 (1.77887)	15873.525	10.14599
PERCOLATION/LEAKAGE THROUGH LAYER 4	3.95244 (1.45379)	14347.369	9.17051
AVERAGE HEAD ON TOP OF LAYER 4	0.071 (0.029)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.040	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.230 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.01042 (0.01136)	37.821	0.02417
CHANGE IN WATER STORAGE	3.935 (1.4637)	14284.38	9.130

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.500
RUNOFF	3.338	12116.6982
DRAINAGE COLLECTED FROM LAYER 3	0.07814	283.65942
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.049626	180.14174
AVERAGE HEAD ON TOP OF LAYER 4	0.460	
MAXIMUM HEAD ON TOP OF LAYER 4	0.866	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	11.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00011

AVERAGE HEAD ON TOP OF LAYER	6	0.230	
PERCOLATION/LEAKAGE THROUGH LAYER	8	0.000198	0.71963
SNOW WATER		3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.3919	
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1107	

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

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	3.0994	0.2583
2	458.9540	0.2942
3	0.6111	0.0339
4	0.0000	0.0000
5	79.2445	344.5414
6	0.0000	0.0000
7	0.1770	0.7500
8	1.3740	0.2290
SNOW WATER	0.000	

Scenario 6

(Waste Height = 190 feet; Filename: GL12M190)

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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:\HELP3\GLRA2\20F.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\20F.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\20F.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\20F.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL12M190.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL12M190.OUT

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TIME: 16:50 DATE: 10/28/2017

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*****
TITLE: GLRA PHASE 2 - 190' WASTE, 12" CS
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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10
THICKNESS = 12.00 INCHES
POROSITY = 0.3980 VOL/VOL
FIELD CAPACITY = 0.2440 VOL/VOL
WILTING POINT = 0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2728 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.119999997000E-03 CM/SEC
NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

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LAYER 2

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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 2280.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL

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INITIAL SOIL WATER CONTENT = 0.2935 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

LAYER 3

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 = 0.0364 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.300000012000 CM/SEC
SLOPE = 2.00 PERCENT
DRAINAGE LENGTH = 200.0 FEET

LAYER 4

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 = 2.00 HOLES/ACRE
FML PLACEMENT QUALITY = 2 - EXCELLENT

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS = 0.23 INCHES
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.8500 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 3.000000000000 CM/SEC

LAYER 6

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 = 2.00 HOLES/ACRE

FML PLACEMENT QUALITY = 2 - EXCELLENT

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3650	VOL/VOL
FIELD CAPACITY	=	0.3050	VOL/VOL
WILTING POINT	=	0.2020	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2637	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.270000010000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 33.%
AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	87.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.905	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.815	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.325	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	675.043	INCHES
TOTAL INITIAL WATER	=	675.043	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE	=	40.37	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	114	
END OF GROWING SEASON (JULIAN DATE)	=	288	

EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 AVERAGE ANNUAL WIND SPEED = 9.20 MPH
 AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
 AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 63.00 %
 AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
 AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
 AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	3.501	12706.902	7.63
EVAPOTRANSPIRATION	30.777	111721.852	67.10
DRAINAGE COLLECTED FROM LAYER 3	6.0788	22066.129	13.25
PERC./LEAKAGE THROUGH LAYER 4	5.526150	20059.926	12.05
AVG. HEAD ON TOP OF LAYER 4	0.0989		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.049906	181.157	0.11
CHANGE IN WATER STORAGE	5.463	19831.844	11.91
SOIL WATER AT START OF YEAR	675.619	2452496.000	
SOIL WATER AT END OF YEAR	681.082	2472327.750	

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	0.0001	0.202	0.00

ANNUAL TOTALS FOR YEAR 2			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	9.671	35105.512	21.25
EVAPOTRANSPIRATION	23.835	86519.555	52.36
DRAINAGE COLLECTED FROM LAYER 3	6.3810	23163.189	14.02
PERC./LEAKAGE THROUGH LAYER 4	5.692628	20664.240	12.51
AVG. HEAD ON TOP OF LAYER 4	0.1045		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.028690	104.145	0.06
CHANGE IN WATER STORAGE	5.605	20345.414	12.31
SOIL WATER AT START OF YEAR	681.082	2472327.750	
SOIL WATER AT END OF YEAR	686.687	2492673.250	
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	-0.0001	-0.271	0.00

ANNUAL TOTALS FOR YEAR 3			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	10.218	37090.484	23.56
EVAPOTRANSPIRATION	26.189	95066.672	60.40
DRAINAGE COLLECTED FROM LAYER 3	5.2315	18990.381	12.07
PERC./LEAKAGE THROUGH LAYER 4	4.482288	16270.707	10.34

AVG. HEAD ON TOP OF LAYER 4	0.0839		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.020050	72.781	0.05
CHANGE IN WATER STORAGE	1.702	6176.781	3.92
SOIL WATER AT START OF YEAR	686.687	2492673.250	
SOIL WATER AT END OF YEAR	688.191	2498133.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.264	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	6.833	24802.316	15.18
EVAPOTRANSPIRATION	29.650	107628.406	65.87
DRAINAGE COLLECTED FROM LAYER 3	4.2965	15596.448	9.55
PERC./LEAKAGE THROUGH LAYER 4	3.905100	14175.513	8.68
AVG. HEAD ON TOP OF LAYER 4	0.0689		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.015396	55.886	0.03
CHANGE IN WATER STORAGE	4.216	15303.348	9.37
SOIL WATER AT START OF YEAR	688.191	2498133.000	
SOIL WATER AT END OF YEAR	692.230	2512793.750	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	-0.108	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	8.951	32492.771	19.75
EVAPOTRANSPIRATION	29.352	106546.383	64.75
DRAINAGE COLLECTED FROM LAYER 3	2.7525	9991.576	6.07
PERC./LEAKAGE THROUGH LAYER 4	2.759549	10017.162	6.09
AVG. HEAD ON TOP OF LAYER 4	0.0444		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.012410	45.048	0.03
CHANGE IN WATER STORAGE	4.262	15471.915	9.40
SOIL WATER AT START OF YEAR	692.230	2512793.750	
SOIL WATER AT END OF YEAR	696.866	2529625.250	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.181	0.00

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.49	139718.734	100.00
RUNOFF	3.313	12026.587	8.61
EVAPOTRANSPIRATION	26.365	95706.164	68.50
DRAINAGE COLLECTED FROM LAYER 3	4.3933	15947.709	11.41
PERC./LEAKAGE THROUGH LAYER 4	4.001009	14523.663	10.39
AVG. HEAD ON TOP OF LAYER 4	0.0713		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.010398	37.745	0.03
CHANGE IN WATER STORAGE	4.408	16000.798	11.45
SOIL WATER AT START OF YEAR	696.866	2529625.250	
SOIL WATER AT END OF YEAR	698.878	2536926.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	2.397	8699.588	6.23
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.265	0.00

ANNUAL TOTALS FOR YEAR 7			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.49	165128.703	100.00
RUNOFF	9.345	33921.156	20.54
EVAPOTRANSPIRATION	27.634	100310.961	60.75
DRAINAGE COLLECTED FROM LAYER 3	2.6774	9718.878	5.89
PERC./LEAKAGE THROUGH LAYER 4	2.701809	9807.567	5.94
AVG. HEAD ON TOP OF LAYER 4	0.0429		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.008936	32.437	0.02
CHANGE IN WATER STORAGE	5.825	21145.109	12.81
SOIL WATER AT START OF YEAR	698.878	2536926.500	
SOIL WATER AT END OF YEAR	707.099	2566771.250	
SNOW WATER AT START OF YEAR	2.397	8699.588	5.27
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.166	0.00

ANNUAL TOTALS FOR YEAR 8			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.30	175329.000	100.00
RUNOFF	2.758	10010.157	5.71
EVAPOTRANSPIRATION	34.535	125360.250	71.50
DRAINAGE COLLECTED FROM LAYER 3	8.2073	29792.611	16.99
PERC./LEAKAGE THROUGH LAYER 4	7.107275	25799.406	14.71
AVG. HEAD ON TOP OF LAYER 4	0.1326		

PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.007847	28.483	0.02
CHANGE IN WATER STORAGE	2.793	10137.541	5.78
SOIL WATER AT START OF YEAR	707.099	2566771.250	
SOIL WATER AT END OF YEAR	709.424	2575209.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.468	1699.519	0.97
ANNUAL WATER BUDGET BALANCE	0.0000	-0.044	0.00

ANNUAL TOTALS FOR YEAR 9			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	44.40	161172.000	100.00
RUNOFF	6.342	23020.797	14.28
EVAPOTRANSPIRATION	28.983	105207.695	65.28
DRAINAGE COLLECTED FROM LAYER 3	4.3963	15958.570	9.90
PERC./LEAKAGE THROUGH LAYER 4	3.810077	13830.579	8.58
AVG. HEAD ON TOP OF LAYER 4	0.0704		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.006954	25.244	0.02
CHANGE IN WATER STORAGE	4.672	16959.943	10.52
SOIL WATER AT START OF YEAR	709.424	2575209.250	
SOIL WATER AT END OF YEAR	714.061	2592041.500	
SNOW WATER AT START OF YEAR	0.468	1699.519	1.05
SNOW WATER AT END OF YEAR	0.503	1827.065	1.13
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.243	0.00

ANNUAL TOTALS FOR YEAR 10			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	36.62	132930.625	100.00

RUNOFF	3.354	12174.972	9.16
EVAPOTRANSPIRATION	26.438	95969.867	72.20
DRAINAGE COLLECTED FROM LAYER 3	4.1384	15022.561	11.30
PERC./LEAKAGE THROUGH LAYER 4	3.651549	13255.124	9.97
AVG. HEAD ON TOP OF LAYER 4	0.0660		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.006255	22.705	0.02
CHANGE IN WATER STORAGE	2.683	9740.504	7.33
SOIL WATER AT START OF YEAR	714.061	2592041.500	
SOIL WATER AT END OF YEAR	715.563	2597492.000	
SNOW WATER AT START OF YEAR	0.503	1827.065	1.37
SNOW WATER AT END OF YEAR	1.685	6117.030	4.60
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

ANNUAL TOTALS FOR YEAR 11			

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	40.15	145744.484	100.00
RUNOFF	7.572	27485.248	18.86
EVAPOTRANSPIRATION	24.304	88222.453	60.53
DRAINAGE COLLECTED FROM LAYER 3	3.9734	14423.562	9.90
PERC./LEAKAGE THROUGH LAYER 4	3.848339	13969.470	9.58
AVG. HEAD ON TOP OF LAYER 4	0.0633		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.005680	20.618	0.01
CHANGE IN WATER STORAGE	4.295	15592.510	10.70
SOIL WATER AT START OF YEAR	715.563	2597492.000	
SOIL WATER AT END OF YEAR	720.569	2615665.000	
SNOW WATER AT START OF YEAR	1.685	6117.030	4.20
SNOW WATER AT END OF YEAR	0.974	3536.720	2.43
ANNUAL WATER BUDGET BALANCE	0.0000	0.081	0.00

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141206.984	100.00
RUNOFF	6.361	23091.598	16.35
EVAPOTRANSPIRATION	26.550	96377.383	68.25
DRAINAGE COLLECTED FROM LAYER 3	4.0563	14724.261	10.43
PERC./LEAKAGE THROUGH LAYER 4	3.810735	13832.966	9.80
AVG. HEAD ON TOP OF LAYER 4	0.0649		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.005213	18.924	0.01
CHANGE IN WATER STORAGE	1.927	6995.021	4.95
SOIL WATER AT START OF YEAR	720.569	2615665.000	
SOIL WATER AT END OF YEAR	723.470	2626196.750	
SNOW WATER AT START OF YEAR	0.974	3536.720	2.50
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.208	0.00

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.95	126868.500	100.00
RUNOFF	3.381	12272.882	9.67
EVAPOTRANSPIRATION	26.055	94580.047	74.55
DRAINAGE COLLECTED FROM LAYER 3	2.0865	7574.140	5.97
PERC./LEAKAGE THROUGH LAYER 4	2.057312	7468.042	5.89
AVG. HEAD ON TOP OF LAYER 4	0.0335		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.004791	17.391	0.01
CHANGE IN WATER STORAGE	3.423	12424.064	9.79
SOIL WATER AT START OF YEAR	723.470	2626196.750	

SOIL WATER AT END OF YEAR	726.893	2638620.750	
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	-0.022	0.00

ANNUAL TOTALS FOR YEAR 14			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.82	126396.602	100.00
RUNOFF	4.052	14709.976	11.64
EVAPOTRANSPIRATION	27.165	98610.187	78.02
DRAINAGE COLLECTED FROM LAYER 3	2.3178	8413.458	6.66
PERC./LEAKAGE THROUGH LAYER 4	2.230937	8098.300	6.41
AVG. HEAD ON TOP OF LAYER 4	0.0372		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.004441	16.123	0.01
CHANGE IN WATER STORAGE	1.280	4646.728	3.68
SOIL WATER AT START OF YEAR	726.893	2638620.750	
SOIL WATER AT END OF YEAR	728.173	2643267.500	
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	0.129	0.00

ANNUAL TOTALS FOR YEAR 15			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	52.41	190248.281	100.00
RUNOFF	9.149	33209.160	17.46
EVAPOTRANSPIRATION	33.438	121378.164	63.80
DRAINAGE COLLECTED FROM LAYER 3	3.6871	13384.331	7.04
PERC./LEAKAGE THROUGH LAYER 4	3.464577	12576.413	6.61
AVG. HEAD ON TOP OF LAYER 4	0.0594		

PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.004138	15.022	0.01
CHANGE IN WATER STORAGE	6.133	22261.889	11.70
SOIL WATER AT START OF YEAR	728.173	2643267.500	
SOIL WATER AT END OF YEAR	734.306	2665529.250	
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	-0.0001	-0.282	0.00

ANNUAL TOTALS FOR YEAR 16			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.14	116668.227	100.00
RUNOFF	2.118	7687.965	6.59
EVAPOTRANSPIRATION	21.042	76383.148	65.47
DRAINAGE COLLECTED FROM LAYER 3	3.8120	13837.498	11.86
PERC./LEAKAGE THROUGH LAYER 4	3.272421	11878.888	10.18
AVG. HEAD ON TOP OF LAYER 4	0.0617		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003883	14.095	0.01
CHANGE IN WATER STORAGE	5.164	18745.416	16.07
SOIL WATER AT START OF YEAR	734.306	2665529.250	
SOIL WATER AT END OF YEAR	738.144	2679462.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.326	4812.322	4.12
ANNUAL WATER BUDGET BALANCE	0.0000	0.100	0.00

ANNUAL TOTALS FOR YEAR 17			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.12	178305.609	100.00

RUNOFF	7.673	27852.926	15.62
EVAPOTRANSPIRATION	31.265	113493.125	63.65
DRAINAGE COLLECTED FROM LAYER 3	8.3967	30479.973	17.09
PERC./LEAKAGE THROUGH LAYER 4	7.282016	26433.719	14.82
AVG. HEAD ON TOP OF LAYER 4	0.1376		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003638	13.205	0.01
CHANGE IN WATER STORAGE	1.781	6466.676	3.63
SOIL WATER AT START OF YEAR	738.144	2679462.500	
SOIL WATER AT END OF YEAR	740.799	2689100.500	
SNOW WATER AT START OF YEAR	1.326	4812.322	2.70
SNOW WATER AT END OF YEAR	0.452	1641.020	0.92
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.293	0.00

ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	48.15	174784.562	100.00
RUNOFF	8.428	30594.051	17.50
EVAPOTRANSPIRATION	32.246	117053.766	66.97
DRAINAGE COLLECTED FROM LAYER 3	2.5531	9267.574	5.30
PERC./LEAKAGE THROUGH LAYER 4	2.529859	9183.390	5.25
AVG. HEAD ON TOP OF LAYER 4	0.0412		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003430	12.449	0.01
CHANGE IN WATER STORAGE	4.919	17856.715	10.22
SOIL WATER AT START OF YEAR	740.799	2689100.500	
SOIL WATER AT END OF YEAR	746.170	2708598.250	
SNOW WATER AT START OF YEAR	0.452	1641.020	0.94
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	46.11	167379.297	100.00
RUNOFF	5.592	20300.488	12.13
EVAPOTRANSPIRATION	32.018	116223.875	69.44
DRAINAGE COLLECTED FROM LAYER 3	4.8678	17670.035	10.56
PERC./LEAKAGE THROUGH LAYER 4	4.308983	15641.609	9.35
AVG. HEAD ON TOP OF LAYER 4	0.0789		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003243	11.773	0.01
CHANGE IN WATER STORAGE	3.629	13173.132	7.87
SOIL WATER AT START OF YEAR	746.170	2708598.250	
SOIL WATER AT END OF YEAR	749.067	2719111.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.733	2659.559	1.59
ANNUAL WATER BUDGET BALANCE	0.0000	-0.005	0.00

ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	46.85	170065.469	100.00
RUNOFF	11.944	43357.066	25.49
EVAPOTRANSPIRATION	27.228	98837.547	58.12
DRAINAGE COLLECTED FROM LAYER 3	2.9911	10857.797	6.38
PERC./LEAKAGE THROUGH LAYER 4	2.787652	10119.175	5.95
AVG. HEAD ON TOP OF LAYER 4	0.0476		
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.2300		
PERC./LEAKAGE THROUGH LAYER 8	0.003084	11.195	0.01
CHANGE IN WATER STORAGE	4.684	17001.908	10.00
SOIL WATER AT START OF YEAR	749.067	2719111.750	
SOIL WATER AT END OF YEAR	754.483	2738773.250	

SNOW WATER AT START OF YEAR	0.733	2659.559	1.56
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.045	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20						
	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION						

TOTALS	3.02 4.27	2.80 4.06	3.39 4.03	3.84 3.00	3.71 3.67	3.76 3.55
STD. DEVIATIONS	1.13 1.77	0.99 1.98	1.11 2.14	1.24 1.74	2.33 1.10	1.33 1.21
RUNOFF						

TOTALS	1.377 0.171	1.765 0.340	1.783 0.205	0.176 0.084	0.121 0.094	0.104 0.307
STD. DEVIATIONS	1.432 0.219	1.285 0.417	1.493 0.288	0.446 0.145	0.199 0.093	0.132 0.606
EVAPOTRANSPIRATION						

TOTALS	0.619 4.200	0.556 3.503	1.287 2.497	3.835 1.683	3.335 1.324	4.622 0.794
STD. DEVIATIONS	0.184 1.474	0.222 1.642	0.532 0.765	0.355 0.218	1.289 0.187	0.971 0.202
LATERAL DRAINAGE COLLECTED FROM LAYER 3						

TOTALS	0.6762 0.0913	0.3949 0.0002	0.2024 0.0467	0.8893 0.1454	0.6746 0.3095	0.3350 0.5993
STD. DEVIATIONS	0.5335 0.1975	0.5742 0.0003	0.3063 0.1291	0.3037 0.2185	0.6112 0.3503	0.5515 0.2680
PERCOLATION/LEAKAGE THROUGH LAYER 4						

TOTALS	0.5756 0.0745	0.3032 0.0012	0.2085 0.0525	0.7856 0.1664	0.5457 0.3433	0.2745 0.6306
STD. DEVIATIONS	0.4325 0.1493	0.4387 0.0019	0.2713 0.1298	0.2241 0.2344	0.4661 0.2995	0.4289 0.1927
PERCOLATION/LEAKAGE THROUGH 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 8						

TOTALS	0.0010	0.0009	0.0010	0.0009	0.0009	0.0009

	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008
STD. DEVIATIONS	0.0013	0.0011	0.0012	0.0010	0.0010	0.0009
	0.0009	0.0009	0.0008	0.0008	0.0007	0.0007

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.1283	0.0822	0.0384	0.1744	0.1280	0.0657
	0.0173	0.0000	0.0092	0.0276	0.0607	0.1137
STD. DEVIATIONS	0.1012	0.1197	0.0581	0.0595	0.1160	0.1081
	0.0375	0.0001	0.0253	0.0415	0.0687	0.0508

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
	0.2300	0.2300	0.2300	0.2300	0.2300	0.2300
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

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

	INCHES		CU. FEET	PERCENT
	-----	-----	-----	-----
PRECIPITATION	43.10	(5.491)	156451.2	100.00
RUNOFF	6.528	(2.9002)	23695.65	15.146
EVAPOTRANSPIRATION	28.253	(3.4349)	102559.87	65.554
LATERAL DRAINAGE COLLECTED FROM LAYER 3	4.36475	(1.77848)	15844.032	10.12714
PERCOLATION/LEAKAGE THROUGH LAYER 4	3.96151	(1.46394)	14380.292	9.19155
AVERAGE HEAD ON TOP OF LAYER 4	0.070	(0.029)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.040	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.230	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.01042	(0.01136)	37.821	0.02417
CHANGE IN WATER STORAGE	3.943	(1.4794)	14313.86	9.149

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.500
RUNOFF	3.338	12116.6982
DRAINAGE COLLECTED FROM LAYER 3	0.07683	278.87720
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.049195	178.57913
AVERAGE HEAD ON TOP OF LAYER 4	0.452	
MAXIMUM HEAD ON TOP OF LAYER 4	0.852	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	11.4 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00011
AVERAGE HEAD ON TOP OF LAYER 6	0.230	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000198	0.71963
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.3919
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1107

*** 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 20		
LAYER	(INCHES)	(VOL/VOL)
1	3.0994	0.2583
2	669.2214	0.2935
3	0.6092	0.0338
4	0.0000	0.0000
5	79.4258	345.3297
6	0.0000	0.0000
7	0.1770	0.7500
8	1.3740	0.2290
SNOW WATER	0.000	

Scenario 7

(Waste Height = 70 feet + Cap; Filename: GL24N70)

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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:\HELP3\GLRA2\20G.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\20G.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\20G.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\20G.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL24N70.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL24N70.OUT

```

TIME: 17:45 DATE: 11/18/2017

```

*****
TITLE: GLRA PHASE 2 - 70' WASTE, 12" CS + CAP
*****

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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 12
THICKNESS = 24.00 INCHES
POROSITY = 0.4710 VOL/VOL
FIELD CAPACITY = 0.3420 VOL/VOL
WILTING POINT = 0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3751 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.419999997000E-04 CM/SEC
NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 4.63
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

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LAYER 2

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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0
THICKNESS = 0.29 INCHES
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL

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INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	4.0000000000	CM/SEC
SLOPE	=	33.30	PERCENT
DRAINAGE LENGTH	=	150.0	FEET

LAYER 3

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.	=	0.39999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.11999997000E-03	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 18

THICKNESS	=	840.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

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	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 7

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0111	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.000000000000	CM/SEC

LAYER 9

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 10

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS = 6.00 INCHES
 POROSITY = 0.3650 VOL/VOL
 FIELD CAPACITY = 0.3050 VOL/VOL
 WILTING POINT = 0.2020 VOL/VOL
 INITIAL SOIL WATER CONTENT = 0.2654 VOL/VOL
 EFFECTIVE SAT. HYD. COND. = 0.270000010000E-05 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
 GOOD STAND OF GRASS, A SURFACE SLOPE OF 33.%
 AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER = 84.90
 FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE = 1.000 ACRES
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 INITIAL WATER IN EVAPORATIVE ZONE = 7.823 INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE = 9.891 INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE = 4.410 INCHES
 INITIAL SNOW WATER = 0.000 INCHES
 INITIAL WATER IN LAYER MATERIALS = 259.562 INCHES
 TOTAL INITIAL WATER = 259.562 INCHES
 TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
 PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE = 40.37 DEGREES
 MAXIMUM LEAF AREA INDEX = 3.50
 START OF GROWING SEASON (JULIAN DATE) = 114
 END OF GROWING SEASON (JULIAN DATE) = 288
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 AVERAGE ANNUAL WIND SPEED = 9.20 MPH
 AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
 AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 63.00 %
 AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
 AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	3.611	13107.210	7.87
EVAPOTRANSPIRATION	30.476	110629.672	66.44
DRAINAGE COLLECTED FROM LAYER 2	11.7852	42780.418	25.69
PERC./LEAKAGE THROUGH LAYER 3	0.000281	1.019	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000280	1.016	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0005		
PERC./LEAKAGE THROUGH LAYER 11	0.055146	200.180	0.12
CHANGE IN WATER STORAGE	-0.058	-209.372	-0.13
SOIL WATER AT START OF YEAR	263.066	954930.187	
SOIL WATER AT END OF YEAR	263.008	954720.812	
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	-0.030	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	9.934	36061.312	21.82
EVAPOTRANSPIRATION	23.535	85431.469	51.70
DRAINAGE COLLECTED FROM LAYER 2	12.2332	44406.383	26.87
PERC./LEAKAGE THROUGH LAYER 3	0.000280	1.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0009		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.004	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000279	1.012	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0008		
PERC./LEAKAGE THROUGH LAYER 11	0.030360	110.208	0.07
CHANGE IN WATER STORAGE	-0.213	-771.796	-0.47
SOIL WATER AT START OF YEAR	263.008	954720.812	
SOIL WATER AT END OF YEAR	262.796	953949.000	
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	-0.035	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	10.575	38387.047	24.39
EVAPOTRANSPIRATION	26.258	95315.773	60.56
DRAINAGE COLLECTED FROM LAYER 2	5.9464	21585.455	13.71
PERC./LEAKAGE THROUGH LAYER 3	0.000141	0.512	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000141	0.511	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		

PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0010		
PERC./LEAKAGE THROUGH LAYER 11	0.020864	75.736	0.05
CHANGE IN WATER STORAGE	0.560	2032.767	1.29
SOIL WATER AT START OF YEAR	262.796	953949.000	
SOIL WATER AT END OF YEAR	263.158	955264.812	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.049	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	45.01	163386.297	100.00
RUNOFF	6.976	25321.680	15.50
EVAPOTRANSPIRATION	29.270	106250.016	65.03
DRAINAGE COLLECTED FROM LAYER 2	8.4459	30658.773	18.76
PERC./LEAKAGE THROUGH LAYER 3	0.000201	0.731	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000201	0.728	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0013		
PERC./LEAKAGE THROUGH LAYER 11	0.015876	57.631	0.04
CHANGE IN WATER STORAGE	0.303	1098.181	0.67
SOIL WATER AT START OF YEAR	263.158	955264.812	
SOIL WATER AT END OF YEAR	263.284	955720.375	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	9.069	32920.285	20.01
EVAPOTRANSPIRATION	28.927	105004.758	63.81
DRAINAGE COLLECTED FROM LAYER 2	7.7160	28009.074	17.02
PERC./LEAKAGE THROUGH LAYER 3	0.000188	0.683	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000187	0.680	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0014		
PERC./LEAKAGE THROUGH LAYER 11	0.012725	46.191	0.03
CHANGE IN WATER STORAGE	-0.395	-1432.487	-0.87
SOIL WATER AT START OF YEAR	263.284	955720.375	
SOIL WATER AT END OF YEAR	263.264	955647.437	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.061	0.00

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.49	139718.734	100.00
RUNOFF	3.356	12181.501	8.72
EVAPOTRANSPIRATION	25.987	94332.969	67.52
DRAINAGE COLLECTED FROM LAYER 2	6.7476	24493.801	17.53
PERC./LEAKAGE THROUGH LAYER 3	0.000169	0.614	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00

PERC./LEAKAGE THROUGH LAYER 7	0.000169	0.612	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0017		
PERC./LEAKAGE THROUGH LAYER 11	0.010620	38.552	0.03
CHANGE IN WATER STORAGE	2.389	8672.004	6.21
SOIL WATER AT START OF YEAR	263.264	955647.437	
SOIL WATER AT END OF YEAR	263.256	955619.875	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	2.397	8699.588	6.23
ANNUAL WATER BUDGET BALANCE	0.0000	-0.093	0.00

ANNUAL TOTALS FOR YEAR 7			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	45.49	165128.703	100.00
RUNOFF	9.651	35033.492	21.22
EVAPOTRANSPIRATION	27.073	98273.406	59.51
DRAINAGE COLLECTED FROM LAYER 2	11.2174	40719.203	24.66
PERC./LEAKAGE THROUGH LAYER 3	0.000252	0.914	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000251	0.911	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0019		
PERC./LEAKAGE THROUGH LAYER 11	0.009101	33.037	0.02
CHANGE IN WATER STORAGE	-2.460	-8930.451	-5.41
SOIL WATER AT START OF YEAR	263.256	955619.875	
SOIL WATER AT END OF YEAR	263.193	955389.000	
SNOW WATER AT START OF YEAR	2.397	8699.588	5.27
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

ANNUAL TOTALS FOR YEAR 8			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.30	175329.000	100.00
RUNOFF	2.689	9759.428	5.57
EVAPOTRANSPIRATION	33.714	122380.633	69.80
DRAINAGE COLLECTED FROM LAYER 2	11.4280	41483.512	23.66
PERC./LEAKAGE THROUGH LAYER 3	0.000289	1.049	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000288	1.046	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0023		
PERC./LEAKAGE THROUGH LAYER 11	0.007974	28.946	0.02
CHANGE IN WATER STORAGE	0.462	1676.477	0.96
SOIL WATER AT START OF YEAR	263.193	955389.000	
SOIL WATER AT END OF YEAR	263.186	955366.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.468	1699.519	0.97
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

ANNUAL TOTALS FOR YEAR 9			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.40	161172.000	100.00
RUNOFF	6.682	24255.648	15.05
EVAPOTRANSPIRATION	28.369	102979.516	63.89
DRAINAGE COLLECTED FROM LAYER 2	9.9891	36260.488	22.50
PERC./LEAKAGE THROUGH LAYER 3	0.000217	0.788	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		

DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000216	0.785	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0025		
PERC./LEAKAGE THROUGH LAYER 11	0.007055	25.611	0.02
CHANGE IN WATER STORAGE	-0.647	-2349.246	-1.46
SOIL WATER AT START OF YEAR	263.186	955366.000	
SOIL WATER AT END OF YEAR	262.504	952889.187	
SNOW WATER AT START OF YEAR	0.468	1699.519	1.05
SNOW WATER AT END OF YEAR	0.503	1827.065	1.13
ANNUAL WATER BUDGET BALANCE	0.0000	-0.017	0.00

ANNUAL TOTALS FOR YEAR 10			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	36.62	132930.625	100.00
RUNOFF	3.444	12499.953	9.40
EVAPOTRANSPIRATION	26.092	94713.773	71.25
DRAINAGE COLLECTED FROM LAYER 2	5.7145	20743.635	15.60
PERC./LEAKAGE THROUGH LAYER 3	0.000139	0.505	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000139	0.503	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0028		
PERC./LEAKAGE THROUGH LAYER 11	0.006337	23.002	0.02
CHANGE IN WATER STORAGE	1.364	4950.206	3.72
SOIL WATER AT START OF YEAR	262.504	952889.187	
SOIL WATER AT END OF YEAR	262.686	953549.437	
SNOW WATER AT START OF YEAR	0.503	1827.065	1.37
SNOW WATER AT END OF YEAR	1.685	6117.030	4.60

ANNUAL WATER BUDGET BALANCE	0.0000	0.057	0.00

ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	40.15	145744.484	100.00
RUNOFF	7.768	28197.131	19.35
EVAPOTRANSPIRATION	23.978	87038.430	59.72
DRAINAGE COLLECTED FROM LAYER 2	9.2187	33463.832	22.96
PERC./LEAKAGE THROUGH LAYER 3	0.000221	0.804	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000221	0.801	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0029		
PERC./LEAKAGE THROUGH LAYER 11	0.005748	20.864	0.01
CHANGE IN WATER STORAGE	-0.820	-2975.790	-2.04
SOIL WATER AT START OF YEAR	262.686	953549.437	
SOIL WATER AT END OF YEAR	262.577	953153.937	
SNOW WATER AT START OF YEAR	1.685	6117.030	4.20
SNOW WATER AT END OF YEAR	0.974	3536.720	2.43
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141206.984	100.00
RUNOFF	6.453	23425.703	16.59
EVAPOTRANSPIRATION	26.039	94522.586	66.94
DRAINAGE COLLECTED FROM LAYER 2	7.8696	28566.566	20.23

PERC./LEAKAGE THROUGH LAYER 3	0.000193	0.700	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000192	0.698	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0032		
PERC./LEAKAGE THROUGH LAYER 11	0.005270	19.131	0.01
CHANGE IN WATER STORAGE	-1.467	-5326.905	-3.77
SOIL WATER AT START OF YEAR	262.577	953153.937	
SOIL WATER AT END OF YEAR	262.084	951363.750	
SNOW WATER AT START OF YEAR	0.974	3536.720	2.50
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.105	0.00

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	34.95	126868.500	100.00
RUNOFF	3.259	11831.491	9.33
EVAPOTRANSPIRATION	25.957	94223.539	74.27
DRAINAGE COLLECTED FROM LAYER 2	4.1698	15136.356	11.93
PERC./LEAKAGE THROUGH LAYER 3	0.000112	0.405	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000111	0.404	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0034		
PERC./LEAKAGE THROUGH LAYER 11	0.004840	17.568	0.01
CHANGE IN WATER STORAGE	1.559	5659.579	4.46
SOIL WATER AT START OF YEAR	262.084	951363.750	
SOIL WATER AT END OF YEAR	263.643	957023.312	

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	-0.031	0.00

ANNUAL TOTALS FOR YEAR 14			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.82	126396.602	100.00
RUNOFF	3.799	13790.444	10.91
EVAPOTRANSPIRATION	27.178	98655.234	78.05
DRAINAGE COLLECTED FROM LAYER 2	5.1552	18713.426	14.81
PERC./LEAKAGE THROUGH LAYER 3	0.000133	0.485	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000133	0.483	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0035		
PERC./LEAKAGE THROUGH LAYER 11	0.004483	16.275	0.01
CHANGE IN WATER STORAGE	-1.316	-4778.887	-3.78
SOIL WATER AT START OF YEAR	263.643	957023.312	
SOIL WATER AT END OF YEAR	262.326	952244.437	
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	0.108	0.00

ANNUAL TOTALS FOR YEAR 15			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	52.41	190248.281	100.00
RUNOFF	9.419	34191.641	17.97
EVAPOTRANSPIRATION	32.726	118796.852	62.44

DRAINAGE COLLECTED FROM LAYER 2	10.0740	36568.484	19.22
PERC./LEAKAGE THROUGH LAYER 3	0.000236	0.855	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000235	0.852	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0037		
PERC./LEAKAGE THROUGH LAYER 11	0.004175	15.154	0.01
CHANGE IN WATER STORAGE	0.186	676.083	0.36
SOIL WATER AT START OF YEAR	262.326	952244.437	
SOIL WATER AT END OF YEAR	262.513	952920.500	
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	0.065	0.00

ANNUAL TOTALS FOR YEAR 16			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	32.14	116668.227	100.00
RUNOFF	2.475	8982.973	7.70
EVAPOTRANSPIRATION	20.753	75333.789	64.57
DRAINAGE COLLECTED FROM LAYER 2	6.8659	24923.062	21.36
PERC./LEAKAGE THROUGH LAYER 3	0.000152	0.553	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000152	0.551	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0039		
PERC./LEAKAGE THROUGH LAYER 11	0.003915	14.212	0.01
CHANGE IN WATER STORAGE	2.042	7414.183	6.35
SOIL WATER AT START OF YEAR	262.513	952920.500	

SOIL WATER AT END OF YEAR	263.229	955522.375	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.326	4812.322	4.12
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

ANNUAL TOTALS FOR YEAR 17			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	49.12	178305.609	100.00
RUNOFF	7.994	29017.947	16.27
EVAPOTRANSPIRATION	30.789	111762.805	62.68
DRAINAGE COLLECTED FROM LAYER 2	12.3903	44976.785	25.22
PERC./LEAKAGE THROUGH LAYER 3	0.000299	1.085	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000298	1.082	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0042		
PERC./LEAKAGE THROUGH LAYER 11	0.003666	13.308	0.01
CHANGE IN WATER STORAGE	-2.056	-7465.089	-4.19
SOIL WATER AT START OF YEAR	263.229	955522.375	
SOIL WATER AT END OF YEAR	262.046	951228.625	
SNOW WATER AT START OF YEAR	1.326	4812.322	2.70
SNOW WATER AT END OF YEAR	0.452	1641.020	0.92
ANNUAL WATER BUDGET BALANCE	0.0000	-0.152	0.00

ANNUAL TOTALS FOR YEAR 18			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	48.15	174784.562	100.00

RUNOFF	8.275	30037.924	17.19
EVAPOTRANSPIRATION	32.102	116531.789	66.67
DRAINAGE COLLECTED FROM LAYER 2	7.8623	28540.326	16.33
PERC./LEAKAGE THROUGH LAYER 3	0.000194	0.703	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000193	0.701	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0045		
PERC./LEAKAGE THROUGH LAYER 11	0.003455	12.541	0.01
CHANGE IN WATER STORAGE	-0.093	-338.150	-0.19
SOIL WATER AT START OF YEAR	262.046	951228.625	
SOIL WATER AT END OF YEAR	262.405	952531.500	
SNOW WATER AT START OF YEAR	0.452	1641.020	0.94
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.130	0.00

ANNUAL TOTALS FOR YEAR 19			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	46.11	167379.297	100.00
RUNOFF	5.552	20153.652	12.04
EVAPOTRANSPIRATION	31.665	114942.461	68.67
DRAINAGE COLLECTED FROM LAYER 2	7.3140	26549.967	15.86
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.651	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0048		
PERC./LEAKAGE THROUGH LAYER 11	0.003266	11.855	0.01

CHANGE IN WATER STORAGE	1.576	5721.263	3.42
SOIL WATER AT START OF YEAR	262.405	952531.500	
SOIL WATER AT END OF YEAR	263.249	955593.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.733	2659.559	1.59
ANNUAL WATER BUDGET BALANCE	0.0000	0.103	0.00

ANNUAL TOTALS FOR YEAR 20			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	46.85	170065.469	100.00
RUNOFF	12.413	45059.895	26.50
EVAPOTRANSPIRATION	27.453	99655.281	58.60
DRAINAGE COLLECTED FROM LAYER 2	7.8820	28611.832	16.82
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000178	0.647	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0049		
PERC./LEAKAGE THROUGH LAYER 11	0.003104	11.269	0.01
CHANGE IN WATER STORAGE	-0.902	-3272.609	-1.92
SOIL WATER AT START OF YEAR	263.249	955593.187	
SOIL WATER AT END OF YEAR	263.080	954980.125	
SNOW WATER AT START OF YEAR	0.733	2659.559	1.56
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.200	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.02 4.27	2.80 4.06	3.39 4.03	3.84 3.00	3.71 3.67	3.76 3.55
STD. DEVIATIONS	1.13 1.77	0.99 1.98	1.11 2.14	1.24 1.74	2.33 1.10	1.33 1.21
RUNOFF						
TOTALS	1.477 0.111	1.879 0.255	1.907 0.176	0.170 0.081	0.107 0.091	0.081 0.335
STD. DEVIATIONS	1.502 0.160	1.330 0.340	1.536 0.318	0.467 0.150	0.206 0.093	0.191 0.634
EVAPOTRANSPIRATION						
TOTALS	0.617 3.951	0.557 3.527	1.280 2.552	3.818 1.480	3.654 1.227	4.479 0.774
STD. DEVIATIONS	0.175 1.459	0.215 1.654	0.521 0.803	0.366 0.228	1.184 0.183	1.240 0.194
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.4907 0.0008	0.1734 0.0299	1.6529 0.3554	1.1281 0.7297	0.3693 1.5596	0.1706 1.8408
STD. DEVIATIONS	0.7026 0.0011	0.4272 0.0806	0.7486 0.8621	1.0587 1.0101	0.6690 1.0201	0.4945 0.9329
PERCOLATION/LEAKAGE THROUGH LAYER 3						
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 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 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 11						

TOTALS	0.0011 0.0009	0.0010 0.0009	0.0010 0.0008	0.0010 0.0008	0.0010 0.0008	0.0009 0.0008
STD. DEVIATIONS	0.0015 0.0010	0.0013 0.0009	0.0013 0.0009	0.0012 0.0008	0.0011 0.0008	0.0010 0.0008
----- AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES) -----						
DAILY AVERAGE HEAD ON TOP OF LAYER 3 -----						
AVERAGES	0.0004 0.0000	0.0002 0.0000	0.0013 0.0003	0.0010 0.0006	0.0003 0.0013	0.0001 0.0015
STD. DEVIATIONS	0.0006 0.0000	0.0004 0.0001	0.0006 0.0008	0.0009 0.0008	0.0005 0.0009	0.0004 0.0008
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
DAILY AVERAGE HEAD ON TOP OF LAYER 9 -----						
AVERAGES	0.0027 0.0028	0.0027 0.0028	0.0027 0.0028	0.0027 0.0028	0.0028 0.0028	0.0028 0.0029
STD. DEVIATIONS	0.0014 0.0014	0.0014 0.0014	0.0014 0.0014	0.0014 0.0014	0.0014 0.0014	0.0014 0.0014

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20 -----						
	INCHES		CU. FEET		PERCENT	
PRECIPITATION	43.10	(5.491)	156451.2		100.00	
RUNOFF	6.670	(3.0096)	24210.82		15.475	
EVAPOTRANSPIRATION	27.917	(3.3312)	101338.75		64.773	
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.50126	(2.45166)	30859.570		19.72473	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00020	(0.00006)	0.736		0.00047	
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)				
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00000	(0.00000)	0.002		0.00000	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00020	(0.00006)	0.734		0.00047	
AVERAGE HEAD ON TOP	0.000	(0.000)				

OF LAYER 7

PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.003 (0.001)		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.01090 (0.01250)	39.564	0.02529
CHANGE IN WATER STORAGE	0.001 (1.3297)	2.50	0.002

PEAK DAILY VALUES FOR YEARS	1 THROUGH	20
	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.500
RUNOFF	3.367	12221.5781
DRAINAGE COLLECTED FROM LAYER 2	0.75059	2724.64673
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000011	0.04174
AVERAGE HEAD ON TOP OF LAYER 3	0.019	
MAXIMUM HEAD ON TOP OF LAYER 3	0.030	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00028
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000011	0.04146
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	
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.005	
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000228	0.82630
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4486
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 20

LAYER	(INCHES)	(VOL/VOL)
1	9.2205	0.3842
2	0.0136	0.0469
3	0.0000	0.0000
4	2.9280	0.2440
5	245.2800	0.2920
6	0.5760	0.0320
7	0.0000	0.0000
8	0.0066	0.0285
9	0.0000	0.0000
10	0.1770	0.7500
11	1.3743	0.2290
SNOW WATER	0.000	

Scenario 8

(Waste Height = 100 feet + Cap; Filename: GL24N100)

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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:\HELP3\GLRA2\20G.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\20G.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\20G.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\20G.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL24N100.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL24N100.OUT

```

TIME: 18: 8 DATE: 11/18/2017

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*****
TITLE: GLRA PHASE 2 - 100' WASTE, 12" CS + CAP
*****

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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 12
THICKNESS = 24.00 INCHES
POROSITY = 0.4710 VOL/VOL
FIELD CAPACITY = 0.3420 VOL/VOL
WILTING POINT = 0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3751 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.419999997000E-04 CM/SEC
NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 4.63
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

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LAYER 2

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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0
THICKNESS = 0.29 INCHES
POROSITY = 0.8500 VOL/VOL
FIELD CAPACITY = 0.0100 VOL/VOL
WILTING POINT = 0.0050 VOL/VOL

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INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	4.0000000000	CM/SEC
SLOPE	=	33.30	PERCENT
DRAINAGE LENGTH	=	150.0	FEET

LAYER 3

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.	=	0.39999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.11999997000E-03	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1200.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

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	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 7

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0111	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.000000000000	CM/SEC

LAYER 9

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 10

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS = 6.00 INCHES
 POROSITY = 0.3650 VOL/VOL
 FIELD CAPACITY = 0.3050 VOL/VOL
 WILTING POINT = 0.2020 VOL/VOL
 INITIAL SOIL WATER CONTENT = 0.2654 VOL/VOL
 EFFECTIVE SAT. HYD. COND. = 0.270000010000E-05 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
 GOOD STAND OF GRASS, A SURFACE SLOPE OF 33.%
 AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER = 84.90
 FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE = 1.000 ACRES
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 INITIAL WATER IN EVAPORATIVE ZONE = 7.823 INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE = 9.891 INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE = 4.410 INCHES
 INITIAL SNOW WATER = 0.000 INCHES
 INITIAL WATER IN LAYER MATERIALS = 364.682 INCHES
 TOTAL INITIAL WATER = 364.682 INCHES
 TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
 PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE = 40.37 DEGREES
 MAXIMUM LEAF AREA INDEX = 3.50
 START OF GROWING SEASON (JULIAN DATE) = 114
 END OF GROWING SEASON (JULIAN DATE) = 288
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 AVERAGE ANNUAL WIND SPEED = 9.20 MPH
 AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
 AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 63.00 %
 AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
 AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	3.611	13107.210	7.87
EVAPOTRANSPIRATION	30.476	110629.672	66.44
DRAINAGE COLLECTED FROM LAYER 2	11.7852	42780.418	25.69
PERC./LEAKAGE THROUGH LAYER 3	0.000281	1.019	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000280	1.016	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0005		
PERC./LEAKAGE THROUGH LAYER 11	0.055146	200.180	0.12
CHANGE IN WATER STORAGE	-0.058	-209.372	-0.13
SOIL WATER AT START OF YEAR	368.186	1336515.750	
SOIL WATER AT END OF YEAR	368.128	1336306.370	
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	-0.030	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	9.934	36061.312	21.82
EVAPOTRANSPIRATION	23.535	85431.469	51.70
DRAINAGE COLLECTED FROM LAYER 2	12.2332	44406.383	26.87
PERC./LEAKAGE THROUGH LAYER 3	0.000280	1.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0009		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.004	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000279	1.012	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0008		
PERC./LEAKAGE THROUGH LAYER 11	0.030360	110.208	0.07
CHANGE IN WATER STORAGE	-0.213	-771.796	-0.47
SOIL WATER AT START OF YEAR	368.128	1336306.370	
SOIL WATER AT END OF YEAR	367.916	1335534.620	
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	-0.035	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	10.575	38387.047	24.39
EVAPOTRANSPIRATION	26.258	95315.773	60.56
DRAINAGE COLLECTED FROM LAYER 2	5.9464	21585.455	13.71
PERC./LEAKAGE THROUGH LAYER 3	0.000141	0.512	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000141	0.511	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		

PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0010		
PERC./LEAKAGE THROUGH LAYER 11	0.020864	75.736	0.05
CHANGE IN WATER STORAGE	0.560	2032.767	1.29
SOIL WATER AT START OF YEAR	367.916	1335534.620	
SOIL WATER AT END OF YEAR	368.278	1336850.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.049	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	6.976	25321.680	15.50
EVAPOTRANSPIRATION	29.270	106250.016	65.03
DRAINAGE COLLECTED FROM LAYER 2	8.4459	30658.773	18.76
PERC./LEAKAGE THROUGH LAYER 3	0.000201	0.731	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000201	0.728	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0013		
PERC./LEAKAGE THROUGH LAYER 11	0.015876	57.631	0.04
CHANGE IN WATER STORAGE	0.303	1098.181	0.67
SOIL WATER AT START OF YEAR	368.278	1336850.370	
SOIL WATER AT END OF YEAR	368.404	1337305.870	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	9.069	32920.285	20.01
EVAPOTRANSPIRATION	28.927	105004.758	63.81
DRAINAGE COLLECTED FROM LAYER 2	7.7160	28009.074	17.02
PERC./LEAKAGE THROUGH LAYER 3	0.000188	0.683	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000187	0.680	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0014		
PERC./LEAKAGE THROUGH LAYER 11	0.012725	46.191	0.03
CHANGE IN WATER STORAGE	-0.395	-1432.487	-0.87
SOIL WATER AT START OF YEAR	368.404	1337305.870	
SOIL WATER AT END OF YEAR	368.384	1337233.000	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.061	0.00

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.49	139718.734	100.00
RUNOFF	3.356	12181.501	8.72
EVAPOTRANSPIRATION	25.987	94332.969	67.52
DRAINAGE COLLECTED FROM LAYER 2	6.7476	24493.801	17.53
PERC./LEAKAGE THROUGH LAYER 3	0.000169	0.614	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00

PERC./LEAKAGE THROUGH LAYER 7	0.000169	0.612	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0017		
PERC./LEAKAGE THROUGH LAYER 11	0.010620	38.552	0.03
CHANGE IN WATER STORAGE	2.389	8672.004	6.21
SOIL WATER AT START OF YEAR	368.384	1337233.000	
SOIL WATER AT END OF YEAR	368.376	1337205.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	2.397	8699.588	6.23
ANNUAL WATER BUDGET BALANCE	0.0000	-0.093	0.00

ANNUAL TOTALS FOR YEAR 7			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	45.49	165128.703	100.00
RUNOFF	9.651	35033.492	21.22
EVAPOTRANSPIRATION	27.073	98273.406	59.51
DRAINAGE COLLECTED FROM LAYER 2	11.2174	40719.203	24.66
PERC./LEAKAGE THROUGH LAYER 3	0.000252	0.914	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000251	0.911	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0019		
PERC./LEAKAGE THROUGH LAYER 11	0.009101	33.037	0.02
CHANGE IN WATER STORAGE	-2.460	-8930.451	-5.41
SOIL WATER AT START OF YEAR	368.376	1337205.500	
SOIL WATER AT END OF YEAR	368.313	1336974.620	
SNOW WATER AT START OF YEAR	2.397	8699.588	5.27
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

ANNUAL TOTALS FOR YEAR 8			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.30	175329.000	100.00
RUNOFF	2.689	9759.428	5.57
EVAPOTRANSPIRATION	33.714	122380.633	69.80
DRAINAGE COLLECTED FROM LAYER 2	11.4280	41483.512	23.66
PERC./LEAKAGE THROUGH LAYER 3	0.000289	1.049	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000288	1.046	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0023		
PERC./LEAKAGE THROUGH LAYER 11	0.007974	28.946	0.02
CHANGE IN WATER STORAGE	0.462	1676.477	0.96
SOIL WATER AT START OF YEAR	368.313	1336974.620	
SOIL WATER AT END OF YEAR	368.306	1336951.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.468	1699.519	0.97
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

ANNUAL TOTALS FOR YEAR 9			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.40	161172.000	100.00
RUNOFF	6.682	24255.648	15.05
EVAPOTRANSPIRATION	28.369	102979.516	63.89
DRAINAGE COLLECTED FROM LAYER 2	9.9891	36260.488	22.50
PERC./LEAKAGE THROUGH LAYER 3	0.000217	0.788	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		

DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000216	0.785	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0025		
PERC./LEAKAGE THROUGH LAYER 11	0.007055	25.611	0.02
CHANGE IN WATER STORAGE	-0.647	-2349.246	-1.46
SOIL WATER AT START OF YEAR	368.306	1336951.500	
SOIL WATER AT END OF YEAR	367.624	1334474.750	
SNOW WATER AT START OF YEAR	0.468	1699.519	1.05
SNOW WATER AT END OF YEAR	0.503	1827.065	1.13
ANNUAL WATER BUDGET BALANCE	0.0000	-0.017	0.00

ANNUAL TOTALS FOR YEAR 10			
	INCHES	CU. FEET	PERCENT
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PRECIPITATION	36.62	132930.625	100.00
RUNOFF	3.444	12499.953	9.40
EVAPOTRANSPIRATION	26.092	94713.773	71.25
DRAINAGE COLLECTED FROM LAYER 2	5.7145	20743.635	15.60
PERC./LEAKAGE THROUGH LAYER 3	0.000139	0.505	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000139	0.503	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0028		
PERC./LEAKAGE THROUGH LAYER 11	0.006337	23.002	0.02
CHANGE IN WATER STORAGE	1.364	4950.206	3.72
SOIL WATER AT START OF YEAR	367.624	1334474.750	
SOIL WATER AT END OF YEAR	367.806	1335135.000	
SNOW WATER AT START OF YEAR	0.503	1827.065	1.37
SNOW WATER AT END OF YEAR	1.685	6117.030	4.60

ANNUAL WATER BUDGET BALANCE	0.0000	0.057	0.00

ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	40.15	145744.484	100.00
RUNOFF	7.768	28197.131	19.35
EVAPOTRANSPIRATION	23.978	87038.430	59.72
DRAINAGE COLLECTED FROM LAYER 2	9.2187	33463.832	22.96
PERC./LEAKAGE THROUGH LAYER 3	0.000221	0.804	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000221	0.801	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0029		
PERC./LEAKAGE THROUGH LAYER 11	0.005748	20.864	0.01
CHANGE IN WATER STORAGE	-0.820	-2975.790	-2.04
SOIL WATER AT START OF YEAR	367.806	1335135.000	
SOIL WATER AT END OF YEAR	367.697	1334739.500	
SNOW WATER AT START OF YEAR	1.685	6117.030	4.20
SNOW WATER AT END OF YEAR	0.974	3536.720	2.43
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	38.90	141206.984	100.00
RUNOFF	6.453	23425.703	16.59
EVAPOTRANSPIRATION	26.039	94522.586	66.94
DRAINAGE COLLECTED FROM LAYER 2	7.8696	28566.566	20.23

PERC./LEAKAGE THROUGH LAYER 3	0.000193	0.700	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000192	0.698	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0032		
PERC./LEAKAGE THROUGH LAYER 11	0.005270	19.131	0.01
CHANGE IN WATER STORAGE	-1.467	-5326.905	-3.77
SOIL WATER AT START OF YEAR	367.697	1334739.500	
SOIL WATER AT END OF YEAR	367.204	1332949.370	
SNOW WATER AT START OF YEAR	0.974	3536.720	2.50
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.105	0.00

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	34.95	126868.500	100.00
RUNOFF	3.259	11831.491	9.33
EVAPOTRANSPIRATION	25.957	94223.539	74.27
DRAINAGE COLLECTED FROM LAYER 2	4.1698	15136.356	11.93
PERC./LEAKAGE THROUGH LAYER 3	0.000112	0.405	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000111	0.404	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0034		
PERC./LEAKAGE THROUGH LAYER 11	0.004840	17.568	0.01
CHANGE IN WATER STORAGE	1.559	5659.579	4.46
SOIL WATER AT START OF YEAR	367.204	1332949.370	
SOIL WATER AT END OF YEAR	368.763	1338608.870	

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	-0.031	0.00

ANNUAL TOTALS FOR YEAR 14			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.82	126396.602	100.00
RUNOFF	3.799	13790.444	10.91
EVAPOTRANSPIRATION	27.178	98655.234	78.05
DRAINAGE COLLECTED FROM LAYER 2	5.1552	18713.426	14.81
PERC./LEAKAGE THROUGH LAYER 3	0.000133	0.485	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000133	0.483	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0035		
PERC./LEAKAGE THROUGH LAYER 11	0.004483	16.275	0.01
CHANGE IN WATER STORAGE	-1.316	-4778.887	-3.78
SOIL WATER AT START OF YEAR	368.763	1338608.870	
SOIL WATER AT END OF YEAR	367.446	1333830.000	
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	0.108	0.00

ANNUAL TOTALS FOR YEAR 15			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	52.41	190248.281	100.00
RUNOFF	9.419	34191.641	17.97
EVAPOTRANSPIRATION	32.726	118796.852	62.44

DRAINAGE COLLECTED FROM LAYER 2	10.0740	36568.484	19.22
PERC./LEAKAGE THROUGH LAYER 3	0.000236	0.855	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000235	0.852	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0037		
PERC./LEAKAGE THROUGH LAYER 11	0.004175	15.154	0.01
CHANGE IN WATER STORAGE	0.186	676.083	0.36
SOIL WATER AT START OF YEAR	367.446	1333830.000	
SOIL WATER AT END OF YEAR	367.633	1334506.120	
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	0.065	0.00

ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	32.14	116668.227	100.00
RUNOFF	2.475	8982.973	7.70
EVAPOTRANSPIRATION	20.753	75333.789	64.57
DRAINAGE COLLECTED FROM LAYER 2	6.8659	24923.062	21.36
PERC./LEAKAGE THROUGH LAYER 3	0.000152	0.553	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000152	0.551	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0039		
PERC./LEAKAGE THROUGH LAYER 11	0.003915	14.212	0.01
CHANGE IN WATER STORAGE	2.042	7414.183	6.35
SOIL WATER AT START OF YEAR	367.633	1334506.120	

SOIL WATER AT END OF YEAR	368.349	1337108.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.326	4812.322	4.12
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

ANNUAL TOTALS FOR YEAR 17			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.12	178305.609	100.00
RUNOFF	7.994	29017.947	16.27
EVAPOTRANSPIRATION	30.789	111762.805	62.68
DRAINAGE COLLECTED FROM LAYER 2	12.3903	44976.785	25.22
PERC./LEAKAGE THROUGH LAYER 3	0.000299	1.085	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000298	1.082	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0042		
PERC./LEAKAGE THROUGH LAYER 11	0.003666	13.308	0.01
CHANGE IN WATER STORAGE	-2.057	-7465.200	-4.19
SOIL WATER AT START OF YEAR	368.349	1337108.000	
SOIL WATER AT END OF YEAR	367.166	1332814.120	
SNOW WATER AT START OF YEAR	1.326	4812.322	2.70
SNOW WATER AT END OF YEAR	0.452	1641.020	0.92
ANNUAL WATER BUDGET BALANCE	0.0000	-0.041	0.00

ANNUAL TOTALS FOR YEAR 18			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.15	174784.562	100.00

RUNOFF	8.275	30037.924	17.19
EVAPOTRANSPIRATION	32.102	116531.789	66.67
DRAINAGE COLLECTED FROM LAYER 2	7.8623	28540.326	16.33
PERC./LEAKAGE THROUGH LAYER 3	0.000194	0.703	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000193	0.701	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0045		
PERC./LEAKAGE THROUGH LAYER 11	0.003455	12.541	0.01
CHANGE IN WATER STORAGE	-0.093	-338.039	-0.19
SOIL WATER AT START OF YEAR	367.166	1332814.120	
SOIL WATER AT END OF YEAR	367.525	1334117.000	
SNOW WATER AT START OF YEAR	0.452	1641.020	0.94
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	46.11	167379.297	100.00
RUNOFF	5.552	20153.652	12.04
EVAPOTRANSPIRATION	31.665	114942.461	68.67
DRAINAGE COLLECTED FROM LAYER 2	7.3140	26549.967	15.86
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.651	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0048		
PERC./LEAKAGE THROUGH LAYER 11	0.003266	11.855	0.01

CHANGE IN WATER STORAGE	1.576	5721.263	3.42
SOIL WATER AT START OF YEAR	367.525	1334117.000	
SOIL WATER AT END OF YEAR	368.369	1337178.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.733	2659.559	1.59
ANNUAL WATER BUDGET BALANCE	0.0000	0.103	0.00

ANNUAL TOTALS FOR YEAR 20			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	46.85	170065.469	100.00
RUNOFF	12.413	45059.895	26.50
EVAPOTRANSPIRATION	27.453	99655.281	58.60
DRAINAGE COLLECTED FROM LAYER 2	7.8820	28611.832	16.82
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000178	0.647	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0049		
PERC./LEAKAGE THROUGH LAYER 11	0.003104	11.269	0.01
CHANGE IN WATER STORAGE	-0.902	-3272.609	-1.92
SOIL WATER AT START OF YEAR	368.369	1337178.750	
SOIL WATER AT END OF YEAR	368.200	1336565.750	
SNOW WATER AT START OF YEAR	0.733	2659.559	1.56
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.200	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.02 4.27	2.80 4.06	3.39 4.03	3.84 3.00	3.71 3.67	3.76 3.55
STD. DEVIATIONS	1.13 1.77	0.99 1.98	1.11 2.14	1.24 1.74	2.33 1.10	1.33 1.21
RUNOFF						
TOTALS	1.477 0.111	1.879 0.255	1.907 0.176	0.170 0.081	0.107 0.091	0.081 0.335
STD. DEVIATIONS	1.502 0.160	1.330 0.340	1.536 0.318	0.467 0.150	0.206 0.093	0.191 0.634
EVAPOTRANSPIRATION						
TOTALS	0.617 3.951	0.557 3.527	1.280 2.552	3.818 1.480	3.654 1.227	4.479 0.774
STD. DEVIATIONS	0.175 1.459	0.215 1.654	0.521 0.803	0.366 0.228	1.184 0.183	1.240 0.194
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.4907 0.0008	0.1734 0.0299	1.6529 0.3554	1.1281 0.7297	0.3693 1.5596	0.1706 1.8408
STD. DEVIATIONS	0.7026 0.0011	0.4272 0.0806	0.7486 0.8621	1.0587 1.0101	0.6690 1.0201	0.4945 0.9329
PERCOLATION/LEAKAGE THROUGH LAYER 3						
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 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 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 11						

TOTALS	0.0011	0.0010	0.0010	0.0010	0.0010	0.0009
	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008
STD. DEVIATIONS	0.0015	0.0013	0.0013	0.0012	0.0011	0.0010
	0.0010	0.0009	0.0009	0.0008	0.0008	0.0008

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)						

DAILY AVERAGE HEAD ON TOP OF LAYER 3						

AVERAGES	0.0004	0.0002	0.0013	0.0010	0.0003	0.0001
	0.0000	0.0000	0.0003	0.0006	0.0013	0.0015
STD. DEVIATIONS	0.0006	0.0004	0.0006	0.0009	0.0005	0.0004
	0.0000	0.0001	0.0008	0.0008	0.0009	0.0008
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
DAILY AVERAGE HEAD ON TOP OF LAYER 9						

AVERAGES	0.0027	0.0027	0.0027	0.0027	0.0028	0.0028
	0.0028	0.0028	0.0028	0.0028	0.0028	0.0029
STD. DEVIATIONS	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014

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

	INCHES		CU. FEET		PERCENT	
	-----		-----		-----	
PRECIPITATION	43.10	(5.491)	156451.2		100.00	
RUNOFF	6.670	(3.0096)	24210.82		15.475	
EVAPOTRANSPIRATION	27.917	(3.3312)	101338.75		64.773	
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.50126	(2.45166)	30859.570		19.72473	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00020	(0.00006)	0.736		0.00047	
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)				
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00000	(0.00000)	0.002		0.00000	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00020	(0.00006)	0.734		0.00047	
AVERAGE HEAD ON TOP	0.000	(0.000)				

OF LAYER 7

PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.003 (0.001)		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.01090 (0.01250)	39.564	0.02529
CHANGE IN WATER STORAGE	0.001 (1.3297)	2.50	0.002

PEAK DAILY VALUES FOR YEARS	1 THROUGH	20
	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.500
RUNOFF	3.367	12221.5781
DRAINAGE COLLECTED FROM LAYER 2	0.75059	2724.64673
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000011	0.04174
AVERAGE HEAD ON TOP OF LAYER 3	0.019	
MAXIMUM HEAD ON TOP OF LAYER 3	0.030	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00028
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000011	0.04146
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	
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.005	
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000228	0.82630
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4486
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 20

LAYER	(INCHES)	(VOL/VOL)
1	9.2205	0.3842
2	0.0136	0.0469
3	0.0000	0.0000
4	2.9280	0.2440
5	350.4000	0.2920
6	0.5760	0.0320
7	0.0000	0.0000
8	0.0066	0.0285
9	0.0000	0.0000
10	0.1770	0.7500
11	1.3743	0.2290
SNOW WATER	0.000	

Scenario 9

(Waste Height = 130 feet + Cap; Filename: GL24N130)

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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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*****

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PRECIPITATION DATA FILE: C:\HELP3\GLRA2\20G.D4
TEMPERATURE DATA FILE: C:\HELP3\GLRA2\20G.D7
SOLAR RADIATION DATA FILE: C:\HELP3\GLRA2\20G.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\GLRA2\20G.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\GLRA2\GL24N130.D10
OUTPUT DATA FILE: C:\HELP3\GLRA2\GL24N130.OUT

```

TIME: 17:44 DATE: 11/18/2017

```

*****
TITLE: GLRA PHASE 2 - 130' WASTE, 12" CS + CAP
*****

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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 12
THICKNESS = 24.00 INCHES
POROSITY = 0.4710 VOL/VOL
FIELD CAPACITY = 0.3420 VOL/VOL
WILTING POINT = 0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3751 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.419999997000E-04 CM/SEC
NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 4.63
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

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LAYER 2

```

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0
THICKNESS = 0.29 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.	=	4.0000000000	CM/SEC
SLOPE	=	33.30	PERCENT
DRAINAGE LENGTH	=	150.0	FEET

LAYER 3

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.	=	0.39999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.11999997000E-03	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1560.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

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	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 7

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0111	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.000000000000	CM/SEC

LAYER 9

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 10

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS = 6.00 INCHES
 POROSITY = 0.3650 VOL/VOL
 FIELD CAPACITY = 0.3050 VOL/VOL
 WILTING POINT = 0.2020 VOL/VOL
 INITIAL SOIL WATER CONTENT = 0.2654 VOL/VOL
 EFFECTIVE SAT. HYD. COND. = 0.270000010000E-05 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
 GOOD STAND OF GRASS, A SURFACE SLOPE OF 33.%
 AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER = 84.90
 FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE = 1.000 ACRES
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 INITIAL WATER IN EVAPORATIVE ZONE = 7.823 INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE = 9.891 INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE = 4.410 INCHES
 INITIAL SNOW WATER = 0.000 INCHES
 INITIAL WATER IN LAYER MATERIALS = 469.802 INCHES
 TOTAL INITIAL WATER = 469.802 INCHES
 TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
 PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE = 40.37 DEGREES
 MAXIMUM LEAF AREA INDEX = 3.50
 START OF GROWING SEASON (JULIAN DATE) = 114
 END OF GROWING SEASON (JULIAN DATE) = 288
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 AVERAGE ANNUAL WIND SPEED = 9.20 MPH
 AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
 AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 63.00 %
 AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
 AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
-----	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	3.611	13107.210	7.87
EVAPOTRANSPIRATION	30.476	110629.672	66.44
DRAINAGE COLLECTED FROM LAYER 2	11.7852	42780.418	25.69
PERC./LEAKAGE THROUGH LAYER 3	0.000281	1.019	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000280	1.016	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0005		
PERC./LEAKAGE THROUGH LAYER 11	0.055146	200.180	0.12
CHANGE IN WATER STORAGE	-0.058	-209.372	-0.13
SOIL WATER AT START OF YEAR	473.306	1718101.370	
SOIL WATER AT END OF YEAR	473.248	1717892.000	
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	-0.030	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	9.934	36061.312	21.82
EVAPOTRANSPIRATION	23.535	85431.469	51.70
DRAINAGE COLLECTED FROM LAYER 2	12.2332	44406.383	26.87
PERC./LEAKAGE THROUGH LAYER 3	0.000280	1.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0009		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.004	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000279	1.012	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0008		
PERC./LEAKAGE THROUGH LAYER 11	0.030360	110.208	0.07
CHANGE IN WATER STORAGE	-0.213	-771.796	-0.47
SOIL WATER AT START OF YEAR	473.248	1717892.000	
SOIL WATER AT END OF YEAR	473.036	1717120.120	
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	-0.035	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	10.575	38387.047	24.39
EVAPOTRANSPIRATION	26.258	95315.773	60.56
DRAINAGE COLLECTED FROM LAYER 2	5.9464	21585.455	13.71
PERC./LEAKAGE THROUGH LAYER 3	0.000141	0.512	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000141	0.511	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		

PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0010		
PERC./LEAKAGE THROUGH LAYER 11	0.020864	75.736	0.05
CHANGE IN WATER STORAGE	0.560	2032.767	1.29
SOIL WATER AT START OF YEAR	473.036	1717120.120	
SOIL WATER AT END OF YEAR	473.398	1718436.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.049	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	6.976	25321.680	15.50
EVAPOTRANSPIRATION	29.270	106250.016	65.03
DRAINAGE COLLECTED FROM LAYER 2	8.4459	30658.773	18.76
PERC./LEAKAGE THROUGH LAYER 3	0.000201	0.731	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000201	0.728	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0013		
PERC./LEAKAGE THROUGH LAYER 11	0.015876	57.631	0.04
CHANGE IN WATER STORAGE	0.303	1098.181	0.67
SOIL WATER AT START OF YEAR	473.398	1718436.000	
SOIL WATER AT END OF YEAR	473.524	1718891.500	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	9.069	32920.285	20.01
EVAPOTRANSPIRATION	28.927	105004.758	63.81
DRAINAGE COLLECTED FROM LAYER 2	7.7160	28009.074	17.02
PERC./LEAKAGE THROUGH LAYER 3	0.000188	0.683	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000187	0.680	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0014		
PERC./LEAKAGE THROUGH LAYER 11	0.012725	46.191	0.03
CHANGE IN WATER STORAGE	-0.395	-1432.487	-0.87
SOIL WATER AT START OF YEAR	473.524	1718891.500	
SOIL WATER AT END OF YEAR	473.504	1718818.620	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.061	0.00

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.49	139718.734	100.00
RUNOFF	3.356	12181.501	8.72
EVAPOTRANSPIRATION	25.987	94332.969	67.52
DRAINAGE COLLECTED FROM LAYER 2	6.7476	24493.801	17.53
PERC./LEAKAGE THROUGH LAYER 3	0.000169	0.614	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00

PERC./LEAKAGE THROUGH LAYER 7	0.000169	0.612	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0017		
PERC./LEAKAGE THROUGH LAYER 11	0.010620	38.552	0.03
CHANGE IN WATER STORAGE	2.389	8672.004	6.21
SOIL WATER AT START OF YEAR	473.504	1718818.620	
SOIL WATER AT END OF YEAR	473.496	1718791.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	2.397	8699.588	6.23
ANNUAL WATER BUDGET BALANCE	0.0000	-0.093	0.00

ANNUAL TOTALS FOR YEAR 7			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.49	165128.703	100.00
RUNOFF	9.651	35033.492	21.22
EVAPOTRANSPIRATION	27.073	98273.406	59.51
DRAINAGE COLLECTED FROM LAYER 2	11.2174	40719.203	24.66
PERC./LEAKAGE THROUGH LAYER 3	0.000252	0.914	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000251	0.911	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0019		
PERC./LEAKAGE THROUGH LAYER 11	0.009101	33.037	0.02
CHANGE IN WATER STORAGE	-2.460	-8930.451	-5.41
SOIL WATER AT START OF YEAR	473.496	1718791.000	
SOIL WATER AT END OF YEAR	473.433	1718560.120	
SNOW WATER AT START OF YEAR	2.397	8699.588	5.27
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

ANNUAL TOTALS FOR YEAR 8			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.30	175329.000	100.00
RUNOFF	2.689	9759.428	5.57
EVAPOTRANSPIRATION	33.714	122380.633	69.80
DRAINAGE COLLECTED FROM LAYER 2	11.4280	41483.512	23.66
PERC./LEAKAGE THROUGH LAYER 3	0.000289	1.049	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000288	1.046	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0023		
PERC./LEAKAGE THROUGH LAYER 11	0.007974	28.946	0.02
CHANGE IN WATER STORAGE	0.462	1676.477	0.96
SOIL WATER AT START OF YEAR	473.433	1718560.120	
SOIL WATER AT END OF YEAR	473.426	1718537.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.468	1699.519	0.97
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

ANNUAL TOTALS FOR YEAR 9			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.40	161172.000	100.00
RUNOFF	6.682	24255.648	15.05
EVAPOTRANSPIRATION	28.369	102979.516	63.89
DRAINAGE COLLECTED FROM LAYER 2	9.9891	36260.488	22.50
PERC./LEAKAGE THROUGH LAYER 3	0.000217	0.788	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		

DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000216	0.785	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0025		
PERC./LEAKAGE THROUGH LAYER 11	0.007055	25.611	0.02
CHANGE IN WATER STORAGE	-0.647	-2349.246	-1.46
SOIL WATER AT START OF YEAR	473.426	1718537.120	
SOIL WATER AT END OF YEAR	472.744	1716060.370	
SNOW WATER AT START OF YEAR	0.468	1699.519	1.05
SNOW WATER AT END OF YEAR	0.503	1827.065	1.13
ANNUAL WATER BUDGET BALANCE	0.0000	-0.017	0.00

ANNUAL TOTALS FOR YEAR 10			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	36.62	132930.625	100.00
RUNOFF	3.444	12499.953	9.40
EVAPOTRANSPIRATION	26.092	94713.773	71.25
DRAINAGE COLLECTED FROM LAYER 2	5.7145	20743.635	15.60
PERC./LEAKAGE THROUGH LAYER 3	0.000139	0.505	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000139	0.503	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0028		
PERC./LEAKAGE THROUGH LAYER 11	0.006337	23.002	0.02
CHANGE IN WATER STORAGE	1.364	4950.206	3.72
SOIL WATER AT START OF YEAR	472.744	1716060.370	
SOIL WATER AT END OF YEAR	472.926	1716720.620	
SNOW WATER AT START OF YEAR	0.503	1827.065	1.37
SNOW WATER AT END OF YEAR	1.685	6117.030	4.60

ANNUAL WATER BUDGET BALANCE	0.0000	0.057	0.00

ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	40.15	145744.484	100.00
RUNOFF	7.768	28197.131	19.35
EVAPOTRANSPIRATION	23.978	87038.430	59.72
DRAINAGE COLLECTED FROM LAYER 2	9.2187	33463.832	22.96
PERC./LEAKAGE THROUGH LAYER 3	0.000221	0.804	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000221	0.801	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0029		
PERC./LEAKAGE THROUGH LAYER 11	0.005748	20.864	0.01
CHANGE IN WATER STORAGE	-0.820	-2975.790	-2.04
SOIL WATER AT START OF YEAR	472.926	1716720.620	
SOIL WATER AT END OF YEAR	472.817	1716325.120	
SNOW WATER AT START OF YEAR	1.685	6117.030	4.20
SNOW WATER AT END OF YEAR	0.974	3536.720	2.43
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141206.984	100.00
RUNOFF	6.453	23425.703	16.59
EVAPOTRANSPIRATION	26.039	94522.586	66.94
DRAINAGE COLLECTED FROM LAYER 2	7.8696	28566.566	20.23

PERC./LEAKAGE THROUGH LAYER 3	0.000193	0.700	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000192	0.698	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0032		
PERC./LEAKAGE THROUGH LAYER 11	0.005270	19.131	0.01
CHANGE IN WATER STORAGE	-1.467	-5326.905	-3.77
SOIL WATER AT START OF YEAR	472.817	1716325.120	
SOIL WATER AT END OF YEAR	472.324	1714534.870	
SNOW WATER AT START OF YEAR	0.974	3536.720	2.50
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.105	0.00

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	34.95	126868.500	100.00
RUNOFF	3.259	11831.491	9.33
EVAPOTRANSPIRATION	25.957	94223.539	74.27
DRAINAGE COLLECTED FROM LAYER 2	4.1698	15136.356	11.93
PERC./LEAKAGE THROUGH LAYER 3	0.000112	0.405	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000111	0.404	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0034		
PERC./LEAKAGE THROUGH LAYER 11	0.004840	17.568	0.01
CHANGE IN WATER STORAGE	1.559	5659.579	4.46
SOIL WATER AT START OF YEAR	472.324	1714534.870	
SOIL WATER AT END OF YEAR	473.883	1720194.500	

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	-0.031	0.00

ANNUAL TOTALS FOR YEAR 14			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.82	126396.602	100.00
RUNOFF	3.799	13790.444	10.91
EVAPOTRANSPIRATION	27.178	98655.234	78.05
DRAINAGE COLLECTED FROM LAYER 2	5.1552	18713.426	14.81
PERC./LEAKAGE THROUGH LAYER 3	0.000133	0.485	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000133	0.483	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0035		
PERC./LEAKAGE THROUGH LAYER 11	0.004483	16.275	0.01
CHANGE IN WATER STORAGE	-1.316	-4778.887	-3.78
SOIL WATER AT START OF YEAR	473.883	1720194.500	
SOIL WATER AT END OF YEAR	472.566	1715415.620	
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	0.108	0.00

ANNUAL TOTALS FOR YEAR 15			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	52.41	190248.281	100.00
RUNOFF	9.419	34191.641	17.97
EVAPOTRANSPIRATION	32.726	118796.852	62.44

DRAINAGE COLLECTED FROM LAYER 2	10.0740	36568.484	19.22
PERC./LEAKAGE THROUGH LAYER 3	0.000236	0.855	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000235	0.852	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0037		
PERC./LEAKAGE THROUGH LAYER 11	0.004175	15.154	0.01
CHANGE IN WATER STORAGE	0.186	676.083	0.36
SOIL WATER AT START OF YEAR	472.566	1715415.620	
SOIL WATER AT END OF YEAR	472.753	1716091.750	
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	0.065	0.00

ANNUAL TOTALS FOR YEAR 16			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	32.14	116668.227	100.00
RUNOFF	2.475	8982.973	7.70
EVAPOTRANSPIRATION	20.753	75333.789	64.57
DRAINAGE COLLECTED FROM LAYER 2	6.8659	24923.062	21.36
PERC./LEAKAGE THROUGH LAYER 3	0.000152	0.553	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000152	0.551	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0039		
PERC./LEAKAGE THROUGH LAYER 11	0.003915	14.212	0.01
CHANGE IN WATER STORAGE	2.042	7414.183	6.35
SOIL WATER AT START OF YEAR	472.753	1716091.750	

SOIL WATER AT END OF YEAR	473.469	1718693.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.326	4812.322	4.12
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

ANNUAL TOTALS FOR YEAR 17			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.12	178305.609	100.00
RUNOFF	7.994	29017.947	16.27
EVAPOTRANSPIRATION	30.789	111762.805	62.68
DRAINAGE COLLECTED FROM LAYER 2	12.3903	44976.785	25.22
PERC./LEAKAGE THROUGH LAYER 3	0.000299	1.085	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000298	1.082	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0042		
PERC./LEAKAGE THROUGH LAYER 11	0.003666	13.308	0.01
CHANGE IN WATER STORAGE	-2.057	-7465.200	-4.19
SOIL WATER AT START OF YEAR	473.469	1718693.500	
SOIL WATER AT END OF YEAR	472.286	1714399.620	
SNOW WATER AT START OF YEAR	1.326	4812.322	2.70
SNOW WATER AT END OF YEAR	0.452	1641.020	0.92
ANNUAL WATER BUDGET BALANCE	0.0000	-0.041	0.00

ANNUAL TOTALS FOR YEAR 18			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.15	174784.562	100.00

RUNOFF	8.275	30037.924	17.19
EVAPOTRANSPIRATION	32.102	116531.789	66.67
DRAINAGE COLLECTED FROM LAYER 2	7.8623	28540.326	16.33
PERC./LEAKAGE THROUGH LAYER 3	0.000194	0.703	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000193	0.701	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0045		
PERC./LEAKAGE THROUGH LAYER 11	0.003455	12.541	0.01
CHANGE IN WATER STORAGE	-0.093	-338.039	-0.19
SOIL WATER AT START OF YEAR	472.286	1714399.620	
SOIL WATER AT END OF YEAR	472.645	1715702.620	
SNOW WATER AT START OF YEAR	0.452	1641.020	0.94
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	46.11	167379.297	100.00
RUNOFF	5.552	20153.652	12.04
EVAPOTRANSPIRATION	31.665	114942.461	68.67
DRAINAGE COLLECTED FROM LAYER 2	7.3140	26549.967	15.86
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.651	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0048		
PERC./LEAKAGE THROUGH LAYER 11	0.003266	11.855	0.01

CHANGE IN WATER STORAGE	1.576	5721.263	3.42
SOIL WATER AT START OF YEAR	472.645	1715702.620	
SOIL WATER AT END OF YEAR	473.489	1718764.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.733	2659.559	1.59
ANNUAL WATER BUDGET BALANCE	0.0000	0.103	0.00

ANNUAL TOTALS FOR YEAR 20			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	46.85	170065.469	100.00
RUNOFF	12.413	45059.895	26.50
EVAPOTRANSPIRATION	27.453	99655.281	58.60
DRAINAGE COLLECTED FROM LAYER 2	7.8820	28611.832	16.82
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000178	0.647	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0049		
PERC./LEAKAGE THROUGH LAYER 11	0.003104	11.269	0.01
CHANGE IN WATER STORAGE	-0.902	-3272.609	-1.92
SOIL WATER AT START OF YEAR	473.489	1718764.370	
SOIL WATER AT END OF YEAR	473.320	1718151.250	
SNOW WATER AT START OF YEAR	0.733	2659.559	1.56
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.200	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.02 4.27	2.80 4.06	3.39 4.03	3.84 3.00	3.71 3.67	3.76 3.55
STD. DEVIATIONS	1.13 1.77	0.99 1.98	1.11 2.14	1.24 1.74	2.33 1.10	1.33 1.21
RUNOFF						
TOTALS	1.477 0.111	1.879 0.255	1.907 0.176	0.170 0.081	0.107 0.091	0.081 0.335
STD. DEVIATIONS	1.502 0.160	1.330 0.340	1.536 0.318	0.467 0.150	0.206 0.093	0.191 0.634
EVAPOTRANSPIRATION						
TOTALS	0.617 3.951	0.557 3.527	1.280 2.552	3.818 1.480	3.654 1.227	4.479 0.774
STD. DEVIATIONS	0.175 1.459	0.215 1.654	0.521 0.803	0.366 0.228	1.184 0.183	1.240 0.194
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.4907 0.0008	0.1734 0.0299	1.6529 0.3554	1.1281 0.7297	0.3693 1.5596	0.1706 1.8408
STD. DEVIATIONS	0.7026 0.0011	0.4272 0.0806	0.7486 0.8621	1.0587 1.0101	0.6690 1.0201	0.4945 0.9329
PERCOLATION/LEAKAGE THROUGH LAYER 3						
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 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 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 11						

TOTALS	0.0011	0.0010	0.0010	0.0010	0.0010	0.0009
	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008
STD. DEVIATIONS	0.0015	0.0013	0.0013	0.0012	0.0011	0.0010
	0.0010	0.0009	0.0009	0.0008	0.0008	0.0008

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)						

DAILY AVERAGE HEAD ON TOP OF LAYER 3						

AVERAGES	0.0004	0.0002	0.0013	0.0010	0.0003	0.0001
	0.0000	0.0000	0.0003	0.0006	0.0013	0.0015
STD. DEVIATIONS	0.0006	0.0004	0.0006	0.0009	0.0005	0.0004
	0.0000	0.0001	0.0008	0.0008	0.0009	0.0008
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
DAILY AVERAGE HEAD ON TOP OF LAYER 9						

AVERAGES	0.0027	0.0027	0.0027	0.0027	0.0028	0.0028
	0.0028	0.0028	0.0028	0.0028	0.0028	0.0029
STD. DEVIATIONS	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014

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

	INCHES		CU. FEET		PERCENT	
	-----		-----		-----	
PRECIPITATION	43.10	(5.491)	156451.2		100.00	
RUNOFF	6.670	(3.0096)	24210.82		15.475	
EVAPOTRANSPIRATION	27.917	(3.3312)	101338.75		64.773	
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.50126	(2.45166)	30859.570		19.72473	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00020	(0.00006)	0.736		0.00047	
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)				
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00000	(0.00000)	0.002		0.00000	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00020	(0.00006)	0.734		0.00047	
AVERAGE HEAD ON TOP	0.000	(0.000)				

OF LAYER 7

PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.003 (0.001)		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.01090 (0.01250)	39.564	0.02529
CHANGE IN WATER STORAGE	0.001 (1.3297)	2.50	0.002

PEAK DAILY VALUES FOR YEARS	1 THROUGH	20
	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.500
RUNOFF	3.367	12221.5781
DRAINAGE COLLECTED FROM LAYER 2	0.75059	2724.64673
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000011	0.04174
AVERAGE HEAD ON TOP OF LAYER 3	0.019	
MAXIMUM HEAD ON TOP OF LAYER 3	0.030	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00028
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000011	0.04146
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	
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.005	
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000228	0.82630
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4486
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 20

LAYER	(INCHES)	(VOL/VOL)
1	9.2205	0.3842
2	0.0136	0.0469
3	0.0000	0.0000
4	2.9280	0.2440
5	455.5200	0.2920
6	0.5760	0.0320
7	0.0000	0.0000
8	0.0066	0.0285
9	0.0000	0.0000
10	0.1770	0.7500
11	1.3743	0.2290
SNOW WATER	0.000	

Scenario 10

(Waste Height = 190 feet + Cap; Filename: GL24N190)

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.	=	4.000000000000	CM/SEC
SLOPE	=	33.30	PERCENT
DRAINAGE LENGTH	=	150.0	FEET

LAYER 3

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2	- EXCELLENT

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 18

THICKNESS	=	2280.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

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	=	0.0320	VOL/VOL

EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 7

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 -	EXCELLENT

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0111	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.000000000000	CM/SEC

LAYER 9

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	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 -	EXCELLENT

LAYER 10

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	0.499999997000E-08	CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 24

THICKNESS = 6.00 INCHES
 POROSITY = 0.3650 VOL/VOL
 FIELD CAPACITY = 0.3050 VOL/VOL
 WILTING POINT = 0.2020 VOL/VOL
 INITIAL SOIL WATER CONTENT = 0.2641 VOL/VOL
 EFFECTIVE SAT. HYD. COND. = 0.270000010000E-05 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
 GOOD STAND OF GRASS, A SURFACE SLOPE OF 33.0%
 AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER = 84.90
 FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE = 1.000 ACRES
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 INITIAL WATER IN EVAPORATIVE ZONE = 7.823 INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE = 9.891 INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE = 4.410 INCHES
 INITIAL SNOW WATER = 0.000 INCHES
 INITIAL WATER IN LAYER MATERIALS = 680.034 INCHES
 TOTAL INITIAL WATER = 680.034 INCHES
 TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
 PITTSBURGH (LEB 2W) PENNSYLVANIA

STATION LATITUDE = 40.37 DEGREES
 MAXIMUM LEAF AREA INDEX = 3.50
 START OF GROWING SEASON (JULIAN DATE) = 114
 END OF GROWING SEASON (JULIAN DATE) = 288
 EVAPORATIVE ZONE DEPTH = 21.0 INCHES
 AVERAGE ANNUAL WIND SPEED = 9.20 MPH
 AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
 AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 63.00 %
 AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
 AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----

2.96	2.67	3.34	3.68	4.10	4.15
4.56	3.64	3.93	3.49	3.49	3.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
28.20	31.20	39.40	50.10	59.80	68.80
73.00	71.40	63.90	52.50	42.60	32.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PITTSBURGH PENNSYLVANIA
AND STATION LATITUDE = 40.37 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.87	166508.078	100.00
RUNOFF	3.611	13107.210	7.87
EVAPOTRANSPIRATION	30.476	110629.672	66.44
DRAINAGE COLLECTED FROM LAYER 2	11.7852	42780.418	25.69
PERC./LEAKAGE THROUGH LAYER 3	0.000281	1.019	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000280	1.016	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0005		
PERC./LEAKAGE THROUGH LAYER 11	0.051040	185.275	0.11
CHANGE IN WATER STORAGE	-0.054	-194.306	-0.12
SOIL WATER AT START OF YEAR	683.538	2481244.250	
SOIL WATER AT END OF YEAR	683.485	2481050.000	
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	-0.0001	-0.191	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.52	165237.547	100.00
RUNOFF	9.934	36061.312	21.82
EVAPOTRANSPIRATION	23.535	85431.469	51.70
DRAINAGE COLLECTED FROM LAYER 2	12.2332	44406.383	26.87
PERC./LEAKAGE THROUGH LAYER 3	0.000280	1.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0009		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.004	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000279	1.012	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0008		
PERC./LEAKAGE THROUGH LAYER 11	0.029064	105.504	0.06
CHANGE IN WATER STORAGE	-0.211	-767.032	-0.46
SOIL WATER AT START OF YEAR	683.485	2481050.000	
SOIL WATER AT END OF YEAR	683.274	2480283.000	
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	-0.094	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.36	157396.828	100.00
RUNOFF	10.575	38387.047	24.39
EVAPOTRANSPIRATION	26.258	95315.773	60.56
DRAINAGE COLLECTED FROM LAYER 2	5.9464	21585.455	13.71
PERC./LEAKAGE THROUGH LAYER 3	0.000141	0.512	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00

PERC./LEAKAGE THROUGH LAYER 7	0.000141	0.511	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0010		
PERC./LEAKAGE THROUGH LAYER 11	0.020235	73.451	0.05
CHANGE IN WATER STORAGE	0.561	2034.761	1.29
SOIL WATER AT START OF YEAR	683.274	2480283.000	
SOIL WATER AT END OF YEAR	683.637	2481600.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.198	716.936	0.46
ANNUAL WATER BUDGET BALANCE	0.0001	0.340	0.00

ANNUAL TOTALS FOR YEAR 4			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.01	163386.297	100.00
RUNOFF	6.976	25321.680	15.50
EVAPOTRANSPIRATION	29.270	106250.016	65.03
DRAINAGE COLLECTED FROM LAYER 2	8.4459	30658.773	18.76
PERC./LEAKAGE THROUGH LAYER 3	0.000201	0.731	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000201	0.728	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0013		
PERC./LEAKAGE THROUGH LAYER 11	0.015505	56.284	0.03
CHANGE IN WATER STORAGE	0.303	1099.732	0.67
SOIL WATER AT START OF YEAR	683.637	2481600.750	
SOIL WATER AT END OF YEAR	683.763	2482058.000	
SNOW WATER AT START OF YEAR	0.198	716.936	0.44
SNOW WATER AT END OF YEAR	0.375	1359.594	0.83
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.196	0.00

ANNUAL TOTALS FOR YEAR 5			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.875	100.00
RUNOFF	9.069	32920.285	20.01
EVAPOTRANSPIRATION	28.927	105004.758	63.81
DRAINAGE COLLECTED FROM LAYER 2	7.7160	28009.074	17.02
PERC./LEAKAGE THROUGH LAYER 3	0.000188	0.683	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000187	0.680	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0014		
PERC./LEAKAGE THROUGH LAYER 11	0.012482	45.310	0.03
CHANGE IN WATER STORAGE	-0.394	-1431.379	-0.87
SOIL WATER AT START OF YEAR	683.763	2482058.000	
SOIL WATER AT END OF YEAR	683.743	2481986.250	
SNOW WATER AT START OF YEAR	0.375	1359.594	0.83
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.165	0.00

ANNUAL TOTALS FOR YEAR 6			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.49	139718.734	100.00
RUNOFF	3.356	12181.501	8.72
EVAPOTRANSPIRATION	25.987	94332.969	67.52
DRAINAGE COLLECTED FROM LAYER 2	6.7476	24493.801	17.53
PERC./LEAKAGE THROUGH LAYER 3	0.000169	0.614	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		

DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000169	0.612	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0017		
PERC./LEAKAGE THROUGH LAYER 11	0.010449	37.930	0.03
CHANGE IN WATER STORAGE	2.389	8672.336	6.21
SOIL WATER AT START OF YEAR	683.743	2481986.250	
SOIL WATER AT END OF YEAR	683.735	2481959.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	2.397	8699.588	6.23
ANNUAL WATER BUDGET BALANCE	0.0001	0.197	0.00

ANNUAL TOTALS FOR YEAR 7			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	45.49	165128.703	100.00
RUNOFF	9.651	35033.492	21.22
EVAPOTRANSPIRATION	27.073	98273.406	59.51
DRAINAGE COLLECTED FROM LAYER 2	11.2174	40719.203	24.66
PERC./LEAKAGE THROUGH LAYER 3	0.000252	0.914	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000251	0.911	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0019		
PERC./LEAKAGE THROUGH LAYER 11	0.008974	32.575	0.02
CHANGE IN WATER STORAGE	-2.460	-8930.008	-5.41
SOIL WATER AT START OF YEAR	683.735	2481959.000	
SOIL WATER AT END OF YEAR	683.672	2481728.500	
SNOW WATER AT START OF YEAR	2.397	8699.588	5.27
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	0.036	0.00

ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	48.30	175329.000	100.00
RUNOFF	2.689	9759.428	5.57
EVAPOTRANSPIRATION	33.714	122380.633	69.80
DRAINAGE COLLECTED FROM LAYER 2	11.4280	41483.512	23.66
PERC./LEAKAGE THROUGH LAYER 3	0.000289	1.049	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000288	1.046	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0023		
PERC./LEAKAGE THROUGH LAYER 11	0.007876	28.590	0.02
CHANGE IN WATER STORAGE	0.462	1677.142	0.96
SOIL WATER AT START OF YEAR	683.672	2481728.500	
SOIL WATER AT END OF YEAR	683.666	2481706.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.468	1699.519	0.97
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.310	0.00

ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	44.40	161172.000	100.00
RUNOFF	6.682	24255.648	15.05
EVAPOTRANSPIRATION	28.369	102979.516	63.89
DRAINAGE COLLECTED FROM LAYER 2	9.9891	36260.488	22.50

PERC./LEAKAGE THROUGH LAYER 3	0.000217	0.788	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000216	0.785	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0025		
PERC./LEAKAGE THROUGH LAYER 11	0.006978	25.328	0.02
CHANGE IN WATER STORAGE	-0.647	-2349.246	-1.46
SOIL WATER AT START OF YEAR	683.666	2481706.000	
SOIL WATER AT END OF YEAR	682.983	2479229.250	
SNOW WATER AT START OF YEAR	0.468	1699.519	1.05
SNOW WATER AT END OF YEAR	0.503	1827.065	1.13
ANNUAL WATER BUDGET BALANCE	0.0001	0.266	0.00

ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	36.62	132930.625	100.00
RUNOFF	3.444	12499.953	9.40
EVAPOTRANSPIRATION	26.092	94713.773	71.25
DRAINAGE COLLECTED FROM LAYER 2	5.7145	20743.635	15.60
PERC./LEAKAGE THROUGH LAYER 3	0.000139	0.505	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000139	0.503	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0028		
PERC./LEAKAGE THROUGH LAYER 11	0.006274	22.773	0.02
CHANGE IN WATER STORAGE	1.364	4950.649	3.72
SOIL WATER AT START OF YEAR	682.983	2479229.250	
SOIL WATER AT END OF YEAR	683.165	2479890.000	

SNOW WATER AT START OF YEAR	0.503	1827.065	1.37
SNOW WATER AT END OF YEAR	1.685	6117.030	4.60
ANNUAL WATER BUDGET BALANCE	0.0000	-0.157	0.00

ANNUAL TOTALS FOR YEAR 11			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	40.15	145744.484	100.00
RUNOFF	7.768	28197.131	19.35
EVAPOTRANSPIRATION	23.978	87038.430	59.72
DRAINAGE COLLECTED FROM LAYER 2	9.2187	33463.832	22.96
PERC./LEAKAGE THROUGH LAYER 3	0.000221	0.804	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000221	0.801	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0029		
PERC./LEAKAGE THROUGH LAYER 11	0.005695	20.674	0.01
CHANGE IN WATER STORAGE	-0.820	-2975.790	-2.04
SOIL WATER AT START OF YEAR	683.165	2479890.000	
SOIL WATER AT END OF YEAR	683.056	2479494.500	
SNOW WATER AT START OF YEAR	1.685	6117.030	4.20
SNOW WATER AT END OF YEAR	0.974	3536.720	2.43
ANNUAL WATER BUDGET BALANCE	0.0001	0.198	0.00

ANNUAL TOTALS FOR YEAR 12			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141206.984	100.00
RUNOFF	6.453	23425.703	16.59
EVAPOTRANSPIRATION	26.039	94522.586	66.94

DRAINAGE COLLECTED FROM LAYER 2	7.8696	28566.566	20.23
PERC./LEAKAGE THROUGH LAYER 3	0.000193	0.700	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000192	0.698	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0032		
PERC./LEAKAGE THROUGH LAYER 11	0.005226	18.971	0.01
CHANGE IN WATER STORAGE	-1.467	-5326.905	-3.77
SOIL WATER AT START OF YEAR	683.056	2479494.500	
SOIL WATER AT END OF YEAR	682.563	2477704.250	
SNOW WATER AT START OF YEAR	0.974	3536.720	2.50
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.056	0.00

ANNUAL TOTALS FOR YEAR 13			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	34.95	126868.500	100.00
RUNOFF	3.259	11831.491	9.33
EVAPOTRANSPIRATION	25.957	94223.539	74.27
DRAINAGE COLLECTED FROM LAYER 2	4.1698	15136.356	11.93
PERC./LEAKAGE THROUGH LAYER 3	0.000112	0.405	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000111	0.404	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0034		
PERC./LEAKAGE THROUGH LAYER 11	0.004802	17.432	0.01
CHANGE IN WATER STORAGE	1.559	5659.689	4.46
SOIL WATER AT START OF YEAR	682.563	2477704.250	

SOIL WATER AT END OF YEAR	684.122	2483364.000	
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	-0.005	0.00

ANNUAL TOTALS FOR YEAR 14			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.82	126396.602	100.00
RUNOFF	3.799	13790.444	10.91
EVAPOTRANSPIRATION	27.178	98655.234	78.05
DRAINAGE COLLECTED FROM LAYER 2	5.1552	18713.426	14.81
PERC./LEAKAGE THROUGH LAYER 3	0.000133	0.485	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000133	0.483	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0035		
PERC./LEAKAGE THROUGH LAYER 11	0.004451	16.157	0.01
CHANGE IN WATER STORAGE	-1.316	-4778.555	-3.78
SOIL WATER AT START OF YEAR	684.122	2483364.000	
SOIL WATER AT END OF YEAR	682.806	2478585.500	
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	-0.107	0.00

ANNUAL TOTALS FOR YEAR 15			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	52.41	190248.281	100.00

RUNOFF	9.419	34191.641	17.97
EVAPOTRANSPIRATION	32.726	118796.852	62.44
DRAINAGE COLLECTED FROM LAYER 2	10.0740	36568.484	19.22
PERC./LEAKAGE THROUGH LAYER 3	0.000236	0.855	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000235	0.852	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0037		
PERC./LEAKAGE THROUGH LAYER 11	0.004146	15.052	0.01
CHANGE IN WATER STORAGE	0.186	676.194	0.36
SOIL WATER AT START OF YEAR	682.806	2478585.500	
SOIL WATER AT END OF YEAR	682.992	2479261.750	
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	0.056	0.00

ANNUAL TOTALS FOR YEAR 16			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	32.14	116668.227	100.00
RUNOFF	2.475	8982.973	7.70
EVAPOTRANSPIRATION	20.753	75333.789	64.57
DRAINAGE COLLECTED FROM LAYER 2	6.8659	24923.062	21.36
PERC./LEAKAGE THROUGH LAYER 3	0.000152	0.553	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000152	0.551	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0039		
PERC./LEAKAGE THROUGH LAYER 11	0.003890	14.122	0.01

CHANGE IN WATER STORAGE	2.043	7414.516	6.36
SOIL WATER AT START OF YEAR	682.992	2479261.750	
SOIL WATER AT END OF YEAR	683.709	2481863.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.326	4812.322	4.12
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.242	0.00

ANNUAL TOTALS FOR YEAR 17			
	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.12	178305.609	100.00
RUNOFF	7.994	29017.947	16.27
EVAPOTRANSPIRATION	30.789	111762.805	62.68
DRAINAGE COLLECTED FROM LAYER 2	12.3903	44976.785	25.22
PERC./LEAKAGE THROUGH LAYER 3	0.000299	1.085	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000298	1.082	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0042		
PERC./LEAKAGE THROUGH LAYER 11	0.003644	13.228	0.01
CHANGE IN WATER STORAGE	-2.057	-7465.311	-4.19
SOIL WATER AT START OF YEAR	683.709	2481863.750	
SOIL WATER AT END OF YEAR	682.526	2477569.750	
SNOW WATER AT START OF YEAR	1.326	4812.322	2.70
SNOW WATER AT END OF YEAR	0.452	1641.020	0.92
ANNUAL WATER BUDGET BALANCE	0.0000	0.149	0.00

ANNUAL TOTALS FOR YEAR 18			
	INCHES	CU. FEET	PERCENT

PRECIPITATION	48.15	174784.562	100.00
RUNOFF	8.275	30037.924	17.19
EVAPOTRANSPIRATION	32.102	116531.789	66.67
DRAINAGE COLLECTED FROM LAYER 2	7.8623	28540.326	16.33
PERC./LEAKAGE THROUGH LAYER 3	0.000194	0.703	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000193	0.701	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0045		
PERC./LEAKAGE THROUGH LAYER 11	0.003435	12.470	0.01
CHANGE IN WATER STORAGE	-0.093	-337.818	-0.19
SOIL WATER AT START OF YEAR	682.526	2477569.750	
SOIL WATER AT END OF YEAR	682.885	2478873.000	
SNOW WATER AT START OF YEAR	0.452	1641.020	0.94
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.131	0.00

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	46.11	167379.297	100.00
RUNOFF	5.552	20153.652	12.04
EVAPOTRANSPIRATION	31.665	114942.461	68.67
DRAINAGE COLLECTED FROM LAYER 2	7.3140	26549.967	15.86
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.651	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0048		

PERC./LEAKAGE THROUGH LAYER 11	0.003248	11.792	0.01
CHANGE IN WATER STORAGE	1.576	5721.263	3.42
SOIL WATER AT START OF YEAR	682.885	2478873.000	
SOIL WATER AT END OF YEAR	683.729	2481934.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.733	2659.559	1.59
ANNUAL WATER BUDGET BALANCE	0.0000	0.167	0.00

ANNUAL TOTALS FOR YEAR 20			
	INCHES	CU. FEET	PERCENT
	-----	-----	-----
PRECIPITATION	46.85	170065.469	100.00
RUNOFF	12.413	45059.895	26.50
EVAPOTRANSPIRATION	27.453	99655.281	58.60
DRAINAGE COLLECTED FROM LAYER 2	7.8820	28611.832	16.82
PERC./LEAKAGE THROUGH LAYER 3	0.000179	0.649	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000178	0.647	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0049		
PERC./LEAKAGE THROUGH LAYER 11	0.003088	11.211	0.01
CHANGE IN WATER STORAGE	-0.902	-3272.830	-1.92
SOIL WATER AT START OF YEAR	683.729	2481934.750	
SOIL WATER AT END OF YEAR	683.560	2481321.500	
SNOW WATER AT START OF YEAR	0.733	2659.559	1.56
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.079	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20						
	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION						

TOTALS	3.02 4.27	2.80 4.06	3.39 4.03	3.84 3.00	3.71 3.67	3.76 3.55
STD. DEVIATIONS	1.13 1.77	0.99 1.98	1.11 2.14	1.24 1.74	2.33 1.10	1.33 1.21
RUNOFF						

TOTALS	1.477 0.111	1.879 0.255	1.907 0.176	0.170 0.081	0.107 0.091	0.081 0.335
STD. DEVIATIONS	1.502 0.160	1.330 0.340	1.536 0.318	0.467 0.150	0.206 0.093	0.191 0.634
EVAPOTRANSPIRATION						

TOTALS	0.617 3.951	0.557 3.527	1.280 2.552	3.818 1.480	3.654 1.227	4.479 0.774
STD. DEVIATIONS	0.175 1.459	0.215 1.654	0.521 0.803	0.366 0.228	1.184 0.183	1.240 0.194
LATERAL DRAINAGE COLLECTED FROM LAYER 2						

TOTALS	0.4907 0.0008	0.1734 0.0299	1.6529 0.3554	1.1281 0.7297	0.3693 1.5596	0.1706 1.8408
STD. DEVIATIONS	0.7026 0.0011	0.4272 0.0806	0.7486 0.8621	1.0587 1.0101	0.6690 1.0201	0.4945 0.9329
PERCOLATION/LEAKAGE THROUGH LAYER 3						

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 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 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

	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11						

TOTALS	0.0011	0.0009	0.0010	0.0009	0.0009	0.0009
	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008
STD. DEVIATIONS	0.0014	0.0011	0.0012	0.0011	0.0010	0.0009
	0.0009	0.0009	0.0008	0.0008	0.0007	0.0007

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)						

DAILY AVERAGE HEAD ON TOP OF LAYER 3						

AVERAGES	0.0004	0.0002	0.0013	0.0010	0.0003	0.0001
	0.0000	0.0000	0.0003	0.0006	0.0013	0.0015
STD. DEVIATIONS	0.0006	0.0004	0.0006	0.0009	0.0005	0.0004
	0.0000	0.0001	0.0008	0.0008	0.0009	0.0008
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
DAILY AVERAGE HEAD ON TOP OF LAYER 9						

AVERAGES	0.0027	0.0027	0.0027	0.0027	0.0028	0.0028
	0.0028	0.0028	0.0028	0.0028	0.0028	0.0029
STD. DEVIATIONS	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014

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

	INCHES		CU. FEET		PERCENT	
	-----		-----		-----	
PRECIPITATION	43.10	(5.491)	156451.2		100.00	
RUNOFF	6.670	(3.0096)	24210.82		15.475	
EVAPOTRANSPIRATION	27.917	(3.3312)	101338.75		64.773	
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.50126	(2.45166)	30859.570		19.72473	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00020	(0.00006)	0.736		0.00047	
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)				
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00000	(0.00000)	0.002		0.00000	
PERCOLATION/LEAKAGE THROUGH	0.00020	(0.00006)	0.734		0.00047	

LAYER 7

AVERAGE HEAD ON TOP OF LAYER 7	0.000 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.003 (0.001)		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.01053 (0.01161)	38.206	0.02442
CHANGE IN WATER STORAGE	0.001 (1.3297)	3.86	0.002

PEAK DAILY VALUES FOR YEARS	1 THROUGH	20
	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.500
RUNOFF	3.367	12221.5781
DRAINAGE COLLECTED FROM LAYER 2	0.75059	2724.64673
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000011	0.04174
AVERAGE HEAD ON TOP OF LAYER 3	0.019	
MAXIMUM HEAD ON TOP OF LAYER 3	0.030	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00028
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000011	0.04146
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	
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.005	
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000204	0.74212
SNOW WATER	3.80	13787.5352
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4486
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

FINAL WATER STORAGE AT END OF YEAR 20		
LAYER	(INCHES)	(VOL/VOL)
1	9.2205	0.3842
2	0.0136	0.0469
3	0.0000	0.0000
4	2.9280	0.2440
5	665.7601	0.2920
6	0.5760	0.0320
7	0.0000	0.0000
8	0.0066	0.0285
9	0.0000	0.0000
10	0.1770	0.7500
11	1.3740	0.2290
SNOW WATER	0.000	

FORM 25 – ATTACHMENT B

Calculations

SCS ENGINEERS

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Leachate Pipe Perforation Calculations	By SRS	Date 2/22/2018
Sheet 1 of 1	Checked MRG	Date 2/27/2018

PURPOSE: CALCULATE THE AMOUNT OF FLOW ALLOWED BY A 5/8" DIA. PERFORATIONS ON HDPE LEACHATE PIPES USING THE ORIFICE EQUATION.

GIVEN:

- FOR CONFIGURATION, USE HDPE PIPE PERFORATION LAYOUT AND LEACHATE PIPE INFORMATION AS NOTED BELOW.

INSIDE DIAMETER OF PIPE =	5.349 INCHES
PIPE WALL THICKNESS =	0.602 INCHES
DISTANCE FROM LINER TO PIPE BOTTOM, DI =	0 INCHES
DIAMETER OF PERFORATION =	0.625 INCHES
MAX LENGTH OF LEACHATE FLOW TO PIPE (PER 10' HELP MODEL) =	200 FT
2. GRAVITY, G =	32.2 FT/SEC^2
3. PEAK LEACHATE PRODUCTION (HELP OUTPUT), Q _{leach} =	2,977 GAL/DAY/ACRE
4. NUMBER OF PERFORATIONS (ORIFICES) PER 1-FT OF PIPE =	10 PERFORATIONS

ASSUMPTIONS:

- MAX HEIGHT OF LEACHATE IN COLLECTION TRENCH, HI = 1.195 INCHES
- ORIFICE COEFFICIENT, Cd = 0.82 UNITLESS
- ONLY USING PERFORATIONS AT BOTTOM OF PIPE.

CALCULATIONS:

1. ESTIMATE HEAD ON PERFORATION (ORIFICE)	
RADIUS OF PIPE, R =	3.277 INCHES
HEIGHT OF LEACHATE OVER ORIFICE, HEAD =	0.235 INCHES
HEAD = HI-DI-(R-R*COS(45)) =	0.020 FT
2. ESTIMATE FLOW THROUGH AN ORIFICE	
ORIFICE AREA, A =	0.00213 FT^2
FLOW, Q = Cd*A* SQRT(2*G*HEAD)	0.0020 FT^3/SEC
Q (per orifice) =	0.88 GAL/MIN
3. ESTIMATE PEAK LEACHATE FLOW TO A LATERAL (flow from landfill cell)	
AREA FLOWING TO A 1-FT SECTION OF PIPE =	200 SF
	0.0046 AC
Q _{max} = Q _{leach} *AC =	0.01 GAL/MIN
4. ESTIMATE FLOW CAPACITY OF LATERAL (flow through perforations)	
Q _{cap} = # PERFORATIONS*1*Q =	8.81 GAL/MIN

CONCLUSIONS:

THE FLOW CAPACITY OF THE PIPE IS GREATER THAN THE MAXIMUM FLOW TO THE LEACHATE LATERAL PER LINEAR FOOT OF PIPE:

8.81 IS GREATER THAN 0.01 THEREFORE THE PERFORATION DESIGN IS ADEQUATE.

SCS ENGINEERS

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Leachate Pipe Sizing Calculations	By SRS	Date 2/22/2018
Sheet 1 of 1	Checked MRG	Date 2/27/2018

PURPOSE: ESTABLISH PIPE SIZE FOR LEACHATE PIPES IN PHASES 8-13.

GIVEN:

1. SDR 11, HDPE PIPES USED

NOMINAL SIZE:	4	6	8	10
INTERNAL DIA (IN):	3.633	5.349	6.963	8.679
N FACTOR:	0.011	0.011	0.011	0.011
AREA (FT ²):	0.072	0.156	0.264	0.411
WET PERIMETER (FT):	0.951	1.400	1.823	2.272
HYD. RADIUS :	0.076	0.111	0.145	0.181

2. USE MANNING'S EQUATION FOR GRAVITY FLOW.

$$Q = 1.49/N * A * R^{(2/3)} * S^{(1/2)}$$

3. USE PEAK DAILY LEACHATE FLOW FROM HELP MODEL RUNS.

FLOW RATE BASED ON MAXIMUM PEAK DAILY FLOW OF 398 CF/DAY/ACRE

ASSUMPTIONS:

1. PIPES ARE FLOWING FULL.

2. USE WORST CASE PIPE SLOPE AND LARGEST DRAINAGE AREA TO LATERAL.

MINIMUM PIPE SLOPE = 2 PERCENT

MAXIMUM LATERAL DRAINAGE AREA = 46.69 ACRES

MAXIMUM HEADER DRAINAGE AREA = 46.69 ACRES

CALCULATIONS:

PIPE SIZE	MAX DRAINAGE AREA (AC)	PEAK FLOW RATE (CF/DAY/AC)	MIN PIPE SLOPE (FT/FT)	MAX FLOW* (CFS)	ALLOWABLE FLOW (CFS)	CAN PIPE HANDLE MAX FLOW?	COMMENTS
4	46.69	398	0.02	0.215	0.247	NO	TOO SMALL, NOT IDEAL FOR CLEANING
6	46.69	398	0.02	0.215	0.692	YES	USE FOR LATERALS
8	46.69	398	0.02	0.215	1.399	YES	USE FOR HEADER/LATERALS
10	46.69	398	0.02	0.215	2.516	YES	LARGER THAN NECESSARY

*max flow based on peak flow and max drainage area

CONCLUSION:

6" HDPE PIPE CAN HANDLE MAXIMUM ANTICIPATED FLOW UP TO 23 ACRES OF DRAINAGE AND IS ADEQUATELY SIZED FOR CLEANING.

6" HDPE PIPE MAY BE USED FOR LATERALS IN LEACHATE COLLECTION SYSTEM. OTHERWISE, USE 8" PIPE.

SCS ENGINEERS

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Stone Filter/Pipe Clogging	By SRS	Date 2/22/2018
Sheet 1 of 1	Checked MRG	Date 2/27/2018

PURPOSE: Check for potential of stone filter material clogging the pipe perforations

GIVEN:

1. Stone Filter material is AASHTO No. 57 or No. 3, sizing information

No. 57 D85 = 0.87 inches

No. 3 D85 = 1.5 inches

2. Leachate pipe perforation size = 0.625 inches

ASSUMPTIONS:

1. Stone clogging of perforations unlikely if D85 / hole diameter > 1

CALCULATIONS:

For No. 57 stone:

D85/hole dia. = 1.4

For No. 3 stone:

D85/hole dia. = 2.4

CONCLUSIONS:

The stone filter material designated for use (AASHTO No. 57 and No. 3) will not clog leachate pipes with the given perforation size.

SCS ENGINEERS

Sheet

1

of

1

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Pipe Strength - Loading on Pipes	By SRS	Date 2/22/2018
	Checked MRG	Date 2/27/2018

Purpose:

Estimate the max load on the leachate pipe in the expansion area.

Given:

- Proposed pipes are perforated and solid wall SDR-11 HDPE, 6" and 8" diameters.
- Pipe perforation information (per perforation design):

Pipe perforation diameter =	0.625	inches
Number of perforations at spacing =	4	holes
Perforation spacing =	6	inches
Number of perforations per foot =	8	holes/foot
Approx. inches of opening per foot of pipe length =	5	inches/foot

Assumptions:

- The prism load method was used for the pipe. This is conservative for a flexible pipe application.
- Landfill at final grade with cap installed.
- Stresses due to depth of waste, final cover (cap), and leachate collection drainage material. Material thickness and density provided in calculations.

Calculations:

Pressure on pipe:

Pressure due to weight of cap, waste, and drainage material, where

Max. prism load, $q = g \cdot h$

Layer thickness/height:

Cap material (topsoil through intermediate cover), $h_c =$

Waste, $h_w =$

Drainage material (top of cushion layer to pipe in trench), $h_l =$

3	ft
196	ft
2	ft

Layer density:

Cap material, $g_c =$

Waste, $g_w =$

Drainage material, $g_l =$

120	pcf
56	pcf
125	pcf

$$q_{\text{total}} = (h_c \cdot g_c) + (h_w \cdot g_w) + (h_l \cdot g_l) =$$

11586	psf

Adjust pressure on pipe to account for perforations:

Corrected Max Pressure, $P_t' = P_t$ (12/12-openings),
per USEPA Lining of Waste Impoundment Disposal Facilities, 1983

P_t' , maximum corrected pressure on leachate pipe =

19861.7	psf

Conclusions:

For strength calculations use P_t' of: 19861.7 psf

SCS ENGINEERS

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Leachate Sump Pump Calculations	By SRS	Date 2/22/2018
	Checked	Date

Purpose: Estimate pipe and pump requirements for Sump 1 in Cell 8.

Given:

1. Drainage area to Sump 1, DA1 = 16.92 acres
2. Max leachate production, Qp = 2,977 gpd/acre
3. Sump/force main information based on permit plans:

Point 1 (sump pump):

Pump Elevation= 477 ft elevation &
 Pressure @ 1= 0 psi
 Velocity @ 2= 0 fps

Point 2 (Pump House):

Discharge Elevation= 484 ft elevation &
 Pressure @ 2= 0.00 psi*
 Desired Velocity @ 2= 1.00 fps**

Pipe (Sump to Pump House):

Pipe size (ID)= 3.633 inches\$ 0.30 ft
 Pipe roughness= 0.0002 ft\$\$
 Pipe friction factor= 0.0178 see #
 Pipe length= 88.23 ft

Assumptions:

1. Portion of drainage area to sump, Sp = 100%
 (remainder of area to rain cover and discharged as stormwater)
2. Notes on pipe information above:
 - & Used elevations of bottom of sump and highest line elevation
 - * Pressure @ 2, none as leachate is discharged to open air within sanitary manhole.
 - ** Velocity @ 2 dependent on pipe sizing approximate as 1 fps for exit velocity
 - \$ using 4-in, SDR 11 HDPE pipe from sump
 - \$\$ assume steel pipe design value for roughness
 - \$\$\$ using 6-in, SDR 17 HDPE pipe for force main
 - # assume turbulent flow for Karman-Nikuradse equation
3. To account flow from other sumps, assume twice the flow rate in the force main pipe.
4. gravity= 32.20 ft/s²
5. leachate density= 62.30 lb/cf
6. leachate flow rate is greater than that calculated in HELP Model.

SCS ENGINEERS

Client GLRA	Project Heilmandale Expansion	Job No. 02215800.05
Subject Leachate Sump Pump Calculations	By SRS	Date 2/22/2018
	Checked	Date

Calculations:

1. Estimate max pumping rate for sump:

DA1*Sp*Qp= Pumping rate, Pr = 34.98 gpm = 0.08 cfs

2. Estimate losses due to piping friction:

pipe loss = friction factor*(length/diameter)*(velocity head)

Where velocity head = (velocity^2)/(gravity*2)

Velocity in sump pipe= 0.08 cfs gives 1.1 fps

Loss in sump pipe = 0.09 ft

Total pipe loss = 0.09 ft

3. Estimate minor losses:

Assume conservatively that minor losses will be 20% of pipe loss.

Total minor losses= 0.02 ft

4. Estimate pressure head @ 2:

pressure head = pressure*144/density

Pressure head= 0 ft

5. Estimate pump head required:

pump head = elevation @2 - elevation@1 + pipe and minor losses+pressure head@2

Pump head= 7.11 ft

6. Check pressure in pipes

pipe pressure= pump head*density

pipe pressure= 3.1 psi

SDR 17 pipe rated for 100 psi

Conclusions:

Provide a pump (or pumps) to handle at a minimum:

7.1 Head (ft) with 35.0 Flow (gpm)

SDR17 pipe is adequate for the pressures anticipated.

Environmental Consultants & Contractors
 319 Chapanoke Road, Suite 114D
 Raleigh, NC 27603
 Phone 919 662-3015 Fax 919 662-3017
 www.scsengineers.com

JOB NO. 02215800.05 T2 Greater Lebanon Refuse Authority LF Phase 2 Expansion
 SHEET NO. 1 OF 2
 CALCULATED BY HJL DATE 12/26/2017
 CHECKED BY _____ DATE _____
 SCALE _____

A. LEACHATE LEAK DETECTION ZONE/LAYER AT MAX. WASTE HEIGHT

- 1) ESTIMATED DESIGN LOAD ON LF FOUNDATION = 190' x 65 PCF = 12,350 PSF (USE 15,000 PSF)
- 2) ULTIMATE TRANSMISSIVITY, $T_{ult} = 1.0 \times 10^{-3} \text{ m}^2/\text{sec} = 10 \text{ cm}^2/\text{sec}$ (GSE PermaNet HL product cut sheet, $i=0.1$)
- 3) SELECT TYPICAL REDUCTION FACTOR: $RF_{IN} = 1.0$ (GDN between GMs OR steel plates setup)
- 4) USING TABLE 4.4, SELECT TYPICAL AVE REDUCTION FACTOR FOR CC: $RF_{CC} = 1.5$
- 5) USING TABLE 4.4, SELECT TYPICAL AVE REDUCTION FACTOR FOR BC: $RF_{BC} = 1.3$
- 6) ASSUME TYPICAL REDUCTION FACTOR FOR CR: $RF_{CR} = 1.2$ (GSE PermaNet HL product cut sheet)

$$T_{ALLOW} = \frac{T_{ULT}}{RF_{IN} \times RF_{CC} \times RF_{BC} \times RF_{CR}} = \frac{1.0 \times 10^{-3} \text{ m}^2/\text{s}}{(1.0)(1.5)(1.3)(1.2)} = 4.3 \times 10^{-4} \text{ m}^2/\text{s}$$

$$= 4.3 \text{ cm}^2/\text{sec}$$

- 7) USE FACTOR OF SAFETY = 2.0 (TYPICAL INDUSTRY STANDARD)

$$T_{DESIGN} = \frac{T_{ALLOW}}{FS} = \frac{4.3 \times 10^{-4} \text{ m}^2/\text{s}}{2.0} = 2.1 \times 10^{-4} \text{ m}^2/\text{s} = 2.1 \text{ cm}^2/\text{sec}$$

- 8) ULTIMATE THICKNESS = 270 mils (GSE PermaNet HL product cut sheet)

DESIGN THICKNESS RETAINED @ 90% = 243 mils = 0.617 cm (Fig B-5 @ 100 hrs.)

$$K_{DESIGN} = \frac{T_{DESIGN}}{\text{THICKNESS}} = \frac{2.1 \text{ cm}^2/\text{s}}{0.617 \text{ cm}} = 3.4 \quad \text{[Value used in HELP Model = 3 cm/sec]}$$

OK

FOR PURPOSES OF SPECIFYING GEOCOMPOSITE TRANSMISSIVITY, ESTABLISH BOUNDARY CONDITIONS WITH DEFORMABLE SUPERSTRATUM (GRAVEL) ABOVE FML & UNDER 15,000 PSF, SEATING PERIOD = 100 HRS AND A GRADIENT = 0.1

SINCE LAB CONDITIONS ACCOUNT FOR INTRUSION, BUT NOT FOR CLOGGING OR CREEP:

$$T_{LAB} = T_{DESIGN} \times FS \times RF_{CC} \times RF_{BC} \times RF_{CR}$$

$$= T_{ULT} = 1.0 \times 10^{-3} \text{ m}^2/\text{s} \quad \& \quad 270 \text{ mil thickness} \quad \text{[Value used in Specs]}$$

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JOB NO. 02215800.05 T2 Greater Lebanon Refuse Authority LF Phase 2 Expansion
SHEET NO. 2 OF 2
CALCULATED BY HJL DATE 12/26/2017
CHECKED BY DATE
SCALE

B. LANDFILL CAP DRAINAGE LAYER

- 1) ESTIMATED DESIGN LOAD ON LF FOUNDATION = 5' x 120 PCF = 600 PSF (USE 1,000 PSF)
- 2) ULTIMATE TRANSMISSIVITY = $T_{ULT} = 1.4 \times 10^{-3} \text{ m}^2/\text{sec}$ (at 1000psf, i=0.33, 300mil FabriNet, Fig. A-9)
- 3) SELECT TYPICAL REDUCTION FACTOR: $RF_{IN} = 1.0$ (included in the soil/GDN test setup)
- 4) USING TABLE 4.4, SELECT TYPICAL AVE REDUCTION FACTOR FOR CC: $RF_{CC} = 1.2$
- 5) USING TABLE 4.4, SELECT TYPICAL AVE REDUCTION FACTOR FOR BC: $RF_{BC} = 2.0$
- 6) ASSUME TYPICAL REDUCTION FACTOR: $RF_{CR} = 1.00$ (Table B-3, at 1000psf)

$$T_{ALLOW} = \frac{T_{ULT}}{RF_{IN} \times RF_{CC} \times RF_{BC} \times RF_{CR}} = \frac{1.4 \times 10^{-3} \text{ m}^2/\text{s}}{(1.0)(1.2)(2.0)(1.0)} = 5.8 \times 10^{-4} \text{ m}^2/\text{s} \\ = 5.8 \text{ cm}^2/\text{sec}$$

- 7) USE FACTOR OF SAFETY = 2.0 (TYPICAL INDUSTRY STANDARD)

$$T_{DESIGN} = \frac{T_{ALLOW}}{FS} = \frac{5.8 \times 10^{-4} \text{ m}^2/\text{s}}{2.0} = 2.9 \times 10^{-4} \text{ m}^2/\text{s} = 2.9 \text{ cm}^2/\text{sec}$$

- 8) ULTIMATE THICKNESS = 300 mils (GSE FabriNet 300 mil product cut sheet)

DESIGN THICKNESS RETAINED @ 98.5% = 296 mils = 0.751 cm (Fig B-3 @ 100 hrs.)

$$K_{DESIGN} = \frac{T_{DESIGN}}{\text{THICKNESS}} = \frac{2.9 \text{ cm}^2/\text{s}}{0.751 \text{ cm}} = 3.9 \text{ cm/sec} \quad [\text{Value used in HELP Model} = 4 \text{ cm/sec}] \\ \text{OK}$$

FOR PURPOSES OF SPECIFYING GEOCOMPOSITE TRANSMISSIVITY, ESTABLISH BOUNDARY CONDITIONS WITH DEFORMABLE SUPERSTRATUM (SOIL) ABOVE GDN/FML & UNDER 1,000 PSF, SEATING PERIOD = 100 HRS AND A GRADIENT = 0.33

SINCE LAB CONDITIONS ACCOUNT FOR INTRUSION, BUT NOT FOR CLOGGING OR CREEP:

$$T_{LAB} = T_{DESIGN} \times FS \times RF_{CC} \times RF_{BC} \times RF_{CR} \\ = T_{ULT} = 1.4 \times 10^{-3} \text{ m}^2/\text{s} \quad \& \quad 300 \text{ mil thickness} \quad [\text{Value used in Specs}]$$



The GSE Drainage Design Manual

Second Edition

Robert Bachus • Dhani Narejo • Richard Thiel • Te-Yang Soong • Mengjia Li

GSE **BioDrain** System
Revolutionary Landfill Drainage Solution

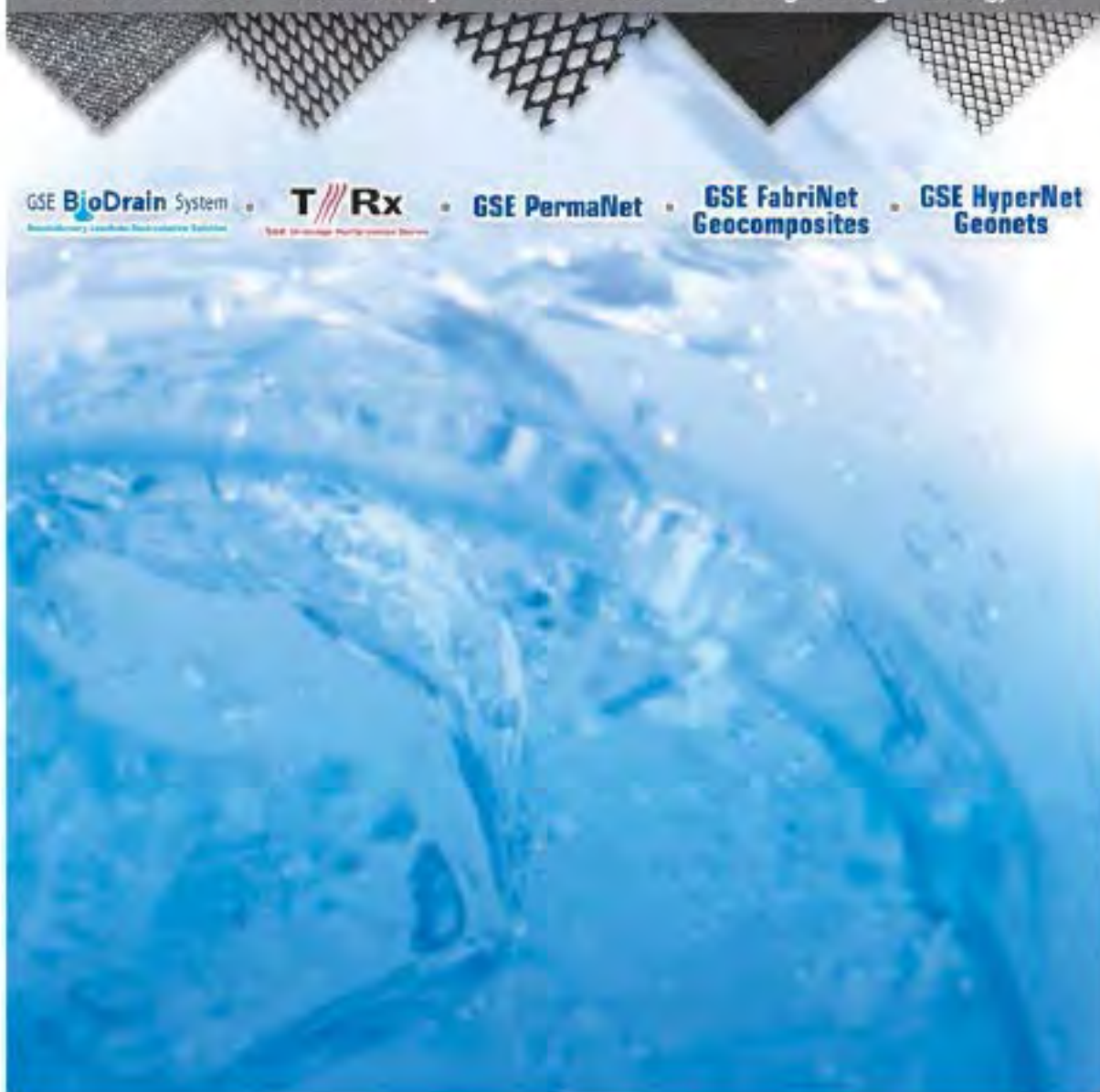
T//Rx

GSE Landfill Perforated Drain

GSE **PermaNet**

GSE **FabriNet**
Geocomposites

GSE **HyperNet**
Geonets



factors for each component. The magnitude of each reduction factor (which should be equal to or greater than 1) should reflect a correction that provides a best estimate of the anticipated reduction. It should not be inflated to a larger value to account for uncertainty, since this has already been accounted for in the factor of safety (FS_D). The allowable transmissivity is shown in Equation 4.24 below (see also GRI procedure GC8):

$$\theta_{allow} = \theta_{req} \cdot FS_D \cdot RF_{CR} \cdot RF_{CC} \cdot RF_{BC} \quad (4.24)$$

where:

θ_{allow} = allowable transmissivity of geocomposites or geonet (m^2/sec),

FS_D = overall factor of safety for drainage (dimensionless),

RF_{CR} = reduction factor for long-term creep (dimensionless),

RF_{CC} = reduction factor for chemical clogging (dimensionless),

RF_{BC} = reduction factor for biological clogging (dimensionless).

The allowable transmissivity (θ_{allow}) in Equation 4.24 should be compared with the 100-hour transmissivity value obtained from a test. The specified 100-hour transmissivity value should be equal to or higher than the allowable value of transmissivity. Typical 100-hour transmissivity data for some products is presented in Appendix A. The designer should contact manufacturers for the most up-to-date information on their products.

In addition to the reduction factors in Equation 4.24, a review of the chemical compatibility of the resin used in the geonet to the fluid that the geonet will be exposed to, should be performed. Most geonets are made of HDPE, which is very resistant in most environments where they are used; therefore, this is seldom an issue. Ultimately, the engineer's review should result in a "go no-go" determination, in which the designer decides that the material is acceptable for use or not. If it is deemed acceptable, no reduction in the required transmissivity is applied due to the chemical degradation associated with chemical compatibility issues.

The allowable transmissivity discussed here should not be confused with the index transmissivity used for purposes of quality control or conformance testing. The latter is typically performed between steel plates for 15 minutes at a pressure of 10,000 or 15,000 psf and is completely unsuitable for the purpose of design. Project specifications can include both performance and index transmissivity requirements, provided that a clear distinction is made between them.

4.3.1 Drainage Factor of Safety, FS_D

The overall drainage factor of safety should be applied to take into account possible uncertainties in the selection and determination of the design parameters. When selecting an appropriate factor of safety for drainage, the designer should evaluate the criticality of the project, considering such factors as: (i) the cost of repair; (ii) the potential for loss of life; (iii) the certainty of the design parameters; and (iv) the probability of failure. Recommended values of FS_D are typically between 2.0 to 3.0 [Giroud, et al., 2000a], with a larger value resulting in a larger required geocomposite transmissivity, and therefore, higher cost. The authors of this design manual believe that lower-end values (i.e., 2.0) are acceptable for most projects, since the performance

of geosynthetic materials is fairly well established. Narejo & Richardson [2002] propose a value of 2.0 as an overall factor of safety for drainage.

4.3.2 Chemical Clogging Reduction Factor, RF_{CC}

The chemical clogging reduction factor is intended to account for the clogging of the geocomposite due to precipitates deposited from high alkalinity soils (typically calcium and magnesium). The designer should evaluate the soils and waste he/she anticipates being placed on the drainage system. GRI-GC8 recommends using values in the range of 1.0 to 1.2 for chemical clogging in the final cover system (see Table 4.4). If the designer finds that high alkalinity soils or other precipitants are not present, use of the lower value (i.e., 1.0) should be acceptable.

The authors believe that the risk for chemical clogging in the landfill gas collection layer should be similar to that in the leak detection systems. Water vapor within the landfill gas that is collected by the landfill gas collection layer will often condense, resulting in liquid which is referred to as condensate. This condensate often has similar characteristics to landfill leachate; therefore, the authors recommend using a range similar to the LDS (Leakage Detection System) range of 1.1 to 1.5, since the layer will have a level of exposure to leachate similar to that of the LDS. In the absence of available information, the designer is urged to choose a conservative value (i.e., 1.5).

Table 4.4. Chemical clogging and biological clogging reduction factors [GRI GC8].

Application	Reduction Factor for Chemical Clogging (RF_{CC})	Reduction Factor for Biological Clogging (RF_{BC})
Cover Drainage Layer	1.0 to 1.2 1.2	1.2 to 3.5 2.0
Leachate Collection and Removal Layer	1.5 to 2.0	1.1 to 1.3
Leakage Detection Layer	1.1 to 1.5 1.5	1.1 to 1.3 1.3

The designer should evaluate the soils he/she anticipates using in the protective layer of the liner system and the materials anticipated in the overlying waste, in order to estimate the risk of chemical clogging of the primary leachate collection layer. GRI-GC8 recommends using values in the range of 1.5 to 2.0 for chemical clogging in the leachate collection system (see Table 4.4). Values at the lower end of the range should be used for municipal solid waste.

GRI-GC8 recommends using values in the range of 1.1 to 1.5 for chemical clogging in the leakage detection layer (see Table 4.4). The designer should evaluate the soils he/she anticipates using in the protective layer of the liner system and the typical materials anticipated in the waste stream, in order to evaluate the risk of chemical clogging.

4.3.3 Biological Clogging Reduction Factor, RF_{BC}

The biological clogging reduction factor accounts for the reduction of flow in the geonet due to the growth of biological organisms such as fungi or algae, or root penetration through the overlying soil. GRI-GC8 recommends using values in the range of 1.2 to 3.5 for biological

clogging in the final cover system (see Table 4.4). The authors consider the upper end of this range to constitute a condition whereby improper design of the cover allows root penetration to occur. Coordination is required with a plant biologist and the cover system designer to understand how prolific and how deep roots may develop. The reduction factor for biological clogging should then represent anticipated design conditions.

GRI-GC8 does not provide explicit recommendations for selecting a biological clogging reduction factor for a landfill gas collection layer. A comparison to the other functions described in GRI-GC8 can nonetheless be made. The authors believe that the risk for biological clogging in the landfill gas collection layer should be similar to the leakage detection layer. The authors recommend using a range similar to that in the leakage detection layer range of 1.1 to 1.3, since the layer's level of exposure to leachate will be similar to that of the LDS. In the absence of available information, the designer is urged to choose a conservative value (i.e., 1.3).

GRI-GC8 recommends using values in the range of 1.1 to 1.3 for biological clogging in the leachate collection system (see Table 4.4). The designer should evaluate the conditions anticipated in the landfill to select an appropriate value for the biological clogging reduction factor. In the absence of available information, the designer is urged to choose a conservative value (i.e., 1.3).

GRI-GC8 recommends using values in the range of 1.1 to 1.3 for biological clogging in the leakage detection system (see Table 4.4). The designer should evaluate the conditions anticipated in the landfill to select an appropriate value for the biological clogging reduction factor. In the absence of available information, the designer is urged to choose a conservative value (i.e., 1.3).

4.3.4 Creep Reduction Factors, RF_{CR}

Performance transmissivity tests are typically conducted for up to 100 hours, as required by GRI test procedure GC8. The decrease in transmissivity with time levels off within 100 hours (and usually much sooner than that), indicating that much of the initial compression and intrusion has already taken place (see Figure 2.10). Reduction factor for creep, RF_{CR} , accounts for the decrease in transmissivity beyond the first 100 hours covered by the performance transmissivity test. The quality of the geonet core, including its structure, thickness, mass and density can have a significant influence on creep reduction factors. Appendix B presents creep reduction factors for geonets manufactured by GSE Lining Technology, Inc. Products from other manufacturers can have creep factors different from those given here.

Regardless of the type of product, creep increases with increasing overburden stress. For this reason, creep reduction factors for cover applications (i.e., cover drainage and gas removal layers) are significantly smaller than those for liner system applications (i.e., LCRS and LDS). As shown in Appendix B, a creep reduction factor of 1.1 is adequate for most cover projects. Creep reduction factors should be selected on the basis of normal stress for LCRS and LDS.

4.4 Design Compression Strength of Geonets and Geocomposites

4.4.1 Introduction

GSE PermaNet 270 mil Geocomposite

GSE PermaNet 270 mil geocomposite is manufactured with a GSE PermaNet geonet heat-bonded on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 6 oz/yd² to 16 oz/yd². The round strand, creep resistant structure of the product ensures continuous flow performance over a broad range of conditions and long durations and is ideal for extremely high compressive stress applications.



AT THE CORE:

A high load geocomposite for extremely high compressive stress applications.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Value		
Geocomposite			6 oz/yd ²	8 oz/yd ²	10 oz/yd ²
Transmissivity ⁽¹⁾ , gal/min/ft (m ² /sec)	ASTM D 4716	1/540,000 ft ²	4.8 (1 x 10 ⁻³)	4.8 (1 x 10 ⁻³)	4.8 (1 x 10 ⁻³)
Double-Sided Composite			6.2 (1.3 x 10 ⁻³)	6.2 (1.3 x 10 ⁻³)	6.2 (1.3 x 10 ⁻³)
Single-Sided Composite					
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft ²	1.0	1.0	1.0
Geonet Core – GSE PermaNet ^(2,3)					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft ²	270	270	270
Transmissivity ⁽¹⁾ , gal/min/ft (m ² /sec)	ASTM D 4716	1/540,000 ft ²	19 (4 x 10 ⁻³)	19 (4 x 10 ⁻³)	19 (4 x 10 ⁻³)
Compressive Strength, lbs/ft ²	ASTM D 6364	1/540,000 ft ²	40,000	40,000	40,000
Creep Reduction Factor	ASTM D 7361	per formulation	1.2 @15,000 psf	1.2 @15,000 psf	1.2 @15,000 psf
Density, g/cm ³	ASTM D 1505	1/50,000 ft ²	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 7179	1/50,000 ft ²	100	100	100
Carbon Black Content, %	ASTM D 4218	1/50,000 ft ²	2.0	2.0	2.0
Geotextile (prior to lamination) ^(2,3)					
Mass per Unit Area, oz/yd ²	ASTM D 5261	1/90,000 ft ²	6	8	10
Grab Tensile Strength, lb	ASTM D 4632	1/90,000 ft ²	160	220	260
Grab Elongation	ASTM D 4632	1/90,000 ft ²	50%	50%	50%
CBR Puncture Strength, lb	ASTM D 6241	1/540,000 ft ²	435	575	725
Trapezoidal Tear Strength, lb	ASTM D 4533	1/90,000 ft ²	65	90	100
AOS, US Sieve (mm)	ASTM D 4751	1/540,000 ft ²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, sec ⁻¹	ASTM D 4491	1/540,000 ft ²	1.5	1.3	1.0
Water Flow Rate, gpm/ft ²	ASTM D 4491	1/540,000 ft ²	110	95	75
UV Resistance, % Retained	ASTM D 4355 (after 500 hours)	per formulation	70	70	70
NOMINAL ROLL DIMENSIONS ⁽⁴⁾					
Roll Width, ft			15	15	15
Roll Length, ft	Double-Sided Composite		210	200	180
	Single-Sided Composite		240	230	220
Roll Area, ft ²	Double-Sided Composite		3,150	3,000	2,700
	Single-Sided Composite		3,600	3,450	3,300

NOTES:

- ⁽¹⁾ This is an index transmissivity value measured at stress = 15,000 psf; gradient = 0.1; time = 15 minutes; boundary conditions = between plates. Contact GSE for performance transmissivity value for use in design.
- ⁽²⁾ All geotextile properties are minimum average roll values except AOS which is maximum average roll value and UV resistance is typical value. Geonet core thickness is nominal value.
- ⁽³⁾ Component properties prior to lamination.
- ⁽⁴⁾ Roll widths and lengths have a tolerance of ±1%.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.



[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

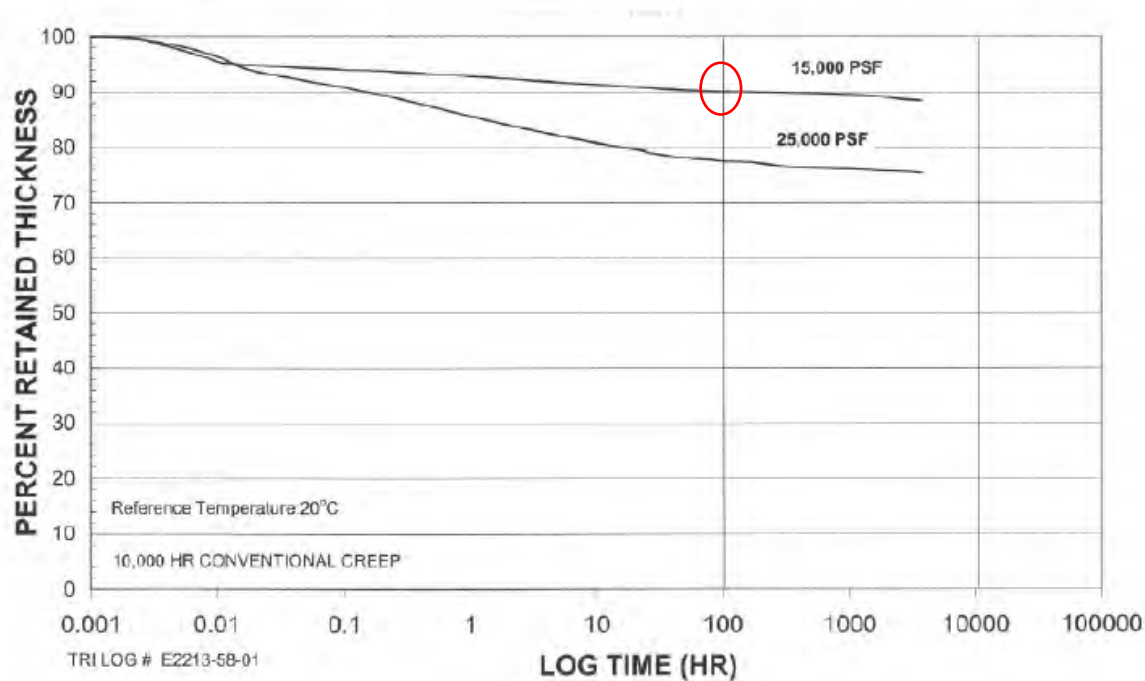


Figure B-5. Creep Curves for GSE PermaNet HL geonet at 15,000 psf and 25,000 psf.

Table B-5. Creep Reduction Factors for GSE PermaNet HL geonet from 100 hours to 50 Years.

Stress (psf)	Creep Reduction Factor
15,000	1.12
25,000	1.16

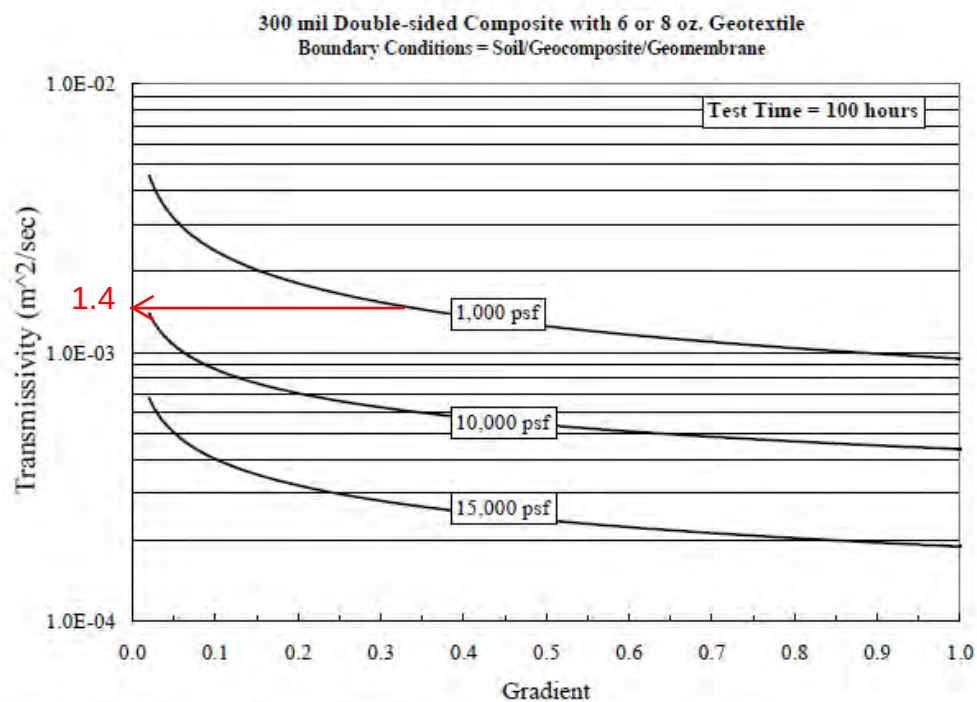


Figure A-9. Performance Transmissivity of a 300 mil GSE FabriNet UF geocomposite under Soil.

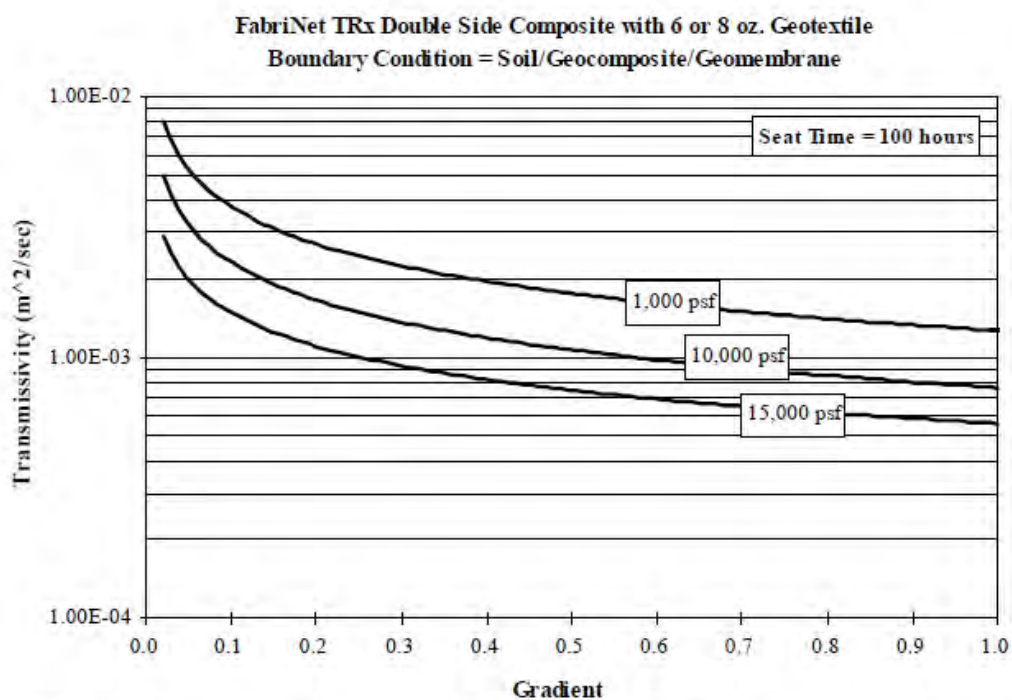


Figure A-10. Performance Transmissivity of GSE FabriNet TRx geocomposite under Soil.

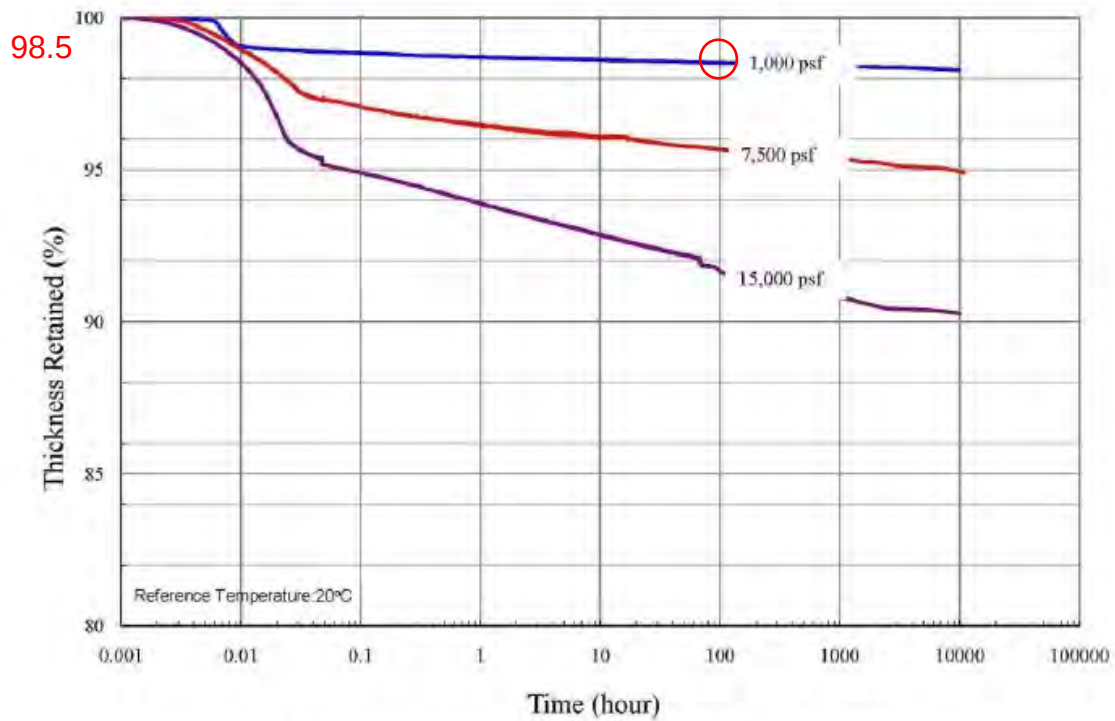


Figure B-3. Creep Curves for a 300 mil GSE HyperNet UF geonet.

Table B-3. Creep Reduction Factors for a 300 mil GSE HyperNet UF geonet from 100 hours to 50 Years.

Stress (psf)	Creep Reduction Factor
1,000	1.00
5,000	1.06
15,000	1.19

Form 28
Closure/Post
– Closure Land Use Plan



FORM 28

CLOSURE/POST – CLOSURE LAND USE PLAN

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 28, reference the item number and identify the date prepared. The "date prepared/revised" on any attached sheets needs to match the "date prepared/revised" on this page.

General References: 273.191, 273.192, 273.321, 273.322, 275.503, 277.191, 277.192, 277.321, 277.322

SECTION A. SITE IDENTIFIER

Applicant/permittee: Greater Lebanon Refuse Authority

Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

SECTION B. POST-CLOSURE LAND USE PLAN

Give Location in Application attached

Instructions: Narrative shall be submitted which contains a detailed description of the proposed use of the facility following closure, including a discussion of the utility and capacity of the revegetated land to support a variety of alternative uses, and the relationship of the use to existing land use policies and plans. Attach appropriate documentation referencing "Form 28; Closure."

- ☒ 1. How the proposed post closure land use is to be achieved and the necessary support activities which maybe needed to achieve the proposed land use.
- ☒ 2. The consideration which has been given to making the proposed post closure land use consistent with landowner plans and applicable State and local land use plans and programs.

SECTION C. CLOSURE PLAN

Give Location in Application attached

Instructions: Narrative shall be submitted describing the activities that are proposed to occur during the post-closure period. Attach appropriate documentation referencing "Form 28; Closure." The plan shall include:

- ☒ 1. Plan for decontamination and removal of equipment, structures and related materials from the facility.
- ☒ 2. An estimate of the year in which final closure will occur, including an explanation of the basis for the estimate.
- ☒ 3. If the facility will close in stages, a description of how and when the facility will begin and implement partial closure. (Schedule for closure)
- ☒ 4. A description of the steps necessary for closure if the facility closes prematurely.
- ☒ 5. A narrative description, including a schedule, of measures that are proposed to be carried out after closure at the facility, including measures relating to:
 - a. Water quality monitoring.
 - b. Gas control and monitoring,
 - c. Leachate collection, treatment, and pumping.
 - d. Erosion and sedimentation control.
 - e. Revegetation including maintenance of the final cover.
 - f. Access control.
 - g. Other maintenance activities.
- ☒ 6. Description of means by which funds will be made available to cover cost of post closure operations, which shall include an assessment of projected post closure maintenance costs, a description of how the necessary funds will be raised, a description of relevant legal documents, and a description of how the funds will be managed prior to closure.
- ☒ 7. The name, address, telephone number, and email address at which the operator can be reached during the post-closure period.

Form 28 – Closure/Post-Closure Land Use Plan
Form 2540-PM-BWM0153, Rev. 6/2005
Greater Lebanon Refuse Authority (Permit No. 101544)
Heilmandale Expansion

B. POST-CLOSURE LAND USE PLAN

- 1. How the proposed post closure land use is to be achieved and the necessary support activities which may be needed to achieve the proposed land use.**

Upon cessation of operations of the GLRA Landfill, uncapped areas will be capped, covered, and revegetated.

- 2. The consideration which has been given to making the proposed post closure land use consistent with landowner plans and applicable State and local land use plans and programs.**

The landfill will remain a vegetated hillside. The grasses will be maintained so as to provide a dense growth of vegetation across the site. This is consistent with applicable State and local land use plans.

C. CLOSURE PLAN

- 1. Plan for decontamination and removal of equipment, structures and related materials from the facility.**

Upon cessation of operations of the GLRA Landfill, landfill equipment such as compactors, heavy dump trucks, etc. will be removed from the site. Decontamination procedures are not required for these items. The office, scalehouse, maintenance building and other such structures will be left on-site except with the possible salvage of the scales with no need for decontamination. The leachate management system will remain in place until it is no longer needed. At that time, manholes, wet wells, tanks, etc. will be triple-rinsed and sealed or removed.

- 2. An estimate of the year in which final closure will occur, including an explanation of the basis for the estimate.**

It is estimated that the expansion will provide approximately 15 years of life at 750 tons per day with an airspace utilization rate of 1,200 pounds per cubic yard.

- 3. If the facility will close in stages, a description of how and when the facility will begin and implement partial closure. (Schedule for closure)**

Placement of final cover, capping, benching and terracing and final revegetation will be completed as areas are brought to final contours.

- 4. A description of the steps necessary for closure if the facility closes prematurely.**

In the event of premature closure, those areas which have not been benched, capped, covered, and revegetated will require those improvements.

5. A narrative description, including a schedule, of measures that are proposed to be carried out after closure at the facility, including measures to:
 - a. Water quality monitoring
 - b. Gas control and monitoring
 - c. Leachate collection, treatment, and pumping
 - d. Erosion and sedimentation control
 - e. Revegetation including maintenance of the final cover
 - f. Access control
 - g. Other maintenance activities.

The following post closure activities will be implemented following closure of the site:

Activity	Description	Frequency
Water quality monitoring	See Form 18 and attached Groundwater Monitoring Plan	Quarterly per Groundwater Monitoring Plan and Form 19
Gas control and monitoring	See Form K	Quarterly
Leachate collection, treatment, and pumping	See Form 25	Daily
Erosion and sedimentation control	See Form I and Form L - PPC Plan	Daily and per PPC Plan, Section G
Revegetation including maintenance of the final cover	See Form H and Form 14	As needed
Access control	See Form 14	Daily
Other maintenance activities	See Form 14 – Operations Plan and Form L – PPC Plan	

6. Description of means by which funds will be made available to cover cost of post closure operations, which shall include an assessment of projected post closure maintenance costs, a description of how the necessary funds will be raised, a description of relevant legal documents, and a description of how the funds will be managed prior to closure. Funding of post closure will be provided by the GLRA. The anticipated post closure costs are presented in the Bonding Worksheets included in **Attachment A**. Funds will be set aside based on the rate of refuse accepted at the site, and will be invested by GLRA prior to closure. Additionally the facility is bonded pursuant to PADEP regulations.
7. The name, address, telephone number and email address at which the operated can be reached during the post-closure period.
 Greater Lebanon Refuse Authority
 1610 Russell Road
 Lebanon, PA 17042
 (717) 867-5790
 Email address: To be established at the time of closure

FORM 28 – ATTACHMENT A

Bonding Worksheets

Bonding Worksheets
Form 2540-FM-BWM0581, Rev. 11/2012
Greater Lebanon Refuse Authority (Permit No. 101544)
Heilmandale Expansion

The Greater Lebanon Refuse Authority (GLRA) has managed the Closure/Post Closure Bonding with an 1109 Trust Fund for its existing Pads 1 through 7. It is anticipated that this fund will be fully funded as required on its closure. Copies of the current bonding worksheets are attached in this section under the heading “1109 Trust A” to demonstrate the current logic in analyzing costs to be attributed to this fund.

It is the intent of the GLRA to manage the expansion of Permit No. 101544 with a separate 1109 Trust Fund as Pads 1 through 7 undergo closure and post closure. Once the Heilmandale Expansion is permitted responsibility for several areas currently listed under 1109 Trust A will both continue to be managed from GLRA General Funds, and begin to accrue funding under “1109 Trust B”. The day that the Heilmandale Expansion begins to accept waste, 1109 Trust A will be modified into “1109 Trust A (rev1) and 1109 Trust B will become the active 1109 Trust Fund receiving the 1109 Trust Fund portion of the tip fee.

Separating the funds in this manner accomplishes the following:

1. Pads 1 through 7 will undergo closure and post closure under the umbrella of a discrete fund.
2. The Heilmandale Expansion will be managed under the umbrella of 1109 Trust B, with funding accruing from the current users of that facility.
3. Any changes in tip fees as a result of changes in cost estimates over time will impact current users.

It is anticipated that the following items will be removed from 1109 Trust A and will become completely a part of 1109 Trust B.

1. Wells, NPDES permits, and surface water monitoring costs common to both will be moved to the Heilmandale Expansion 1109 Trust Fund pages.
2. Flare Costs
3. Leachate Transportation Costs
4. Title V Permit Costs
5. Contiguous Landowner Testing
6. Other Monitoring and Reporting (Bonding Worksheet H)
7. Borrow Area Closure (Bonding Worksheet J)

Data/Assumptions used for 1109 Worksheets

Source: SCS Engineers Expansion Application, Plan Sheets, and WQMP

Heilmandale Expansion – Day 1 of Opening

- Worksheet B - Entire acreage will need to be capped
- Worksheet C - 13 GW Monitoring Wells - 3 upgradient M-008A, M-020, M-020B, M-23A and 10 downgradient M-010A, M-011, M-011B, M-012, M-12D (new) M-017, M-017D, M-018, M-57 (new), M-57D (new)
- Worksheet C-2 - Includes cost for annual GW Monitoring network review
- Worksheet D -Surface Locations LOC001 thru 004
- Worksheet D -NPDES Outfall 001 and 004
- Worksheet E – Includes all CLO monitoring (well testing) costs.
- Worksheet F - LFG perimeter monitoring in vadose zone (wells 1,4,6,7,9)
- Worksheet G – Includes Control System (flare) maintenance, stack testing, electric, etc.
- Worksheet H - Includes costs associated with Title V *reporting* requirements
- Worksheet I – Includes leachate system maintenance/repair costs (pumps, force main, blower) in addition to transport and treatment
- Worksheet I-2 – Monitoring costs include Tank 100 and LDZ - 3 sumps
- Worksheet I-2 - Leachate volume– Use help model max annual leachate for area with intermediate cover
- Worksheet J - Borrow area – 10 acre open at closure
- Worksheet K – include borrow areas; use SCS expansion site specific data for footprint, sw conveyance, ponds; SCS cost data used for maintenance; include Tank 100

Active Site – Day 1 of Closure Period

- Worksheet B - 24.2 acres (Phase 3) will be capped in 2027 (5 yrs after closure)
- Worksheet C - 25 GW Monitoring Wells– 2 upgradient (M-004 and M-035) and 23 downgradient (M-24/M-38, M-33/M-33D, M-34a/M-34D, M-36/M-36D, M-39/M-39D, M-40/M-40D, M-50/M-50D, M-51/M-51D, M-52/M-52D, M-53/M-53D, M-54/M-54D)
- Worksheet D – NPDES Stormwater Outfalls 002 and 003
- Worksheet E - No CLO monitoring (well testing) costs
- Worksheet F - LFG perimeter monitoring in vadose zone (17 wells)
- Worksheet G - No Control System (flare) costs associated with closure
- Worksheet H - No Title V *reporting* costs
- Worksheet I –includes pump maintenance, transport and treatment costs
- Worksheet I-2 – Includes monitoring costs for LDZ 001 thru 007

- Worksheet I-2 - Leachate volume– Phase III capping 24.2 acres, use help model max annual leachate for area with intermediate cover ; other 28.2 acres, use annual leachate for capped area
- Worksheet J - No borrow area open
- Worksheet K – zero for borrow areas and tank 100, active site-specific for footprint, sw conveyance, ponds; SCS cost data used for maintenance

**BONDING WORKSHEETS
FOR
Landfills and Disposal Impoundments**

Revised November 2012



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF AND WASTE MANAGEMENT

General Information

Permits: Please list all permits, approvals, licenses, registrations, other bonds, etc. for this facility.

I.D.# ¹	Authority ²	Summary ³		
101544	DEP Bureau of Solid Waste Management South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200 (717) 705-4706	Municipal Solid Waste Facility (Active)	10/10/1990 Renewal 11/2/2009	10/07/2020
100825	DEP Bureau of Solid Waste Management South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200 (717) 705-4706	Municipal Solid Waste Facility (Closed)	03/18/1986	10/10/1990
0080322	DEP Bureau of Water Quality Protection South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200 (717) 705-4707	Facility NPDES Permit Industrial Wastewater	11/08/2002 Renewal 3/1/2018	02/28/2023
7909	DEP Bureau of Mining Programs South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Mine Operators License	1/1/2018	12/31/2018
38020301C	DEP Pottsville District Mining Office 5 West Laurel Boulevard Pottsville, PA 17901-2522	Noncoal Surface Mining Permit, Peters-Kettering Borrow Area	7/23/2003	7/23/2018
PA0224227	DEP Pottsville District Mining Office 5 West Laurel Blvd Pottsville, PA 17901	NPDES Permit, Peters-Kettering Borrow Area	07/23/2003	07/23/2018
38120301	DEP Pottsville District Mining Office 5 West Laurel Boulevard Pottsville, PA 17901-2522	Noncoal Surface Mining Permit, Cedar Run Borrow Area	7/16/2014	7/16/2019
38120301GP104	DEP Pottsville District Mining Office 5 West Laurel Boulevard Pottsville, PA 17901-2522	NPDES General Permit, Cedar Run Borrow Area	7/16/2014	7/16/2019

PAC380012	Lebanon County Conservation District 2120 Cornwall Road, Suite 5 Lebanon PA 17042-9788	NPDES Permit for Cedar Run Stockpile (District File # 38-915-007-16)	12/07/2016	12/06/2021
38-05017	DEP Air Quality Program South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Title V Air Quality Permit	01/01/2016	12/31/2020
Permit by Rule	DEP Bureau of Solid Waste Management South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Leaf and Grass Clippings Compost Operations	02/05/1992	N/A
00000001A	Department of the Interior US Fish and Wildlife Service PO Box 779 Hadley MA 01035-0775	Canada Goose Depredation	03/01/2016	06/30/2018
3813822	DEP South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Joint Permit for Algicide, Herbicide, or Fish Control Chemical Lebanon County GLRA Schilling Pond	04/06/2018	04/05/2023
3813823	DEP South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Joint Permit for Algicide, Herbicide, or Fish Control Chemical Lebanon County GLRA Southeast Basin	04/06/2018	04/05/2023
WTT0422	DEP Bureau of Waste Management South Central Region 909 Elmerton Avenue Harrisburg, PA 17110	DEP Waste Tire Transporter License	05/30/2013	5/31/2019
RP000101	Commonwealth of PA Department of Agriculture Harrisburg, PA 17110-9408	Dead Animal	12/31/2012	12/31/2018
D38-111	DEP Southcentral Region Dam Safety & Tech Services 909 Elmerton Avenue Harrisburg PA 17110-8200	Dam Construction Permit Treatment Pond 14 (Closed)	4/13/2012	6/30/2016
D38-111 PASPGP-4	U.S. Army Corps of Engineers Baltimore District 1631 S. Atherton ST. Suite 101 State College, PA 16801-6260	Clean Water Act General Permit for Pond 14 Dam (Closed)	4/13/2012	6/30/2016
082009126	District 8-0 Hauling Permit Office 2140 Herr Street Harrisburg, PA 17120	Road Crossing (Closed)	07/01/2011	03/09/2012
WH10243	DEP Bureau of Waste Management South Central Region 909 Elmerton Avenue Harrisburg, PA 17110	DEP Waste Hauler License (Closed)	04/30/2014	04/30/2016

9907D128359	Federal Communications Commission Gettysburg PA 17325-7245	Radio Station License (Closed)	11/17/1999	05/12/2011

- ¹ List the permit I.D. number, registration number, etc. If there is no number, put in "none".
- ² List the issuing authority's name, address and telephone number
- ³ List any closure features or monitoring requirements. As examples: For storage tanks, list the number, type and size of tanks. For NPDES permits list the number of outfalls to be monitored and ponds/plants to be maintained and/or closed.

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544 Schilling

BONDING WORKSHEET A DECONTAMINATING THE FACILITY

Project Summary¹:

None: Assumption is made that no decontamination of the Facility will be required.

1. Maximum volume of solid waste required to be moved or disposed as part of closure (includes cost for solidification). _____
2. Estimated volume of contaminated soils or materials (from accidents, spills, prior remediation's). _____
3. Total volume of waste (line 1 + line 2). _____
4. Unit cost to dispose off-site (include any analyses or transportation cost). _____
5. Total cost to dispose of waste (line 3 x line 4). _____
6. Estimated volume of contaminated liquid generated during decontamination. _____
7. Unit cost to treat/dispose of contaminated liquids (including any transportation) _____
8. Total cost to dispose of contaminated liquids (line 6 x line 7). _____
9. Estimated volume of fill material _____
10. Unit cost of acquiring, transporting, placing and stabilizing (i.e. revegetating) fill material (include costs for off-site purchase if soil not available on-site). _____
11. Total cost to fill (line 9 x line 10). _____
12. Equipment decontamination cost _____ LS

Total cost – all Worksheet A \$ N/A
(Put final total on summary cost sheet – line 1)

¹ List the areas/equipment that will need to be decontaminated and include any assumptions made. Multiple sheets should be used to estimate the costs for different areas.

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544 Schilling

**BONDING WORKSHEET B
CAP AND FINAL COVER PLACEMENT**

How do I start? Select a likely "worst case" scenario where you would have a maximum amount of the facility open and in need of closure. Provide a description of the scenario with references to site development stages.

My approved cap and final cover design consists of (top to bottom):

Worksheets represent existing Schilling Expansion fill area (52.4 acre, Pads 1-7) at time of closure – estimated in year 2022; Phase I and II capping will already be in place. Costs associated with the following are accounted for in Heilmandale Expansion 1109 Trust: 1)wells, NPDES permit, surface water monitoring common to both, 2) flare, 3)leachate system maintenance,4) Title V Permit, 5)contiguous landowner testing, 6) other monitoring/reporting on worksheet H, and 7) borrow area closure.

1. Volume of fill required for area not at final/intermediate grade, but would require filling prior to capping: 0 CY
2. Maximum area to be capped and covered (this should include all areas at final grade and not capped, intermediate grades and areas to be filled to get to intermediate grades then capped): 24.2 acres
3. Closure design, surveying and development of construction drawings (use \$750.00/acre of number 2). \$ 18,150
 - a. Construction and maintenance of access roads. \$ 19,800 LS

Material Volumes/Areas:

4. Earthen Materials

a. Structural Fill	<u>0</u> CY	(Specification ¹)	<u>N/A</u>
b. Intermediate Cover	<u>39,000</u> CY	(Specification ¹)	<u>6"(-)</u>
c. Clay Cap Material	<u>0</u> CY	(Specification ¹)	<u>N/A</u>
d. Final Cover Soil	<u>78,100</u> CY	(Specification ¹)	<u>6"(-)</u>
e. Sand/Stone	<u>0</u> CY	(Specification ¹)	<u>N/A</u>
f. Other	<u>0</u> CY	(Specification ¹)	<u>N/A</u>

5. Synthetic Materials

a. Geotextile	<u>2,108,300</u> Sq.Ft.	(Type)	<u>10 oz Non-Woven Geotextile</u>
b. FML	<u>1,054,200</u> Sq.Ft.	(Type)	<u>40 mil LLDPE</u>
c. Drainage Layer	<u>1,054,200</u> Sq.Ft.	(Type)	<u>GDN</u>
d. Other	<u>0</u> Sq.Ft.	(Type)	<u>N/A</u>

6. Cap Penetrations: Estimate the number of cap penetrations that will need to be installed for closure of the facility including, but not limited to gas extraction wells, cleanouts, valve pits, etc. 80

¹ Provide a brief description of the material specification (i.e. ¾" minus, 12" minus – 12" lifts, etc.)

Material Unit Costs:

7. Unit cost to place or regrade material to reach final grades (this may include additional waste placement to reach grade) 15.45 \$/CY

Are sufficient soils available in permitted on-site borrow areas to complete job?
(Attach maps that identify sources and stockpiles)

Yes, off- site

8. Earthen Materials

a. Structural Fill

Stockpile	Borrow	Onsite	Offsite	Processing Req'd	
				Yes	No
☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

b. Intermediate Cover

☐	☒	☐	☒	☐	☐

Unit cost to place² 6.78 \$/CY

c. Clay Cap Material

☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

d. Final Cover Soil

☐	☒	☐	☒	☐	☐

Unit cost to place² 6.78 \$/CY

e. Sand/Stone

☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

f. Other

☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

9. Synthetic Materials

a. Geotextile

Unit cost to place³ 0.31 \$/sq. ft.

b. FML

Unit cost to place³ 0.27 \$/sq. ft.

c. Drainage Layer

Unit cost to place³ 0.49 \$/sq. ft.

d. Other

Unit cost to place³ 0 \$/sq. ft.

² The unit costs should include all associated costs including, but not limited to cost of material, excavation, transportation, processing and placement.

³ The unit price should include the material cost, transportation cost, handling cost and installation cost.

10. Cap Penetration Unit Cost

List the unit cost to fabricate and install each cap penetration

Unit cost to place 175 \$/each11. Unit cost to construct E & S structures
(i.e. channels, letdowns, etc.)20,600 \$/acre

12. Revegetation Cost

(Seeding rate used: _____ lbs/acre)

(Lime rate used: _____ tons/acre)

(Fertilizer rate used: _____ tons/acre)

(Mulch rate used: _____ tons/acre)

Unit cost to revegetate³ 4,000 \$/acre

13. Cost Summary

a. Fill (line 1 x line 7)	\$ <u>0</u>
b. Construction Drawings (line 3)	\$ <u>18,150</u>
c. Construction Roads (line 3a)	\$ <u>21,275</u>
d. Structural Fill (line 4a x line 8a)	\$ <u>0</u>
e. Intermediate Cover (line 4b x line 8b)	\$ <u>264,542</u>
f. Clay Cap Material (line 4c x line 8c)	\$ <u>0</u>
g. Final Cover (line 4d x line 8d)	\$ <u>529,761</u>
h. Sand/Stone (line 4e x line 8e)	\$ <u>0</u>
i. Other (line 4f x line 8f)	\$ <u>0</u>
j. Geotextile (line 5a x line 9a)	\$ <u>651,465</u>
k. FML (line 5b x line 9b)	\$ <u>282,315</u>
l. Drainage Layer (line 5c x line 9c)	\$ <u>521,196</u>
m. Other (line 5d x line 9d)	\$ <u>0</u>
n. Penetrations (line 6 x line 10)	\$ <u>14,000</u>
o. E & S Structures (line 2 x line 11)	\$ <u>498,520</u>
p. Revegetation (line 12 x line 2)	\$ <u>96,800</u>

Subtotal \$ **2,898,000**CQA costs (use 5% of subtotal) \$ 144,900**Total** \$ **3,042,900**

(Place this total on Summary Cost Worksheet – line 2)

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET C**
GROUNDWATER MONITORING SYSTEM

1. Number of wells in the approved monitoring plan. 25
 - a. Shallowest well depth 42 ft.
 - b. Deepest well depth 200 ft.
 - c. Average well depth 85 ft.
 - d. Number with dedicated pumps 25
2. Unit cost to upgrade an existing well with a dedicated pump 1,984 \$/well
3. Unit cost to install a well (assume average well depth, and include drilling, installation, developing and pump installation) 2,792 \$/well
4. Number of wells to be installed (wells in the approved plan that haven't been installed) 0
5. Number of wells to be replaced over the life of the monitoring period (use 10% of line 1 and round up) 3
6. Number of pumps to be replaced/repared (use 25% of line 1 over the monitoring period) 7
7. Unit cost to purge and sample a well (assume average well depth, and include methane monitoring, record keeping and shipping) 90 \$/well
8. Unit cost to analyze sample(s)
 - a. Quarterly
(25 PA Code §273.284, §277.284 or §288.254) 556 \$/well
 - b. Annually (25 PA Code §273.284, §277.284 or §288.254) 860 \$/well
9. Unit cost to analyze data (includes review of lab QA/QC data, database input, form completion, statistical analysis and data review) 126 \$/well
10. Cost to purge, sample and analyze – quarterly (line 7 + line 8a + line 9) 772 \$/well
11. Cost to purge, sample and analyze – annually (line 7 + line 8b + line 9) 1,076 \$/well
12. Number of years of sampling (30 + time to close) 31 years

13. Cost Summary –Groundwater Monitoring System

a. System upgrade ([line 1 – line 1d] x line 2)	\$ _____
b. Wells to be Installed (line 3 x line 4)	\$ _____
c. Wells to be replaced (line 3 x line 5)	\$ <u>8,375</u>
d. Pumps to be replaced (line 2 x line 6)	\$ <u>13,886</u>
e. Cost of Quarterly Monitoring (line 1 x "4" x line 10 x line 12)	\$ <u>1,794,395</u>
f. Cost of Annual Monitoring (line 1 x line 11 x line 12)	\$ <u>833,732</u>
Subtotal	\$ <u>2,650,400</u>

Adjustment for resampling, assessments, etc.

a. Use 0% of subtotal if no assessments in last 2 yrs.	
b. Use 5% of subtotal if assessment in last 2 yrs.	
c. Use 10% if currently in assessment, abatement or increase monitoring	\$ <u>0</u>

Total **\$ 2,650,400**

(Place this total on Summary Cost Worksheet – line 3)

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET D
SURFACE WATER MONITORING****Solid Waste Surface Water Sampling**

1. Number of surface points monitored for Solid Waste Permit	<u>N/A</u>
2. Unit cost to sample a surface point (record keeping and shipping)	<u> </u> \$/point
3. Unit cost to analyze sample(s)	
a. Quarterly (25 PA Code §273.284 or §288.254)	<u> </u> \$/point
b. Annually (25 PA Code §273.284 or §288.254)	<u> </u> \$/point
4. Unit cost to analyze data (includes review of lab QA/QC data, database input, form completion, and data review)	<u> </u> \$/point
5. Cost to sample and analyze – quarterly (line 2 + line 3a + line 4)	<u> </u> \$/point
6. Cost to sample and analyze – annually (line 2 + line 3b + line 4)	<u> </u> \$/point
7. Number of years of sampling (30 + time to close)	<u> </u>

NPDES Surface Discharge Sampling

8. Number of outfalls monitored	<u>2</u>
9. Monitoring frequency (i.e. monthly, quarterly, etc)	<u>semi-annual</u>
10. Number of samples to be taken per point/year	<u>2</u>
11. Unit cost to sample a surface point (record keeping and shipping)	<u>35</u>
12. Unit cost to analyze sample(s) (including data review and completing DMR)	<u>176</u>
13. Number of years of sampling (30 + time to close)	<u>31</u>
14. Cost Summary –Surface Water Monitoring	
a. Cost of Quarterly Surface Water Monitoring (line 1 x “4” x line 5 x line 7)	\$ <u>N/A</u>
b. Cost of Annual Surface Water Monitoring (line 1 x line 6 x line 7)	\$ <u>N/A</u>
c. Cost of NPDES Monitoring (line 8 x line 10 x [line 11 + line 12] x line 13)	\$ <u>26,164</u>
d. NPDES renewals over post-closure period (includes application development, fees, etc.) use 10% of line 14c	\$ <u>N/A</u>

Subtotal\$	\$ <u>26,200</u>

Adjustment for resampling, assessments, etc.

- a. Use 0% of subtotal if no assessments in last 2 yrs.
- b. Use 5% of subtotal if assessment in last 2 yrs.
- c. Use 10% if in assessment, abatement or increased monitoring

\$ 0

Total \$ **26,200**

(Place this total on Summary Cost Worksheet – line 4)

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling

BONDING WORKSHEET E PRIVATE WATER SUPPLY MONITORING

1. Number of private water supplies monitored. _____ N/A
2. Unit cost to sample a well (include methane monitoring, record keeping and shipping) _____ \$/well
3. Unit cost to analyze sample(s) quarterly (Act 101 Section 1103) _____ \$/well
4. Unit cost to analyze data (includes review of lab QA/QC data, database input, form completion, and data review) _____ \$/well
5. Total cost for quarterly sampling (line 2 + line 3 + line 4) _____ \$/well
6. Number of years of sampling (30 + time to close) _____ years
7. Cost Summary –Private Water Supply Monitoring
 - a. Cost of quarterly monitoring
(line 5 x 4 x line 6) \$ _____

Total \$ _____ N/A

(Place this total on Summary Cost Worksheet – line 5)

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET F
GAS MONITORING SYSTEM**

1.	Number of probes in the approved monitoring plan.	<u>17</u>
a.	Shallowest probe depth <u> </u> ft.	
b.	Deepest probe depth <u> </u> ft.	
c.	Average probe depth <u> </u> ft.	
d.	Number of probes installed <u>17</u>	
2.	Unit cost to install a probe (including, drilling, and installation)	<u>2,000</u> \$/probe
3.	Number of probes to be installed (probes in the approved plan that haven't been installed)	<u>0</u>
4.	Number of probes to be replaced over the life of the monitoring period (use 5% of line 1 and round up)	<u>1</u>
5.	Unit cost to monitor a probe (include record keeping)	<u>40</u> \$/probe
6.	Number of probes and structure monitoring events per year	<u>4</u>
7.	Number of years of monitoring (30 + time to close)	<u>31</u> years
8.	Cost Summary –Gas Monitoring System	
a.	System completion (line 3 x line 2) \$	\$ <u>0</u>
b.	Probe replacement (line 2 x line 4) \$	\$ <u>2,000</u>
c.	Probe Monitoring (line 1 x line 5 x line 6 x line 7)	\$ <u>84,320</u>
	Subtotal	\$ <u>86,300</u>

Adjustment for resampling, assessments, etc.

- a. Use 0% of subtotal if no assessments in last 2 yrs.
- b. Use 5% of subtotal if assessment in last 2 yrs.
- c. Use 10% if in assessment or increased monitoring

Total \$ 86,300

(Place this total on Summary Cost Worksheet – line 6)

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET G
GAS COLLECTION SYSTEM**

1. Number of wells in the approved monitoring plan. 7
- a. Shallowest well depth 51 ft.
 - b. Deepest well depth 108 ft.
 - c. Average well depth 84 ft.
 - d. Number of wells installed 14
 - e. Number of pumping wells 0
2. Cost for flare or other control device installation \$ 0 LS
3. Unit cost to install a well (including, drilling, installation, and connection to active system) 8,400 \$/well
4. Unit cost to install a gas well requiring liquid removal (including, drilling, installation, and connection to active system) 8,400 \$/well
5. Number of wells to be installed (wells in the approved plan that haven't been installed) 0
6. Number of gas wells requiring liquid removal to be installed 0
7. Estimate the length of collection piping to be installed 500 LF
8. Unit cost to install collection piping (include excavation, pipe bedding, pipe, backfilling, regrading, revegetating, surveying and QA/QC) 42.0 \$/LF
9. Number of wells to be replaced/repaired over the life of the monitoring period (use 10% of line 1 and round up) 1
10. Unit cost to monitor well and balance system monthly (include monitoring of methane, oxygen, carbon dioxide or nitrogen, temperature, pressure, and NSPS record keeping) 20 \$/well
11. Unit cost to conduct surface monitoring (NSPS) 8,700 \$/year
12. Control System Information N/A
 - a. number and size of blowers _____
 - b. flare dimensions and capacity _____
 - c. current flow rate _____
 - d. other features -
13. Cost of electricity to run system N/A \$/year
14. Cost to maintain system (including daily check, weekly charts, maintenance, etc.) N/A \$/year
15. Cost of annual blower maintenance (including greasing, bearing check and alignment) N/A \$/year

a.	Additional well installation (line 5 x line 3)	\$	<u>0</u>
b.	Additional pumping well installation (line 4 x line 6)	\$	<u>0</u>
c.	Cost of collection piping (line 7 x line 8)	\$	<u>21,000</u>
d.	Well replacement (line 3 x line 9)	\$	<u>8,400</u>
e.	Enclosed ground flare system (line 2)	\$	<u>0</u>

f.	Cost of monitoring/balancing (line 1 x "12" x line 10 x line 19)	\$	<u>52,080</u>
g.	Cost of surface monitoring (line 11 x "1.5" x line 19)	\$	<u>404,550</u>
h.	Electric Cost (line 13 x line 19)	\$	<u>N/A</u>
i.	System maintenance cost (line 14 x line 19)	\$	<u>N/A</u>
j.	Blower maintenance cost (line 15 x line 19)	\$	<u>N/A</u>
k.	Stack testing cost (line 16 x [line 19/5])	\$	<u>N/A</u>
l.	Condensate management cost (line 18 x line 19)	\$	<u>N/A</u>

Adjustment for miscellaneous maintenance items (including; knockout pot maintenance, thermocouple replacement, flame detector replacement, flame arrester maintenance, flare maintenance, enrichment/startup gas replacement, pneumatic valve maintenance, sump maintenance, panel board maintenance, etc.)

- Use 0% of subtotal if system¹ < 2yrs old
- Use 5% of subtotal if system¹ is > 2 yrs old, but < 5yrs old
- Use 10% if system¹ is > 5 yrs old

\$ 45,600

Total	(Installation subtotal + M & M subtotal + Misc. Maintenance)	\$	531,700

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Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling

BONDING WORKSHEET H OTHER MONITORING AND REPORTING

Please list the annual costs to maintain the following permits/registrations that apply. Additional space is provided for items applicable to your facility, but not listed.

1. Title V or other air permit (include the annual permit fee, cost to complete emissions inventory and emissions fees)	\$	N/A
2. NSPS Annual Report preparation cost	\$	0
3. Local permit or Host Agreement requirements	\$	0
4. UST/AST registration	\$	_____
5. Other _____	\$	_____
6. Other _____	\$	_____
7. Other _____	\$	_____
8. Other _____	\$	_____
9. Other _____	\$	_____
10. Number of years of monitoring/maintenance (30 + time to close)		_____ years

Total (sum of lines 1 to 9 x line 10) \$ N/A

(Place this total on Summary Cost Worksheet – line 8)

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET I
LEACHATE MANAGEMENT**

Leachate Management System Narrative: Provide a detailed description of the leachate management system. You need to include all features of the system including but not limited to landfill sumps (with number and size of pumps and controllers), length of conveyance system, number and type of storage facilities, and treatment/disposal method. A schematic should be attached as back up.

1. Number of years of leachate management
(30 years + closure period) _____ 31 years
2. Annual leachate volume generated _____ 2,873,648 gallons
3. Annual cost to manage leachate volume (include pump and pipe maintenance, electricity and monitoring)¹ \$ _____ 24,615

Discharge to POTW

4. Unit cost to discharge leachate to a POTW _____ 0.011 \$/gal

On-site Treatment (including pretreatment)

5. Unit cost for treatment of leachate (include equipment maintenance, electricity, personnel, chemicals, sludge disposal, etc.) _____ N/A \$/gal
6. Annual cost to maintain NPDES permit (include sampling, analysis, report preparation, and factor in five year renewal application preparation and fees) \$ _____ N/A

Interim Trucking of Leachate

7. Unit cost to transport and dispose of leachate _____ \$/gal
8. NPDES Permit (cost to prepare application, fees and sampling/analysis) \$ _____
9. Cost to construct on-site treatment or pretreatment system or connection to POTW \$ _____
10. Unit cost for treatment of leachate (include equipment maintenance, electricity, personnel, chemicals, etc.) _____ \$/gal
11. Annual cost to maintain NPDES permit (include sampling, analysis, report preparation, and factor in five year renewal application preparation and fees) \$ _____

¹ Does not include storage of leachate which is contained on Worksheet K

12. Cost Summary:

a. Cost to manage/convey leachate
(line 1 x line 3) \$ 763,076

If discharge to POTW

b. Discharge to POTW cost (line 1 x line 2 x line 4) \$ 993,758

If have on-site treatment

c. Treatment cost (line 1 x line 2 x line 5) \$ N/A

d. NPDES maintenance cost (line 1 x line 6) \$ N/A

If you currently truck leachate

e. Cost of trucking leachate for three years
(line 2 x "3" x line 7) \$ N/A

f. NPDES permit (line 8) \$ N/A

g. Cost to construct on-site treatment system or connection to
POTW (line 9) \$ N/A

h. Treatment cost ([line 1 – "3"] x line 2 x line 10) \$ N/A

i. NPDES maintenance cost ([line 1 – "3"] x line 11) \$ N/A

If you currently store leachate in impoundments

j. Size of pond(s) N/A acres

k. Estimate volume of material to be removed (including liner
system and minimum of 12" of soil) CY

l. Unit cost to dispose of materials (Worksheet A, line 4) \$/CY

m. Cost to dispose of materials (line k x line l) \$

n. Volume of structural backfill CY

o. Cost for backfill (line n x Worksheet B, line 8a) \$

p. Revegetation cost \$ LS

Subtotal \$ **1,756,800**
(sum of a – i) +m+o+p)

Adjustment for maintenance, equipment replacement and contingencies, etc. Please note that these are cumulative and you must add all of the percentages that apply to arrive at the final adjustment percentage. The minimum adjustment is 10%.

a. Add 10% of subtotal if pumps are used to convey leachate.

b. Add 5 % of subtotal if flow volume to POTW is restricted.

c. Add 10% of subtotal if leachate is stored in ponds

d. Add 10% of subtotal if onsite treatment

e. Add 15% if trucking leachate

f. Add 10% if current leachate generation exceeds 5MG/year

Final adjustment factor: 10 %

g. Adjustment (subtotal x factor) \$ 175,680

Total (subtotal + adjustment) \$ **1,932,500**

(Place this total on Summary Cost Worksheet – line 9)

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET J
BORROW AREA CLOSURE**

How do I start? Select a likely "worst case" scenario where you would have a maximum amount of the borrow area open and in need of closure. Provide a description of the scenario with references to site development stages.

1. Size of borrow area _____ N/A acres
2. Volume of material required for regrading: _____ CY
3. Unit cost to regrade (provide equipment and rates) _____ CY

Are sufficient soils available to complete job? Yes – off-site stockpiles
(list deficit amount and attach maps that identify sources and stockpiles)

4. Earthen Materials		CY					Processing Req'd	
			Stockpile	Borrow	Onsite	Offsite	Yes	No
a. Structural Fill	_____	CY	☐	☒	☐	☐	☐	☐
b. Unit cost to place ¹	<u>6</u>	\$/CY						
c. Topsoil	<u>8</u>	CY	☐	☒	☐	☐	☐	☐
d. Unit cost to place ¹	_____	\$/CY						

5. Revegetation Cost

(Seeding rate used: _____ lbs/acre)
 (Lime rate used: _____ tons/acre)
 (Fertilizer rate used: _____ tons/acre)
 (Mulch rate used: _____ tons/acre)

Unit cost to revegetate _____ \$/acre

6. E & S Controls _____ \$/acre
7. Bond Maintenance Cost (required if off-site borrow area) \$ _____ LS
8. Other costs (provide detail) \$ _____

¹ The unit costs should include all associated costs including, but not limited to cost of material, excavation, transportation, processing and placement.

9. Cost Summary

a. Fill/Regrading (line 2 x line 3)	\$ _____
b. Structural Fill (line 4a x line 4b)	\$ _____
c. Topsoil (line 4c x line 4d)	\$ _____
d. Revegetation (line 1 x line 5)	\$ _____ 0
e. E & S Controls (line 6)	\$ _____ 0
f. Bond maintenance (line 7)	\$ _____ 0
g. Other (line 8)	\$ _____ 0

Subtotal \$ _____

CQA/Project Management costs (use 5% of subtotal) \$ _____

Total \$ _____ **N/A**

(Place this total on Summary Cost Worksheet – line 10)

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET K
FACILITY MAINTENANCE COSTS**

1. Size of facility	<u>362</u> acres
2. Size of waste placement footprint	<u>52.4</u> acres
3. Size of borrow areas on site	<u>0</u> acres
4. Size of leachate ponds on site	<u>0</u> acres
5. Size of sedimentation ponds on site	<u>1.9</u> acres
6. Length of stormwater conveyance ditches	<u>23,100</u> LF
7. Number of years of site management (30 years + closure period)	<u>31</u> years
8. Annual Cost to repair cap and final cover ¹	
a. Acres (use 1% of line 2)	<u>0.47</u> acres
b. Unit cost ² to repair final cover	<u>5,500</u> \$/acre
c. Unit cost ² to repair cap	<u>60,100</u> \$/acre
d. Unit cost ² to repair vegetation	<u>4,000</u> \$/acre
e. Total unit cost (line b + line c + line d)	<u>69,600</u> \$/acre
9. Annual Cost to repair and maintain E&S facilities ¹	
a. Channel repair length (use 3% of line 6)	<u>621</u> LF
b. Sedimentation pond repair volume (use 20% of line 5)	<u>0.4</u> acres
c. Unit cost ² to repair channels	<u>21</u> \$/LF
d. Unit cost ² to repair ponds	<u>1,000</u> \$/acre
e. Total annual cost (line a x line c) + (line b x line d)	<u>13,123</u> \$/YR
10. Annual Cost to repair and maintain leachate ponds ¹	
a. Leachate pond repair volume (use 20% of line 4)	<u>0</u> acres
b. Unit cost ² to repair leachate pond(s)	<u>0</u> \$/acre
11. Annual cost to repair and maintain leachate tanks	
a. Number and size of tanks	<u>N/A</u>
b. Annual unit cost ¹ to maintain tanks	\$ <u>N/A</u>
12. Annual cost to repair fences and gates (attach details)	\$ <u>200</u> LS

¹ After the site is stabilized, the Department may allow a reduction in these requirements.² Please refer to the instructions. This estimate should reflect unit costs to bring in a contractor to complete the work and should include mobilization, equipment cost, operator costs, material costs and clean-up and inspection costs.

13. Annual cost to maintain site roads

a. Length of site roads ²	<u>8,510</u> LF
b. Annual length of site roads to be repaired (2% of line 13a)	<u>170</u> LF
c. Unit cost to repair roads ¹	<u>125.0</u> \$/LF

14. Cost Summary – Facility Maintenance

a. Cost to repair cap/cover (line 7 x line 8a x line 8e)	\$ <u>1,130,582</u>
b. Cost to maintain E&S facilities (line 7 x line 9e)	\$ <u>406,798</u>
c. Cost to maintain leachate ponds (line 7 x line 10a x line 10b)	\$ <u>0</u>
d. Cost to maintain leachate tanks (line 7 x line 11a x line 11b)	\$ <u>0</u>
e. Cost to repair fences and gates (line 7 x line 12)	\$ <u>6,200</u>
f. Cost to maintain site roads (line 7 x line 13b x line 13c)	\$ <u>659,525</u>
Subtotal	\$ <u>2,203,100</u>

1. Please refer to the instructions. This estimate should reflect unit costs to bring in a contractor to complete the work and should include mobilization, equipment cost, operator costs, material costs and clean-up and inspection costs. Costs not incurred annually should be determine and divided among the years between events. The costs should also include replacements of pumps and meters, electricity used (pumps, heat tracing, etc.) valve replacement and sludge disposal.
2. This should include access to all maintenance and monitoring areas including but not limited to the disposal area, ponds, leachate conveyance system, tanks, discharge locations, gas extraction system wells, gas probes, groundwater monitoring system and surface water monitoring points.

Adjustment for maintenance, equipment replacement and contingencies, etc. Please note that these are cumulative and you must add all of the percentages that apply to arrive at the final adjustment percentage. The minimum adjustment is 10%.

- a. Add 5% of subtotal if final slopes or benches have been modified from what is specified in 25 PA Code §273.234(f)
- b. Add 5% of subtotal if more than 30 % stormwater channels are unlined
- c. Add 5% of subtotal if the length of site access roads exceeds 5 miles
- d. Add 10% for mowing

Final adjustment factor: 15 %

- e. Adjustment (subtotal x factor) \$ 330,465

Total (subtotal + adjustment) **\$ 2,533,600**

(Place this total on Summary Cost Worksheet – line 11)

¹ After the site is stabilized, the Department may allow a reduction in these requirements.

² Please refer to the instructions. This estimate should reflect unit costs to bring in a contractor to complete the work and should include mobilization, equipment cost, operator costs, material costs and clean-up and inspection costs.

Date Prepared

July 9, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Schilling**BONDING WORKSHEET L
SUMMARY COST WORKSHEET****Cost Summary - Landfills**

1. Decontaminating the Facility	\$ _____
2. Capping/Closure	\$ <u>3,042,900</u>
3. Groundwater Monitoring System	\$ <u>2,650,400</u>
4. Surface Water Monitoring	\$ <u>26,200</u>
5. Private Water Supply Monitoring	\$ _____
6. Gas Monitoring	\$ <u>86,300</u>
7. Gas Collection and Maintenance	\$ <u>531,700</u>
8. Other Monitoring	\$ _____
9. Leachate Management	\$ <u>1,932,500</u>
10. Borrow Area Closure	\$ _____
11. Maintenance Costs	\$ <u>2,533,600</u>
12. Other Costs ¹ _____	\$ _____ 0
13. Other Costs ¹ _____	\$ _____ 0
Subtotal	\$ <u>10,803,600</u>

Inflation

14. Inflation rate (projected inflation for the next three years based on the inflation for the prior three years).	_____ 4 %
15. Inflation cost for facility (subtotal x line 14)	\$ <u>432,144</u>

Contingency and administrative fees

16. Administrative fees (5%) (subtotal x 0.05)	\$ <u>540,180</u>
17. Project Management (5%) (subtotal x 0.05)	\$ <u>540,180</u>
18. Contingency fee amount (subtotal x rate of contingency fee from Table 1)	\$ <u>810,270</u>

Total (subtotal + line 15 + line 16 + line 17 + 18) **\$ 13,126,400**

¹ You should include any costs that would be incurred by the Department, but were not included in these sheets. Provide separate sheets for documentation.

**BONDING WORKSHEETS
FOR
Landfills and Disposal Impoundments**

Revised November 2012



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF AND WASTE MANAGEMENT

General Information

Permits: Please list all permits, approvals, licenses, registrations, other bonds, etc. for this facility.

I.D.# ¹	Authority ²	Summary ³		
101544	DEP Bureau of Solid Waste Management South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200 (717) 705-4706	Municipal Solid Waste Facility (Active)	10/10/1990 Renewal 11/2/2009	10/07/2020
100825	DEP Bureau of Solid Waste Management South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200 (717) 705-4706	Municipal Solid Waste Facility (Closed)	03/18/1986	10/10/1990
0080322	DEP Bureau of Water Quality Protection South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200 (717) 705-4707	Facility NPDES Permit Industrial Wastewater	11/08/2002 Renewal 3/1/2018	02/28/2023
7909	DEP Bureau of Mining Programs South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Mine Operators License	1/1/2018	12/31/2018
38020301C	DEP Pottsville District Mining Office 5 West Laurel Boulevard Pottsville, PA 17901-2522	Noncoal Surface Mining Permit, Peters-Kettering Borrow Area	7/23/2003	7/23/2018
PA0224227	DEP Pottsville District Mining Office 5 West Laurel Blvd Pottsville, PA 17901	NPDES Permit, Peters-Kettering Borrow Area	07/23/2003	07/23/2018
38120301	DEP Pottsville District Mining Office 5 West Laurel Boulevard Pottsville, PA 17901-2522	Noncoal Surface Mining Permit, Cedar Run Borrow Area	7/16/2014	7/16/2019
38120301GP104	DEP Pottsville District Mining Office 5 West Laurel Boulevard Pottsville, PA 17901-2522	NPDES General Permit, Cedar Run Borrow Area	7/16/2014	7/16/2019

PAC380012	Lebanon County Conservation District 2120 Cornwall Road, Suite 5 Lebanon PA 17042-9788	NPDES Permit for Cedar Run Stockpile (District File # 38-915-007-16)	12/07/2016	12/06/2021
38-05017	DEP Air Quality Program South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Title V Air Quality Permit	01/01/2016	12/31/2020
Permit by Rule	DEP Bureau of Solid Waste Management South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Leaf and Grass Clippings Compost Operations	02/05/1992	N/A
00000001A	Department of the Interior US Fish and Wildlife Service PO Box 779 Hadley MA 01035-0775	Canada Goose Depredation	03/01/2016	06/30/2018
3813822	DEP South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Joint Permit for Algicide, Herbicide, or Fish Control Chemical Lebanon County GLRA Schilling Pond	04/06/2018	04/05/2023
3813823	DEP South Central Region 909 Elmerton Avenue Harrisburg PA 17110-8200	Joint Permit for Algicide, Herbicide, or Fish Control Chemical Lebanon County GLRA Southeast Basin	04/06/2018	04/05/2023
WTT0422	DEP Bureau of Waste Management South Central Region 909 Elmerton Avenue Harrisburg, PA 17110	DEP Waste Tire Transporter License	05/30/2013	5/31/2019
RP000101	Commonwealth of PA Department of Agriculture Harrisburg, PA 17110-9408	Dead Animal	12/31/2012	12/31/2018
D38-111	DEP Southcentral Region Dam Safety & Tech Services 909 Elmerton Avenue Harrisburg PA 17110-8200	Dam Construction Permit Treatment Pond 14 (Closed)	4/13/2012	6/30/2016
D38-111 PASPGP-4	U.S. Army Corps of Engineers Baltimore District 1631 S. Atherton ST. Suite 101 State College, PA 16801-6260	Clean Water Act General Permit for Pond 14 Dam (Closed)	4/13/2012	6/30/2016
082009126	District 8-0 Hauling Permit Office 2140 Herr Street Harrisburg, PA 17120	Road Crossing (Closed)	07/01/2011	03/09/2012
WH10243	DEP Bureau of Waste Management South Central Region 909 Elmerton Avenue Harrisburg, PA 17110	DEP Waste Hauler License (Closed)	04/30/2014	04/30/2016

9907D128359	Federal Communications Commission Gettysburg PA 17325-7245	Radio Station License (Closed)	11/17/1999	05/12/2011

- ¹ List the permit I.D. number, registration number, etc. If there is no number, put in "none".
- ² List the issuing authority's name, address and telephone number
- ³ List any closure features or monitoring requirements. As examples: For storage tanks, list the number, type and size of tanks. For NPDES permits list the number of outfalls to be monitored and ponds/plants to be maintained and/or closed.

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544 Heilmandale
Expansion

BONDING WORKSHEET A DECONTAMINATING THE FACILITY

Project Summary¹:

None: Assumption is made that no decontamination of the Facility will be required.

1. Maximum volume of solid waste required to be moved or disposed as part of closure (includes cost for solidification). _____
2. Estimated volume of contaminated soils or materials (from accidents, spills, prior remediation's). _____
3. Total volume of waste (line 1 + line 2). _____
4. Unit cost to dispose off-site (include any analyses or transportation cost). _____
5. Total cost to dispose of waste (line 3 x line 4). _____
6. Estimated volume of contaminated liquid generated during decontamination. _____
7. Unit cost to treat/dispose of contaminated liquids (including any transportation) _____
8. Total cost to dispose of contaminated liquids (line 6 x line 7). _____
9. Estimated volume of fill material _____
10. Unit cost of acquiring, transporting, placing and stabilizing (i.e. revegetating) fill material (include costs for off-site purchase if soil not available on-site). _____
11. Total cost to fill (line 9 x line 10). _____
12. Equipment decontamination cost _____ LS

Total cost – all Worksheet A

\$ _____ **N/A**
(Put final total on summary cost sheet – line 1)

¹ List the areas/equipment that will need to be decontaminated and include any assumptions made. Multiple sheets should be used to estimate the costs for different areas.

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET B
CAP AND FINAL COVER PLACEMENT**

How do I start? Select a likely "worst case" scenario where you would have a maximum amount of the facility open and in need of closure. Provide a description of the scenario with references to site development stages.

My approved cap and final cover design consists of (top to bottom):

Reference: SCS Engineers Heilmandale Expansion Design documents
These worksheets represent Heilmandale Expansion area at year one.

1. Volume of fill required for area not at final/intermediate grade, but would require filling prior to capping: 0 CY
2. Maximum area to be capped and covered (this should include all areas at final grade and not capped, intermediate grades and areas to be filled to get to intermediate grades then capped): 46.7 acres
3. Closure design, surveying and development of construction drawings (use \$750.00/acre of number 2). \$ 35,000
 - a. Construction and maintenance of access roads. \$ 19,800 LS

Material Volumes/Areas:

4. Earthen Materials
 - a. Structural Fill 0 CY (Specification¹) N/A
 - b. Intermediate Cover 75,300 CY (Specification¹) 6"(-)
 - c. Clay Cap Material 0 CY (Specification¹) N/A
 - d. Final Cover Soil 150,700 CY (Specification¹) 6"(-)
 - e. Sand/Stone 0 CY (Specification¹) N/A
 - f. Other 0 CY (Specification¹) N/A
5. Synthetic Materials
 - a. Geotextile 4,067,600 Sq.Ft. (Type) 10 oz Non-Woven Geotextile
 - b. FML 2,033,800 Sq.Ft. (Type) 40 mil LLDPE
 - c. Drainage Layer 2,033,800 Sq.Ft. (Type) GDN
 - d. Other 0 Sq.Ft. (Type) N/A
6. Cap Penetrations: Estimate the number of cap penetrations that will need to be installed for closure of the facility including, but not limited to gas extraction wells, cleanouts, valve pits, etc. 70

¹ Provide a brief description of the material specification (i.e. ¾" minus, 12" minus – 12" lifts, etc.)

Material Unit Costs:

7. Unit cost to place or regrade material to reach final grades (this may include additional waste placement to reach grade) 15.45 \$/CY

Are sufficient soils available in permitted on-site borrow areas to complete job?
(Attach maps that identify sources and stockpiles)

Yes, off- site

8. Earthen Materials

a. Structural Fill

Stockpile	Borrow	Onsite	Offsite	Processing Req'd	
				Yes	No
☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

b. Intermediate Cover

☐	☒	☐	☒	☐	☐

Unit cost to place² 6.78 \$/CY

c. Clay Cap Material

☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

d. Final Cover Soil

☐	☒	☐	☒	☐	☐

Unit cost to place² 6.78 \$/CY

e. Sand/Stone

☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

f. Other

☐	☐	☐	☐	☐	☐

Unit cost to place² 0.00 \$/CY

9. Synthetic Materials

a. Geotextile

Unit cost to place³ 0.31 \$/sq. ft.

b. FML

Unit cost to place³ 0.27 \$/sq. ft.

c. Drainage Layer

Unit cost to place³ 0.49 \$/sq. ft.

d. Other

Unit cost to place³ 0 \$/sq. ft.

² The unit costs should include all associated costs including, but not limited to cost of material, excavation, transportation, processing and placement.

³ The unit price should include the material cost, transportation cost, handling cost and installation cost.

10. Cap Penetration Unit Cost

List the unit cost to fabricate and install each cap penetration

Unit cost to place 175 \$/each11. Unit cost to construct E & S structures
(i.e. channels, letdowns, etc.)12,200 \$/acre

12. Revegetation Cost

(Seeding rate used: _____ lbs/acre)

(Lime rate used: _____ tons/acre)

(Fertilizer rate used: _____ tons/acre)

(Mulch rate used: _____ tons/acre)

Unit cost to revegetate³ 4,000 \$/acre

13. Cost Summary

a. Fill (line 1 x line 7)	\$ <u>174,508</u>
b. Construction Drawings (line 3)	\$ <u>35,000</u>
c. Construction Roads (line 3a)	\$ <u>19800</u>
d. Structural Fill (line 4a x line 8a)	\$ <u>0</u>
e. Intermediate Cover (line 4b x line 8b)	\$ <u>510,769</u>
f. Clay Cap Material (line 4c x line 8c)	\$ <u>0</u>
g. Final Cover (line 4d x line 8d)	\$ <u>1,022,216</u>
h. Sand/Stone (line 4e x line 8e)	\$ <u>0</u>
i. Other (line 4f x line 8f)	\$ <u>0</u>
j. Geotextile (line 5a x line 9a)	\$ <u>1,256,888</u>
k. FML (line 5b x line 9b)	\$ <u>544,652</u>
l. Drainage Layer (line 5c x line 9c)	\$ <u>1,005,511</u>
m. Other (line 5d x line 9d)	\$ <u>0</u>
n. Penetrations (line 6 x line 10)	\$ <u>12,180</u>
o. E & S Structures (line 2 x line 11)	\$ <u>569,618</u>
p. Revegetation (line 12 x line 2)	\$ <u>186,760</u>

Subtotal \$ **5,337,900**CQA costs (use 5% of subtotal) \$ 266,900**Total** \$ **5,604,800**

(Place this total on Summary Cost Worksheet – line 2)

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET C**
GROUNDWATER MONITORING SYSTEM

1. Number of wells in the approved monitoring plan.	<u>13</u>
a. Shallowest well depth <u>42</u> ft.	
b. Deepest well depth <u>200</u> ft.	
c. Average well depth <u>85</u> ft.	
d. Number with dedicated pumps <u>13</u>	
2. Unit cost to upgrade an existing well with a dedicated pump	<u>1,949</u> \$/well
3. Unit cost to install a well (assume average well depth, and include drilling, installation, developing and pump installation)	<u>2,792</u> \$/well
4. Number of wells to be installed (wells in the approved plan that haven't been installed)	<u>0</u>
5. Number of wells to be replaced over the life of the monitoring period (use 10% of line 1 and round up)	<u>2</u>
6. Number of pumps to be replaced/repared (use 25% of line 1 over the monitoring period)	<u>4</u>
7. Unit cost to purge and sample a well (assume average well depth, and include methane monitoring, record keeping and shipping)	<u>107</u> \$/well
8. Unit cost to analyze sample(s)	
a. Quarterly (25 PA Code §273.284, §277.284 or §288.254)	<u>556</u> \$/well
b. Annually (25 PA Code §273.284, §277.284 or §288.254)	<u>860</u> \$/well
9. Unit cost to analyze data (includes review of lab QA/QC data, database input, form completion, statistical analysis and data review)	<u>121</u> \$/well
10. Cost to purge, sample and analyze – quarterly (line 7 + line 8a + line 9)	<u>784</u> \$/well
11. Cost to purge, sample and analyze – annually (line 7 + line 8b + line 9)	<u>1,088</u> \$/well
12. Number of years of sampling (30 + time to close)	<u>31</u> years

13. Cost Summary –Groundwater Monitoring System

a. System upgrade ([line 1 – line 1d] x line 2)	\$ _____
b. Wells to be Installed (line 3 x line 4)	\$ _____
c. Wells to be replaced (line 3 x line 5)	\$ <u>5,583</u>
d. Pumps to be replaced (line 2 x line 6)	\$ <u>7,935</u>
e. Cost of Quarterly Monitoring (line 1 x "4" x line 10 x line 12)	\$ <u>948,125</u>
f. Cost of Annual Monitoring (line 1 x line 11 x line 12)	\$ <u>438,554</u>
Subtotal	\$ <u>1,400,200</u>

Adjustment for resampling, assessments, etc.

a. Use 0% of subtotal if no assessments in last 2 yrs.	
b. Use 5% of subtotal if assessment in last 2 yrs.	
c. Use 10% if currently in assessment, abatement or increase monitoring	\$ <u>0</u>

Total **\$ 1,400,200**

(Place this total on Summary Cost Worksheet – line 3)

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET D
SURFACE WATER MONITORING****Solid Waste Surface Water Sampling**

1. Number of surface points monitored for Solid Waste Permit	<u>4</u>
2. Unit cost to sample a surface point (record keeping and shipping)	<u>23.33</u> \$/point
3. Unit cost to analyze sample(s)	
a. Quarterly (25 PA Code §273.284 or §288.254)	<u>590</u> \$/point
b. Annually (25 PA Code §273.284 or §288.254)	<u>590</u> \$/point
4. Unit cost to analyze data (includes review of lab QA/QC data, database input, form completion, and data review)	<u>121</u> \$/point
5. Cost to sample and analyze – quarterly (line 2 + line 3a + line 4)	<u>734.33</u> \$/point
6. Cost to sample and analyze – annually (line 2 + line 3b + line 4)	<u>734.33</u> \$/point
7. Number of years of sampling (30 + time to close)	<u>31 years</u>

NPDES Surface Discharge Sampling

8. Number of outfalls monitored	<u>3/1</u>
9. Monitoring frequency (i.e. monthly, quarterly, etc)	<u>semi-annual/monthly</u>
10. Number of samples to be taken per point/year	<u>2/12</u>
11. Unit cost to sample a surface point (record keeping and shipping)	<u>23.33/142.00</u> \$/point
12. Unit cost to analyze sample(s) (including data review and completing DMR)	<u>176.00/550.00</u> \$/point
13. Number of years of sampling (30 + time to close)	<u>31 years</u>
14. Cost Summary –Surface Water Monitoring	
a. Cost of Quarterly Surface Water Monitoring (line 1 x “4” x line 5 x line 7)	\$ <u>273,172</u>
b. Cost of Annual Surface Water Monitoring (line 1 x line 6 x line 7)	\$ <u>91,057</u>
c. Cost of NPDES Monitoring (line 8 x line 10 x [line 11 + line 12] x line 13)	\$ <u>37,076/257,424</u>
d. NPDES renewals over post-closure period (includes application development, fees, etc.) use 10% of line 14c	\$ <u>29,450</u>

Subtotal\$ \$ **688,200**

Adjustment for resampling, assessments, etc.

- a. Use 0% of subtotal if no assessments in last 2 yrs.
- b. Use 5% of subtotal if assessment in last 2 yrs.
- c. Use 10% if in assessment, abatement or increased monitoring

\$ 0

Total \$ **688,200**

(Place this total on Summary Cost Worksheet – line 4)

Date Prepared

July 6, 2018

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101544
Heilmandale Expansion**BONDING WORKSHEET E
PRIVATE WATER SUPPLY MONITORING**

1. Number of private water supplies monitored. 12
2. Unit cost to sample a well (include methane monitoring, record keeping and shipping) 0 \$/well
3. Unit cost to analyze sample(s) quarterly (Act 101 Section 1103) 800.00 \$/well
4. Unit cost to analyze data (includes review of lab QA/QC data, database input, form completion, and data review) 121.22 \$/well
5. Total cost for quarterly sampling (line 2 + line 3 + line 4) 921.22 \$/well
6. Number of years of sampling (30 + time to close) 31 years
7. Cost Summary –Private Water Supply Monitoring
 - a. Cost of quarterly monitoring
(line 5 x 4 x line 6) \$ 114,231

Total \$ 1,370,800

(Place this total on Summary Cost Worksheet – line 5)

Date Prepared

July 6, 2018

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I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET F
GAS MONITORING SYSTEM**

1.	Number of probes in the approved monitoring plan.	<u>22</u>
a.	Shallowest probe depth <u> </u> ft.	
b.	Deepest probe depth <u> </u> ft.	
c.	Average probe depth <u> </u> ft.	
d.	Number of probes installed <u>22</u>	
2.	Unit cost to install a probe (including, drilling, and installation)	<u>2,000</u> \$/probe
3.	Number of probes to be installed (probes in the approved plan that haven't been installed)	<u>0</u>
4.	Number of probes to be replaced over the life of the monitoring period (use 5% of line 1 and round up)	<u>2</u>
5.	Unit cost to monitor a probe (include record keeping)	<u>40</u> \$/probe
6.	Number of probes and structure monitoring events per year	<u>4</u>
7.	Number of years of monitoring (30 + time to close)	<u>31</u> years
8.	Cost Summary –Gas Monitoring System	
a.	System completion (line 3 x line 2) \$	\$ <u>0</u>
b.	Probe replacement (line 2 x line 4) \$	\$ <u>4,000</u>
c.	Probe Monitoring (line 1 x line 5 x line 6 x line 7)	\$ <u>109,120</u>
	Subtotal	\$ <u>113,100</u>

Adjustment for resampling, assessments, etc.

- a. Use 0% of subtotal if no assessments in last 2 yrs.
- b. Use 5% of subtotal if assessment in last 2 yrs.
- c. Use 10% if in assessment or increased monitoring

Total \$ 113,100

(Place this total on Summary Cost Worksheet – line 6)

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET G
GAS COLLECTION SYSTEM**

1. Number of wells in the approved monitoring plan. 48
- a. Shallowest well depth 51 ft.
 - b. Deepest well depth 108 ft.
 - c. Average well depth 84 ft.
 - d. Number of wells installed 48
 - e. Number of pumping wells 0
2. Cost for flare or other control device installation \$ 0 LS
3. Unit cost to install a well (including, drilling, installation, and connection to active system) 8,400 \$/well
4. Unit cost to install a gas well requiring liquid removal (including, drilling, installation, and connection to active system) 8,400 \$/well
5. Number of wells to be installed (wells in the approved plan that haven't been installed) 0
6. Number of gas wells requiring liquid removal to be installed 0
7. Estimate the length of collection piping to be installed 2,000 LF
8. Unit cost to install collection piping (include excavation, pipe bedding, pipe, backfilling, regrading, revegetating, surveying and QA/QC) 42.0 \$/LF
9. Number of wells to be replaced/repaired over the life of the monitoring period (use 10% of line 1 and round up) 5
10. Unit cost to monitor well and balance system monthly (include monitoring of methane, oxygen, carbon dioxide or nitrogen, temperature, pressure, and NSPS record keeping) 20 \$/well
11. Unit cost to conduct surface monitoring (NSPS) 8,700 \$/event
12. Control System Information
 - a. number and size of blowers 2 blowers @ 15hp each
 - b. flare dimensions and capacity 8'x40'; max 1700 cfm
 - c. current flow rate 669
 - d. other features -
13. Cost of electricity to run system 7,200 \$/year
14. Cost to maintain system (including daily check, weekly charts, maintenance, etc.) 41,100 \$/year
15. Cost of annual blower maintenance (including greasing, bearing check and alignment) 16,400 \$/year

16. Cost of stack testing (once per five years)	<u>11,900</u> \$/event
17. Estimate the volume of condensate generated per year	<u>365,000</u> gallons
18. Cost of condensate management (including pumping, testing and treatment/disposal)	<u>10</u> \$/year
19. Number of years to run system (30 + time to close)	<u>31</u> years
20. Cost Summary –Gas Collection System	<u> </u>

System Installation

a. Additional well installation (line 5 x line 3)	\$ <u>0</u>
b. Additional pumping well installation (line 4 x line 6)	\$ <u>0</u>
c. Cost of collection piping (line 7 x line 8)	\$ <u>84,000</u>
d. Well replacement (line 3 x line 9)	\$ <u>42,000</u>
e. Enclosed ground flare system (line 2)	\$ <u>0</u>

System Installation Subtotal \$ 126,000
(sum lines a to e)

f. Cost of monitoring/balancing (line 1 x "12" x line 10 x line 19)	\$ <u>357,120</u>
g. Cost of surface monitoring (line 11 x "1.5" x line 19)	\$ <u>404,550</u>
h. Electric Cost (line 13 x line 19)	\$ <u>223,200</u>
i. System maintenance cost (line 14 x line 19)	\$ <u>1,274,100</u>
j. Blower maintenance cost (line 15 x line 19)	\$ <u>508,400</u>
k. Stack testing cost (line 16 x [line 19/5])	\$ <u>71,400</u>
l. Condensate management cost (line 18 x line 19)	\$ <u> </u>

System Monitoring and Maintenance Subtotal \$ 2,838,800
(sum lines f to l)

Adjustment for miscellaneous maintenance items (including; knockout pot maintenance, thermocouple replacement, flame detector replacement, flame arrester maintenance, flare maintenance, enrichment/startup gas replacement, pneumatic valve maintenance, sump maintenance, panel board maintenance, etc.)

- a. Use 0% of subtotal if system¹ < 2yrs old
- b. Use 5% of subtotal if system¹ is > 2 yrs old, but < 5yrs old
- c. Use 10% if system¹ is > 5 yrs old

\$ 283,880

Total (Installation subtotal + M & M subtotal + Misc. Maintenance) \$ 3,248,700
(Place this total on Summary Cost Worksheet – line 7)

¹ The age of the system would be considered from the date that the active system went on-line. Expansions of the systems are assumed to occur, however, this does not change the age of the system unless a majority of the existing system is replaced/upgraded.

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET H**
OTHER MONITORING AND REPORTING

Please list the annual costs to maintain the following permits/registrations that apply. Additional space is provided for items applicable to your facility, but not listed.

1. Title V or other air permit (include the annual permit fee, cost to complete emissions inventory and emissions fees)	\$ <u>2,112</u>
2. NSPS Annual Report preparation cost	\$ <u>0</u>
3. Local permit or Host Agreement requirements	\$ <u>0</u>
4. UST/AST registration	\$ <u>274</u>
5. Other _____	\$ <u>0</u>
6. Other _____	\$ <u>0</u>
7. Other _____	\$ <u>0</u>
8. Other _____	\$ <u>0</u>
9. Other _____	\$ <u>0</u>
10. Number of years of monitoring/maintenance (30 + time to close)	<u>31</u> years

Total (sum of lines 1 to 9 x line 10) \$ 74,000

(Place this total on Summary Cost Worksheet – line 8)

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET I
LEACHATE MANAGEMENT**

Leachate Management System Narrative: Provide a detailed description of the leachate management system. You need to include all features of the system including but not limited to landfill sumps (with number and size of pumps and controllers), length of conveyance system, number and type of storage facilities, and treatment/disposal method. A schematic should be attached as back up.

1. Number of years of leachate management
(30 years + closure period) 31 years
2. Annual leachate volume generated 5,544,240 gallons
3. Annual cost to manage leachate volume (include pump and pipe maintenance, electricity and monitoring)¹ \$ 28,677

Discharge to POTW

4. Unit cost to discharge leachate to a POTW 0.011 \$/gal

On-site Treatment (including pretreatment)

5. Unit cost for treatment of leachate (include equipment maintenance, electricity, personnel, chemicals, sludge disposal, etc.) 0 \$/gal
6. Annual cost to maintain NPDES permit (include sampling, analysis, report preparation, and factor in five year renewal application preparation and fees) \$ 0

Interim Trucking of Leachate

7. Unit cost to transport and dispose of leachate 0 \$/gal
8. NPDES Permit (cost to prepare application, fees and sampling/analysis) \$ 0
9. Cost to construct on-site treatment or pretreatment system or connection to POTW \$ 0
10. Unit cost for treatment of leachate (include equipment maintenance, electricity, personnel, chemicals, etc.) 0 \$/gal
11. Annual cost to maintain NPDES permit (include sampling, analysis, report preparation, and factor in five year renewal application preparation and fees) \$ 0

¹ Does not include storage of leachate which is contained on Worksheet K

12. Cost Summary:

a. Cost to manage/convey leachate
(line 1 x line 3) \$ 888,983

If discharge to POTW

b. Discharge to POTW cost (line 1 x line 2 x line 4) \$ 1,917,295

If have on-site treatment

c. Treatment cost (line 1 x line 2 x line 5) \$ 0

d. NPDES maintenance cost (line 1 x line 6) \$ 0

If you currently truck leachate

e. Cost of trucking leachate for three years
(line 2 x "3" x line 7) \$ 0

f. NPDES permit (line 8) \$ 0

g. Cost to construct on-site treatment system or connection to
POTW (line 9) \$ 0

h. Treatment cost ([line 1 – "3"] x line 2 x line 10) \$ 0

i. NPDES maintenance cost ([line 1 – "3"] x line 11) \$ 0

If you currently store leachate in impoundments

j. Size of pond(s) 0 acres

k. Estimate volume of material to be removed (including liner
system and minimum of 12" of soil) 0 CY

l. Unit cost to dispose of materials (Worksheet A, line 4) 0 \$/CY

m. Cost to dispose of materials (line k x line l) \$ 0

n. Volume of structural backfill 0 CY

o. Cost for backfill (line n x Worksheet B, line 8a) \$ 0

p. Revegetation cost \$ 0 LS

Subtotal \$ **2,806,300**
(sum of a – i) +m+o+p)

Adjustment for maintenance, equipment replacement and contingencies, etc. Please note that these are cumulative and you must add all of the percentages that apply to arrive at the final adjustment percentage. The minimum adjustment is 10%.

a. Add 10% of subtotal if pumps are used to convey leachate.

b. Add 5 % of subtotal if flow volume to POTW is restricted.

c. Add 10% of subtotal if leachate is stored in ponds

d. Add 10% of subtotal if onsite treatment

e. Add 15% if trucking leachate

f. Add 10% if current leachate generation exceeds 5MG/year

Final adjustment factor: 20 %

g. Adjustment (subtotal x factor) \$ 561,260

Total (subtotal + adjustment) \$ **3,367,600**

(Place this total on Summary Cost Worksheet – line 9)

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101544
Heilmandale Expansion**BONDING WORKSHEET J
BORROW AREA CLOSURE**

How do I start? Select a likely "worst case" scenario where you would have a maximum amount of the borrow area open and in need of closure. Provide a description of the scenario with references to site development stages.

1. Size of borrow area 10 acres
2. Volume of material required for regrading: 435,600 ~~CY~~ SF
3. Unit cost to regrade (provide equipment and rates) 1.0 ~~\$/CY~~ SF

Are sufficient soils available to complete job? Yes – off-site stockpiles
(list deficit amount and attach maps that identify sources and stockpiles)

							Processing Req'd	
			Stockpile	Borrow	Onsite	Offsite	Yes	No
4. Earthen Materials								
a. Structural Fill		CY	☐	☒	☐	☒	☐	☐
b. Unit cost to place ¹	<u>6.78</u>	\$/CY						
c. Topsoil	<u>8,100</u>	CY	☐	☒	☐	☒	☐	☐
d. Unit cost to place ¹	<u>6.78</u>	\$/CY						

5. Revegetation Cost

(Seeding rate used: N/A lbs/acre)

(Lime rate used: N/A tons/acre)

(Fertilizer rate used: N/A tons/acre)

(Mulch rate used: N/A tons/acre)

Unit cost to revegetate N/A \$/acre

6. E & S Controls N/A \$/acre
7. Bond Maintenance Cost (required if off-site borrow area) \$ N/A LS
8. Other costs (provide detail) \$ N/A

¹ The unit costs should include all associated costs including, but not limited to cost of material, excavation, transportation, processing and placement.

9. Cost Summary

a. Fill/Regrading (line 2 x line 3)	\$ <u>435,600</u>
b. Structural Fill (line 4a x line 4b)	\$ _____
c. Topsoil (line 4c x line 4d)	\$ <u>54,943</u>
d. Revegetation (line 1 x line 5)	\$ <u>0</u>
e. E & S Controls (line 6)	\$ <u>0</u>
f. Bond maintenance (line 7)	\$ <u>0</u>
g. Other (line 8)	\$ <u>0</u>

Subtotal \$ **490,500**

CQA/Project Management costs (use 5% of subtotal) \$ 24,525

Total \$ **515,000**

(Place this total on Summary Cost Worksheet – line 10)

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET K
FACILITY MAINTENANCE COSTS**

1. Size of facility	<u>362</u> acres
2. Size of waste placement footprint	<u>46.7</u> acres
3. Size of borrow areas on site	<u>0</u> acres
4. Size of leachate ponds on site	<u>0</u> acres
5. Size of sedimentation ponds on site	<u>5.1</u> acres
6. Length of stormwater conveyance ditches	<u>23,700</u> LF
7. Number of years of site management (30 years + closure period)	<u>31</u> years
8. Annual Cost to repair cap and final cover ¹	
a. Acres (use 1% of line 2)	<u>0.47</u> acres
b. Unit cost ² to repair final cover	<u>5,500</u> \$/acre
c. Unit cost ² to repair cap	<u>60,100</u> \$/acre
d. Unit cost ² to repair vegetation	<u>4,000</u> \$/acre
e. Total unit cost (line b + line c + line d)	<u>69,600</u> \$/acre
9. Annual Cost to repair and maintain E&S facilities ¹	
a. Channel repair length (use 3% of line 6)	<u>711</u> LF
b. Sedimentation pond repair volume (use 20% of line 5)	<u>1.0</u> acres
c. Unit cost ² to repair channels	<u>21</u> \$/LF
d. Unit cost ² to repair ponds	<u>1,000</u> \$/acre
e. Total annual cost (line a x line c) + (line b x line d)	<u>15,577</u> \$/YR
10. Annual Cost to repair and maintain leachate ponds ¹	
a. Leachate pond repair volume (use 20% of line 4)	<u>0</u> acres
b. Unit cost ² to repair leachate pond(s)	<u>0</u> \$/acre
11. Annual cost to repair and maintain leachate tanks	
a. Number and size of tanks	<u>1 tank, Size: Million gallon</u>
b. Annual unit cost ¹ to maintain tanks	\$ <u>4,532</u>
12. Annual cost to repair fences and gates (attach details)	\$ <u>200</u> LS

¹ After the site is stabilized, the Department may allow a reduction in these requirements.² Please refer to the instructions. This estimate should reflect unit costs to bring in a contractor to complete the work and should include mobilization, equipment cost, operator costs, material costs and clean-up and inspection costs.

13. Annual cost to maintain site roads

a. Length of site roads ²	<u>7,925</u> LF
b. Annual length of site roads to be repaired (2% of line 13a)	<u>159</u> LF
c. Unit cost to repair roads ¹	<u>125.0</u> \$/LF

14. Cost Summary – Facility Maintenance

a. Cost to repair cap/cover (line 7 x line 8a x line 8e)	\$ <u>1,007,383</u>
b. Cost to maintain E&S facilities (line 7 x line 9e)	\$ <u>482,885</u>
c. Cost to maintain leachate ponds (line 7 x line 10a x line 10b)	\$ <u>0</u>
d. Cost to maintain leachate tanks (line 7 x line 11a x line 11b)	\$ <u>140,504</u>
e. Cost to repair fences and gates (line 7 x line 12)	\$ <u>6,200</u>
f. Cost to maintain site roads (line 7 x line 13b x line 13c)	\$ <u>614,188</u>
Subtotal	\$ <u>2,251,200</u>

1. Please refer to the instructions. This estimate should reflect unit costs to bring in a contractor to complete the work and should include mobilization, equipment cost, operator costs, material costs and clean-up and inspection costs. Costs not incurred annually should be determine and divided among the years between events. The costs should also include replacements of pumps and meters, electricity used (pumps, heat tracing, etc.) valve replacement and sludge disposal.
2. This should include access to all maintenance and monitoring areas including but not limited to the disposal area, ponds, leachate conveyance system, tanks, discharge locations, gas extraction system wells, gas probes, groundwater monitoring system and surface water monitoring points.

Adjustment for maintenance, equipment replacement and contingencies, etc. Please note that these are cumulative and you must add all of the percentages that apply to arrive at the final adjustment percentage. The minimum adjustment is 10%.

- a. Add 5% of subtotal if final slopes or benches have been modified from what is specified in 25 PA Code §273.234(f)
- b. Add 5% of subtotal if more than 30 % stormwater channels are unlined
- c. Add 5% of subtotal if the length of site access roads exceeds 5 miles
- d. Add 10% for mowing

Final adjustment factor: 15 %

- e. Adjustment (subtotal x factor) \$ 337,680

Total (subtotal + adjustment) **\$ 2,588,900**

(Place this total on Summary Cost Worksheet – line 11)

¹ After the site is stabilized, the Department may allow a reduction in these requirements.

² Please refer to the instructions. This estimate should reflect unit costs to bring in a contractor to complete the work and should include mobilization, equipment cost, operator costs, material costs and clean-up and inspection costs.

Date Prepared

July 6, 2018

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

I.D. Number

101544
Heilmandale Expansion**BONDING WORKSHEET L
SUMMARY COST WORKSHEET****Cost Summary - Landfills**

1. Decontaminating the Facility	\$ _____
2. Capping/Closure	\$ <u>5,604,800</u>
3. Groundwater Monitoring System	\$ <u>1,400,200</u>
4. Surface Water Monitoring	\$ <u>688,200</u>
5. Private Water Supply Monitoring	\$ <u>1,370,800</u>
6. Gas Monitoring	\$ <u>113,100</u>
7. Gas Collection and Maintenance	\$ <u>3,248,700</u>
8. Other Monitoring	\$ <u>74,000</u>
9. Leachate Management	\$ <u>3,367,600</u>
10. Borrow Area Closure	\$ <u>515,000</u>
11. Maintenance Costs	\$ <u>2,588,900</u>
12. Other Costs ¹ _____	\$ _____ 0
13. Other Costs ¹ _____	\$ _____ 0
Subtotal	\$ <u>18,971,300</u>

Inflation

14. Inflation rate (projected inflation for the next three years based on the inflation for the prior three years).	_____ 4.0 %
15. Inflation cost for facility (subtotal x line 14)	\$ <u>758,900</u>

Contingency and administrative fees

16. Administrative fees (5%) (subtotal x 0.05)	\$ <u>948,565</u>
17. Project Management (5%) (subtotal x 0.05)	\$ <u>948,565</u>
18. Contingency fee amount (subtotal x rate of contingency fee from Table 1)	\$ <u>1,422,848</u>

Total (subtotal + line 15 + line 16 + line 17 + 18) **\$ 23,050,200**

¹ You should include any costs that would be incurred by the Department, but were not included in these sheets. Provide separate sheets for documentation.

Form 45
Protection of Capacity



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

DEP USE ONLY
Date Received

FORM 45 PROTECTION OF CAPACITY

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided herein. Improperly completed forms may be rejected by the Department, may be considered to be violations of the Department's Rules and Regulations, and may result in assessment of fines and penalties.

General References: Act 101-Section 273.138, 273.222

SECTION A. APPLICANT IDENTIFIER

Applicant Name
Greater Lebanon Refuse Authority

SECTION B. FACILITY INFORMATION

Facility Name: Greater Lebanon Refuse Authority - Heilmandale Expansion

County: Lebanon Township or Municipality North Lebanon, North Annville, Swatara

Instruction: Applications submitted to the Department for the following permits under the Solid Waste Management Act shall include a narrative description of the agreement or arbitration award between the applicant and the county and host municipality for the weight or volume (including rates, terms, or conditions) of municipal waste generated within their boundaries to be delivered for disposal or processing at the proposed facility:

- (1) A permit for a new municipal waste landfill or resource recovery facility.
- (2) A permit that results in additional capacity for a municipal waste landfill or resource recovery facility.
- (3) In the case of an existing facility, a permit modification that results in an increase in the average or maximum daily volume of waste that may be received for processing or disposal at the facility.

Act 101, Section 1111(e) provides two exemptions to the above requirement for an agreement or arbitration award. These are (a) resource recovery facilities financed by the host municipality or municipal authority, and (b) facilities for disposal of ash residue from municipal waste incinerators which, prior to July 28, 1988 agree to provide capacity to all municipalities located within the county and which can be documented to the Department.

SECTION C. ACT 101 REQUIREMENTS

Is the proposed application subject to the requirements of Section 1111 of Act 101? ☒ Yes ☐ No

If no, explain. If yes, complete B. and C. below. This information must be provided on Attached 8½ x 11 inch sheets.

SECTION D. HOST MUNICIPALITY

For the host municipality(ies):

SEE ATTACHED

1. Identify the host municipality(ies):
2. Describe the weight or volume of municipal waste generated within the host municipality that will be delivered to the proposed facility, and the period of time over which such waste will be delivered.
3. Describe the rates, terms, or conditions of the agreement or arbitration award allowing such waste to be delivered, or attach a copy of the agreement or arbitration award.
4. If there is no agreement or arbitration award between the host municipality and the applicant, provide a detailed description of the current status of the negotiations, including a projected date by which an agreement or arbitration award will be reached.

SECTION E. HOST COUNTY

For the host county(ies)

SEE ATTACHED

1. Identify the host county(ies):
2. Describe the weight or volume of municipal waste generated within the host municipality that will be delivered to the proposed facility, and the period of time over which such waste will be delivered.
3. Describe the rates, terms, or conditions of the agreement or arbitration award allowing such waste to be delivered, or attach a copy of the agreement or arbitration award.
4. If there is no agreement or arbitration award between the host municipality and the applicant, provide a detailed description of the current status of the negotiations, including a projected date by which an agreement or arbitration award will be reached.

ORDINANCE NO. 42
LEBANON COUNTY MUNICIPAL WASTE MANAGEMENT ORDINANCE

WHEREAS, the Municipal Waste Planning, Recycling and Waste Reduction Act of July 28, 1988, P.L. 528, No. 101 was approved on July 26 1988; and

WHEREAS, Act 101 gave the County of Lebanon, Commonwealth of Pennsylvania (the "County") primary responsibility for planning for municipal waste processing and disposal within its boundaries and the primary authority to control the flow of municipal waste generated within its boundaries; and

WHEREAS, Act 101 authorizes a County with an approved municipal waste management plan that was submitted under the Act to require that all municipal wastes generated within its boundaries shall be processed or disposed at a designated processing or disposal facility;

WHEREAS, Act 101 authorizes a County, in carrying out its duties under Section 303, to adopt ordinances, resolutions, regulations and standards for the processing and disposal of municipal waste; and

WHEREAS, Section 303 (d) of Act 101 authorizes Counties to enter into a written agreement with another person, including a municipal authority, pursuant to which that person undertakes to fulfill some or all of the County's responsibility under Act 101 for municipal waste planning and implementation of the approved County plan; and

WHEREAS, In the case United Haulers Assn. v. Oneida-Herkimer Solid Waste Management Authority, 127 S.Ct. 1786 (2007) the United States Supreme Court affirmed the right of public solid waste disposal facilities to institute and manage flow control of municipal solid waste; and

WHEREAS, the purpose and requirements of Act 101 will be best carried forth by (a) adopting this Ordinance and (b) entering into an Agreement with Authority ("Municipal Waste Management Agreement") which will empower and require Authority (i) to implement and carry forth the 2010 Plan and (ii) to fulfill certain duties of the County under Act 101.

NOW, THEREFORE, it is hereby enacted and ordained by the County of Lebanon, Commonwealth of Pennsylvania, as follows:

Section 1. Definitions

The following capitalized terms, when used in this Ordinance, shall have the meaning set forth below.

"Act 97". The Solid Waste Management Act, Act of July 7, 1980, P.S. 380, No. 97 as now or hereafter amended.

“Act 101”. The Municipal Waste Planning, Recycling and Waste Reduction Act, Act of July 28, 1988, P.L. 528, No. 101, as now or hereafter amended.

“Authority”. Greater Lebanon Refuse Authority, a municipality authority organized and existing under the Municipality Authorities Act, as amended.

“Authority Rules and Regulations”. The rules and regulations adopted and revised from time to time by the Authority.

“Capacity Assurance”. The promise by the Authority for the capacity agreed to between the County and the Authority for the period between the date of the promise and the end of the Planning Period.

“County”. The County of Lebanon, Commonwealth of Pennsylvania.

“Municipal Waste Management Agreement”. The agreement between the County and the Authority defining and delegating certain of the County’s municipal waste management powers and responsibilities to the Authority, as authorized by Act 101.

“Designated Facility”. Any Municipal Waste storage, collection, transfer, processing or disposal facility or site constructed, owned or operated by or on behalf of the Authority.

“Municipal Waste”. Municipal Waste as defined in Section 103 of Act 101.

“Person”. Any individual, firm, partnership, corporation, association, institution, cooperative enterprise, municipality, municipal authority, governmental entity or agency, or any other legal entity whatsoever which is recognized by law as the subject or rights and duties. In connection with any provisions of the Ordinance prescribing a fine, penalty, imprisonment, denial or grant of any license, or any combination of the forgoing, the term “Person” shall include the officers and directors of any corporation or other legal entity having officers and directors.

“Plan”. The Lebanon County Municipal Waste Management Plan of 2010, as now or hereafter amended.

“Planning Period”. The ten year period for which the plan is written.

“Recycling”. The collection, separation, recovery and sale or reuse of metals, glass, paper, leaf waste, plastics and other materials which would otherwise be disposed or processed as municipal waste or the mechanized separation and treatment of municipal waste (other than through combustion) and creation and recovery of reusable materials other than a fuel for the creation of energy.

“Regulated Municipal Waste”. Any solid waste generated or collected within the County which is garbage, refuse, industrial lunchroom or office waste and other material, including solid, liquid, semisolid or contained gaseous material, resulting from operation or residential, municipal, com-

mercial or institutional establishments and from community activities and any sludge not meeting the definition of residual or hazardous waste under Act 97 from a municipal, commercial or institutional water supply treatment plant, wastewater treatment plant or air pollution control facility. The term does not include Source Separated Recyclable Materials.

“Source Separated Recyclable Materials”. Materials generated or collected within the County that are separated from Municipal Waste at the point of origin for the purpose of recycling. The term is limited to clear glass, colored glass, aluminum, steel and bimetallic cans, high-grade office paper, newsprint, corrugated paper, plastics and other marketable grades of paper.

“System”. The overall municipal waste management system, and every aspect thereof, owned or operated or utilized by or on behalf of the County or the Authority in implementation of the Plan, including without limitation, equipment, vehicles, offices, staff, transfer stations, landfills and the like.

Section 2. Operation by Licensed Collectors; Compliance; Fees.

(a) Licensing. Any Person engaged in the business of collecting, hauling or disposing of Municipal Waste generated in this County shall, prior to engaging in such business or activity, obtain a license for the specific purpose of conducting such business or activities, which license shall be issued and administered by the Authority. No person who is required to be licensed by the Authority to collect Municipal Waste within the System for processing or disposal may collect, transport or dispose of Municipal Waste generated within the County, without a license. Any vehicle licensed by the State of Pennsylvania under “Act 90” shall receive an Authority license upon proper documentation of that license, at no charge.

(b) Compliance with Rules, Regulation and Ordinances. In carrying out activities relating to Municipal Waste collection, transportation or disposal within this County, all Municipal Waste collectors and transporters shall comply with all regulations, rules, and standards pertaining to the collection, transportation, and disposal of Municipal Waste as promulgated by the State, all ordinances, resolutions, rules, regulations and standards pertaining to the collection, transportation and disposal of Municipal Waste as may hereinafter be enacted by this County and all resolutions, rules, regulation and standards adopted by the Authority pursuant to this Ordinance and the Municipal Waste Management Agreement

(c) Fees. The Authority shall have the power to establish and collect a license fee to be paid by any Person applying for such license in accordance with the requirement of this Section 2.

Section 3. Waste Flow Control

(a) Delivery to Designated Facility. Except as provided in (b) and (c) below, all Regulated Municipal Waste shall be delivered to a Designated Facility.

(b) Delivery to Other Sites. Delivery of Regulated Municipal Waste to other sites pursuant to the Plan may occur only as permitted by rule, regulation, ordinance, or order duly issued by the Authority.

(c) Recycling. Nothing herein shall be deemed to prohibit Source Separation or Recycling or to affect any sites at which Source Separation or Recycling may take place.

Section 4. Disposal Capacity

Provision shall be made in the Municipal Waste Management Agreement between the County and the Authority for the Authority to provide Capacity Assurance for the Planning Period.

Section 5. System Administration

(a) Pursuant to the Municipal Waste Management Agreement between the County and the Authority, the Authority shall have the power and its duty shall be to implement the Plan, or as hereafter amended, and this Ordinance and, in order to carry forth such power and duty, to adopt and enforce Authority Rules and Regulations.

(b) Authority Rules and Regulations shall, at a minimum:

(i) identify those categories of materials from Regulated Municipal Waste which shall be subject to site designation;

(ii) identify the Designated Facility for each selected category of Regulated Municipal Waste;

(iii) specify such pre-disposal processing or separation or other requirements as are deemed necessary or convenient for the efficient, effective, reliable and safe operation of a Designated Facility and the System;

(iv) govern the issuance, administration and revocation of licenses, including without limitation, application procedures, fees, standards and conditions for licenses, record and reporting requirements, equipment and vehicle requirements, and any other matters deemed necessary or convenient by the Authority for the efficient, effective, reliable and safe operation of a Designated Facility and the System, including without limitation:

(A) withholding, suspending or revoking licenses; and

(B) establishing fees for use of the System; and

(C) establishing fees and penalties for violations of Authority Rules and Regulations (which fees and penalties may be established as determined by the Authority in an amount designed to protect the System and to compensate the Authority for the costs, damages and lost revenues related to any such violation).

(c) Authority Rules and Regulations shall ensure the efficient, effective, reliable and safe operation of the System. Authority Rules and Regulations shall be consistent with, and shall carry forth, the Plan. All fees shall be reasonable and uniform, provided, however, that different fees may be charged for:

- (i) different categories of Regulated Municipal Waste as established by the Authority;
- (ii) different points of entry into the System.

Section 6. Facilities.

No Person shall use or permit to be used any property owned or occupied by that Person within the County as a Municipal Waste processing or disposal facility for Municipal Waste generated within the County unless such use is authorized pursuant to the provisions of Act 101, and is consistent with, and is reflected in, the Plan.

Section 7. Unlawful Activities; Public Nuisance.

It shall be unlawful for any Person to violate, cause or assist in the violation of any provision of this Ordinance, or violate, cause or assist in the violation of any rule, regulation, resolution or standard promulgated by the Authority pursuant to this Ordinance and the Municipal Waste Management Agreement, or any rules, regulation, resolution or standard promulgated by the County consistent with this Ordinance and the provisions of Act 101 and the Plan. All unlawful conduct shall also constitute a public nuisance.

Section 8. Enforcement and Penalties.

(a) The Authority shall have the power, and its duty shall be, to bring any and all enforcement proceedings authorized by Act 101 or this Ordinance.

(b) Any Person who engages in unlawful conduct as defined in this Ordinance shall, upon conviction thereof, in a summary proceeding before a district justice, be sentenced to pay a fine of Two Thousand Dollars (\$2,000) per occurrence, to be paid to the use of the Authority, with costs of prosecution.

(c) Any Person who engages in unlawful conduct as defined in this Ordinance, shall, in accordance with applicable provisions of the laws of the Commonwealth, be subject to the provisions of Act 101, Chapter 17, as such provisions with respect to enforcement and remedies may apply to any such unlawful conduct.

Section 9. Revocation of License.

Upon finding that any Person has engaged in unlawful conduct as defined in Section 6 of this Ordinance, the Authority may, (a) revoke any license issued by the Authority to the Person and (b) deny any subsequent application by that Person or any Person who or which was, or who or which is, affiliated with, related to, or controlled by, any Person who was, at the time of commitment of such unlawful conduct, or any time thereafter, an officer, director, shareholder, partner, or joint venturer of, under contract with, employed by, or related or affiliated in any manner with such Person, for issuance of this license required by Section 2 hereof.

Section 10. Injunctions; Concurrent Remedies.

(a) Restraining Violation. In addition to any other remedy provided in this Ordinance, the County or the Authority may institute a suit in equity where unlawful conduct or a public nuisance exists as defined in this Ordinance for an injunction to restrain a violation of this ordinance or of any rules, regulations, resolutions, or standards promulgated or issued by the County pursuant to this Ordinance and the Municipal Waste Management Agreement.

(b) Concurrent Remedies. The penalties and remedies prescribed by this Ordinance shall be deemed concurrent. The existence or exercise of any remedy shall not prevent the County or the Authority from exercising any other remedy provided by this Ordinance or otherwise provided at law or equity.

Section 11. Construction.

The terms and provisions of this Ordinance are to be liberally construed, so as best to achieve and to effectuate the goals and purpose hereof. This Ordinance shall be construed in pari materia with Act 97 and Act 101.

Section 12. Municipal Ordinances.

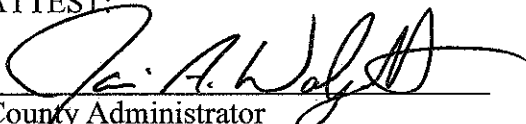
Pursuant to Section 304(d) of Act 101, the provisions of this Ordinance shall supersede the provisions of any municipal ordinance to the extent that the provisions of any such municipal ordinance are inconsistent with, or conflict with, the provisions of this Ordinance, except as otherwise provided by Section 502(0) of Act 101.

Section 13. Severability.

If any sentence, clause, section or part of this Ordinance is for any reason found to be unconstitutional, illegal or invalid, such unconstitutionality, illegality or invalidity shall not affect or impair any remaining provisions, sentences, clauses or parts of this Ordinance. It is hereby declared as the intent of the Lebanon County Board of Commissioners that this Ordinance would have been adopted had such unconstitutional, illegal or invalid sentence, clause, section or part thereof had not been included herein.

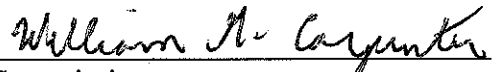
Enacted this 24th day of February 2011 and included in the minutes of a regular meeting of the BOARD OF COUNTY COMMISSIONERS.

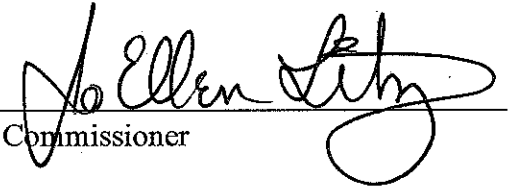
ATTEST:


County Administrator

SIGNATURE:


Commissioner


Commissioner


Commissioner



FORM 54 BACKGROUND METEOROLOGICAL MONITORING

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 54, reference the item number and identify the date prepared. The "date prepared/revised" on any attached sheets needs to match the "date prepared/revised" on this page.

General References: Chapter 273.136 and 277.136; February 2000 EPA document, "Meteorological Monitoring Guidance for Regulatory Modeling Applications," EPA-454/R-99-005, <http://www.epa.gov/scram001/guidance/guide/mmgrma.pdf>.

SECTION A. SITE IDENTIFIER

Applicant/permittee: Greater Lebanon Refuse Authority

Site Name: GLRA Municipal Waste Landfill

Facility ID (as issued by DEP): 101544

SECTION B. TYPE OF FACILITY

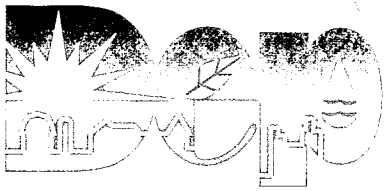
☐ New Municipal Waste Landfill ☐ New Construction/Demolition Waste Landfill	☒ Existing Municipal Waste Landfill ☐ Existing Construction/Demolition Waste Landfill ☒ Expansion or Increase in Daily Volume of a Municipal Waste Land ☐ Expansion or Increase in Daily Volume of a Construction/Demolition Waste Landfill

SECTION C. DATA COLLECTION PROTOCOL

A permit application for construction of a new landfill, or for an expansion in capacity or daily volume of an existing landfill, must include a determination of normal and adverse weather conditions based on site-specific meteorological data for odors. Prior to the installation of equipment and collection of meteorological data, a protocol for the installation and data collection shall be approved by the Department. One year of meteorological data is required, unless a shorter period of time is approved by the Department. In addition, on existing landfill can install meteorological equipment at anytime as part of a minor permit modification. This form must be completed and submitted as part of the minor permit application.

A data collection protocol shall include the following:

1. Indicate the proposed data collection point as latitude and longitude.
2. When will data collection begin and end?
3. Describe instruments used for monitoring. The data collection device must, at a minimum, measure wind speed and direction and record the information electronically on an hourly basis.
4. Describe how data will be collected.
5. Describe how the data will be processed and quality assured.



Pennsylvania Department of Environmental Protection

909 Elmerton Avenue
Harrisburg, PA 17110-8200

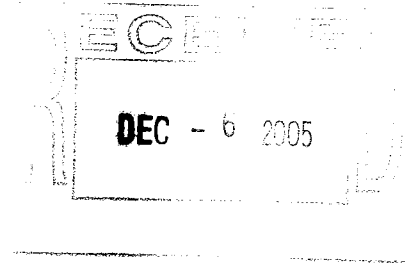
DEC - 1 2005

Southcentral Regional Office

717-705-4706
FAX - 717-705-4930

CERTIFIED MAIL NO. 7002 2030 0007 9115 9910

Mr. Lawrence D. Taylor, Staff Engineer
Greater Lebanon Refuse Authority
1610 Russell Road
Lebanon, PA 17046-1427



Re: Minor Permit Modification - Metrological Monitoring
Greater Lebanon Refuse Authority
Permit No. 101544
APS ID No. 565971
North Lebanon & North Annville Townships
Lebanon County

Dear Mr. Taylor:

Enclosed is a minor permit modification to Solid Waste Permit No. 101544 for the operation of Greater Lebanon Refuse Authority, issued in accordance with Article V of the Solid Waste Management Act, 35 P.S. Sections 6018.101, et seq.

This modification approves the construction and operation of a metrological monitoring station.

Compliance with the terms and conditions set forth in the permit is mandatory. You have the right to file an appeal as to these terms and conditions.

Any person aggrieved by this action may appeal, pursuant to Section 4 of the Environmental Hearing Board Act, 35 P.S. Section 7514, and the Administrative Agency Law, 2 Pa. C.S. Chapter 5A, to the Environmental Hearing Board, Second Floor, Rachel Carson State Office Building, 400 Market Street, PO Box 8457, Harrisburg, PA 17105-8457, 717-787-3483. TDD users may contact the Board through the Pennsylvania Relay Service, 800-654-5984. Appeals must be filed with the Environmental Hearing Board within 30 days of receipt of written notice of this action unless the appropriate statute provides a different time period. Copies of the appeal form and the Board's rules of practice and procedure may be obtained from the Board. The appeal form and the Board's rules of practice and procedure are also available in braille or on audiotape from the Secretary to the Board at 717-787-3483. This paragraph does not, in and of itself, create any right of appeal beyond that permitted by applicable statutes and decisional law.



Mr. Lawrence D. Taylor

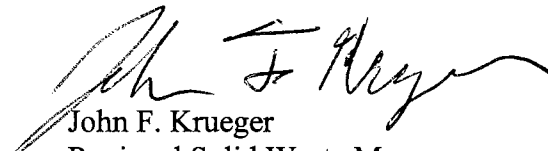
- 2 -

IF YOU WANT TO CHALLENGE THIS ACTION, YOUR APPEAL MUST REACH THE BOARD WITHIN 30 DAYS. YOU DO NOT NEED A LAWYER TO FILE AN APPEAL WITH THE BOARD.

IMPORTANT LEGAL RIGHTS ARE AT STAKE, HOWEVER, SO YOU SHOULD SHOW THIS DOCUMENT TO A LAWYER AT ONCE. IF YOU CANNOT AFFORD A LAWYER, YOU MAY QUALIFY FOR FREE PRO BONO REPRESENTATION. CALL THE SECRETARY TO THE BOARD (717-787-3483) FOR MORE INFORMATION.

If you have any questions about the enclosed permit or requirements of the Solid Waste Management Act, please call Mr. Ajaz Uddin at 717-705-4706.

Sincerely,



John F. Krueger
Regional Solid Waste Manager
Waste Management Program

Enclosure(s)

cc: North Lebanon Township
North Annville Township
Lebanon County Planning Department

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTE MANAGEMENT PROGRAM
SOUTHCENTRAL REGION

FORM NO. 13-A

MODIFICATION TO SOLID WASTE DISPOSAL AND/OR PROCESSING PERMIT

Under the provisions of Act 97, the Solid Waste Management Act of July 7, 1980, as amended, Solid Waste Permit Number 101544, issued on March 18, 1983 to:

Greater Lebanon Refuse Authority
1610 Russell Road
Lebanon, PA 17046-1427

North Lebanon and North Annville Townships, Lebanon County

is hereby modified as follows:

- ° This permit modification is issued based upon the following submission:
 1. Application for Minor Permit Modification, prepared by Gannett Fleming, received October 14, 2003, consisting of the following:
 - Form GIF, General Information Form
 - Form A, Application for Municipal Waste Permit
 - Form B, Professional Certification
 - Form B-1, Application for Certification
 - Form C-1, Compliance History Certification
 - Form 54, Background Meteorological Monitoring
 - Sheet No. 1 of 1, Project Location
 - Supporting Information

This modification shall be attached to the existing Solid Waste Permit described above and shall become a part thereof effective on DEC - 1 2005.



FOR THE DEPARTMENT OF ENVIRONMENTAL PROTECTION

Permit Conditions:

1. Greater Lebanon Refuse Authority will install and maintain its background meteorological monitoring instruments in accordance with the procedures outlined in its October 13, 2005 Application for a Minor Permit Modification Construction of Meteorological Monitoring Station.
2. Greater Lebanon Refuse Authority will maintain its hourly averaged wind speed and wind direction records for the lifetime of the facility.
3. Nothing herein shall be construed to supersede, amend or authorize violation of the provisions of any valid and applicable local law ordinance, or regulation, provided that said local law, ordinance or regulation is not preempted by the Pennsylvania Solid Waste Management Act, the Act of July 7, 1980, Act 97, 35 P.S. § 6018.101, et seq.

FORM 54
BACKGROUND METEOROLOGICAL MONITORING
PERMIT APPLICATION

Applicant/Permittee: GREATER LEBANON REFUSE AUTHORITY
Site Name: GREATER LEBANON REFUSE AUTHORITY
Facility ID (as issued by DEP): 101544

SECTION C. DATA COLLECTION PROTOCOL

1. The data collection point will be located at Lat 40 deg 22 min 4 sec and Long 76 deg 29 min 36 sec (See attached Topographic map and site specific map).

2. The data will be collected as a continuous year round collection during the life of the facility and post-closure monitoring period.

3. Instrument Description:

The meteorological station's 40 foot tower will collect data from the following instruments: three-cup anemometer with wind vane, thermometer, and tipping rain bucket. The required anemometer/wind vane will be utilized to measure wind speed at an accuracy of ± 0.2 m/s + 5% of observed, and wind direction at an accuracy of ± 5 degrees. Instruments appropriate for collection of temperature data, barometric data, and rainfall will be selected for those purposes as well.

4. Describe how data will be collected.

Data will be averaged over a minimum of a one hour periods from data sampled every second and stored on a tower mounted datalogger. Data will then be downloaded to data storage on the GLRA network via either a short haul modem, ethernet, or wireless interface and made available to appropriate workstations. Data download will occur Monday through Friday during normal business hours and archived accordingly. A 5 year archive of data will be maintained.

5. Describe how the data will be processed and quality assured.

On a daily basis, equipment functionality and data will be reviewed and summarized by office personnel. Observed malfunctions will be brought to the attention of the Superintendent/Asst. Superintendent for corrective action or service by appropriate personnel. Instrument readings will be in compliance with manufacturer's instructions and or EPA guidelines, and verified by an Annual Audit for Quality Assurance purposes. The Quality Assurance Plan is contained at Appendix A

FORM 54
BACKGROUND METEOROLOGICAL MONITORING
PERMIT APPLICATION

Applicant/Permittee: GREATER LEBANON REFUSE AUTHORITY
Site Name: GREATER LEBANON REFUSE AUTHORITY
Facility ID (as issued by DEP): 101544

DATA COLLECTION PROTOCOL

SITE DESCRIPTION:

Situated in North Lebanon Township, Lebanon County, the Greater Lebanon Refuse Authority is an existing municipal waste landfill, founded in 1957. Today, the GLRA is responsible for managing an extensive solid waste disposal system for the south-central DEP region that is in accordance with the 1990 Lebanon County Solid Waste Management Plan. The GLRA operates the County's solid waste disposal facility in a manner that protects the health and safety of Lebanon County residents and the quality of our environment.

The GLRA is located in the Lebanon Valley, an area between South Mountain, which rises to an elevation of 800-1000 feet, and the Blue Mountain Chain, which rises to an elevation of 1300-1500 feet¹.

As a humid continental region, Lebanon's climate is dependent on the slow-reacting temperature changes of the Atlantic Ocean, which results in few extremes occurring. Summer temperatures are moderate, with daytime highs reaching in the 80's and nighttime temperatures hitting approximately 60°. Cloud cover is low in the summer season, with Lebanon receiving a little over half of the possible sunshine. Summer rainfall occurs mostly in the late afternoon or early evening. Winters in Lebanon are fairly cold, with daytime temperatures reaching the 30's and nighttime temperatures dipping into the 20's. There are two types of snowfall that occur in Lebanon: deep lows that form off the coasts of the Carolinas and low pressure disturbances that form in the Mississippi Valley. The first storm normally occurs in December and is usually less than 10 inches¹.

Lebanon's rainfall is distributed fairly evenly throughout the year, with spring and summer accounting for 55% of the years total. Lebanon's average annual precipitation is 37 inches¹.

¹ "Lebanon County Climate". http://www.ems.psu.edu/PA_Climatologist/lebanon/

MONITOR LOCATION: (See attached Topographic Map Sheet and Site Plan)

Latitude and Longitude of Monitor: Lat 40 deg 22 min 4 sec

Long 76 deg 29 min 36 sec

INSTRUMENT DESCRIPTION AND LOCATION:

The meteorological station's 40 foot tower will collect data from the following instruments: three-cup anemometer with wind vane, thermometer, and tipping rain bucket. The mandatory anemometer/wind vane will be utilized to measure wind speed at an accuracy of $\pm 0.2 \text{ m/s} + 5\%$ of observed, and wind direction at an accuracy of ± 5 degrees. Instruments appropriate for collection of temperature data, barometric data, and rainfall will be selected for those purposes as well.

The main purpose of siting instruments is to place the instrument in a location where accurate measurements are able to be taken that represent the state of the atmosphere in a specific area, and are consistent with the data collection program objectives. In addition the instruments should be placed in a secure location, visible to staff on a daily basis for monitoring purposes, appropriately sited to accurately measure the desired parameters. The location selected is within the facility fenced perimeter, adjacent to the maintenance facility for observation purposes. The first siting priority to consider is the criteria for wind instrumentation.

"The standard exposure of wind instruments over level, open terrain is 10 meters above the ground"², yet, ideal measurement height may vary according to data needs. The definition of open terrain is an area where the horizontal distance between the instrument and any obstruction is at least ten times the height of the obstruction. An obstruction may be natural (tree, hedges, etc.) or man-made (buildings, for example). The required wind instrument will also be securely mounted on a non-rotating mast, which will ensure a quality reading. In this permit application the critical, required component, is wind speed and direction. The location of this instrument must take into account not only currently existing structures, but the design elevation of the landfill cell. This information is included on the Site plan (attached). The design elevation of the wind sensor is approximately 493 ft. msl; that of the landfill (see drawing) at approximately 620 ft. msl. The minimum separation distance is therefore approximately 1270 ft. The site selected satisfies this requirement, as well as the same criteria applied to other distant obstructions. While the tower location should be four times the height of the building away, power and communications considerations were considered in the site selection. The site selected will allow hard wiring power and communications to the equipment. The site selected is 192 feet away from the maintenance facility (elev. 474, height above local ground 23 feet). While 10 times the height of this obstruction would be 230 feet, this location seems an acceptable compromise considering the elevation difference of 14 feet between the ground elevation and the top of the building. Other obstructions reviewed immediately contiguous to the site were a cyclone

² World Meteorological Organization, 1971.

fence and power lines with transmission poles. While they are less than the required siting distance they were considered acceptable compromises.

Solar arrays and wireless communication were not considered a cost effective solution when consideration is given to the desire for data “at will” during the working day.

Other optional instruments that are being included in the meteorological tower involve temperature, humidity, and precipitation. As with the wind instrument, each has a specific siting requirement.

Humidity and temperature sensors are recommended to be mounted over a plot of level, open ground at least nine meters in diameter. This ground surface should be covered with either soil or short, unwatered grass. The surface will not be constructed of asphalt or concrete. The sensors will not be any closer to obstructions than a distance four times their height. They will be at least 30 meters from large, paved areas and not close to steep slopes, hollows or ridges. It is the intent of this application to mount the instruments on the tower in accordance with manufacturers recommendations.

The precipitation gauge is to be mounted on level ground so that the opening of the instrument is horizontal. The gauge is to be shielded from the wind but not put into an area where there will be extreme disturbance caused by the shield. Obstructions to the wind will not be closer than two to four times the obstruction height from the instrument. The ground surface around the rain monitor will be soil or vegetation. It will not be paved as this may cause splashing into the gauge, which will result in an inaccurate reading. The gauge will be mounted a minimum of 30 centimeters above the ground and should be high enough so that it will not be covered by snow. It is the intent of this application to mount the precipitation gauge on the tower in accordance with the manufacturer’s recommendations.

DATA COLLECTION AND ARCHIVING:

Data will be averaged over a minimum of a one hour periods from data sampled every second and stored on a tower mounted datalogger. Data will then be downloaded to data storage on the GLRA network via either a short haul modem, ethernet, or wireless interface and made available to appropriate workstations. Data download will occur Monday through Friday during normal business hours and archived accordingly. A 5 year archive of data will be maintained.

QUALITY ASSURANCE/CONTROL PLAN:

As necessary, equipment functionality and data will be reviewed and summarized by office personnel. Observed malfunctions will be brought to the attention of the Superintendent/Asst. Superintendent for corrective action or service by appropriate personnel. Instrument readings will be in compliance with manufacturer’s instructions and

or EPA guidelines, and verified by an Annual Audit for Quality Assurance purposes. The Quality Assurance Plan is contained at Appendix A.

APPENDIX A
QUALITY ASSURANCE/QUALITY CONTROL PLAN
FOR METEOROLOGICAL MONITORING

Greater Lebanon Refuse Authority
North Lebanon Township, Lebanon County

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1.0 Overview of Monitoring Program

1.1 Purpose and Objective

1.1.1 Purposes: GLRA intends to monitor local weather conditions utilizing standard equipment that meets or exceeds USEPA Meteorological Monitoring Standards. The data will be used to analyze and maintain accurate meteorological information.

1.1.2 Objective: Collect and record accurate data in a usable format

1.2 **Siting of Station:** The GLRA is located in the Lebanon Valley, an area between South Mountain, which rises to an elevation of 800-1000 feet, and the Blue Mountain Chain, which rises to an elevation of 1300-1500 feet. As a humid continental region, Lebanon's climate is dependent on the slow-reacting temperature changes of the Atlantic Ocean, which results in few extremes occurring. Summer temperatures are moderate, with daytime highs reaching in the 80's and nighttime temperatures hitting approximately 60°. Cloud cover is low in the summer season, with Lebanon receiving a little over half of the possible sunshine. Summer rainfall occurs mostly in the late afternoon or early evening. Winters in Lebanon are fairly cold, with daytime temperatures reaching the 30's and nighttime temperatures dipping into the 20's. There are two types of snowfall that occur in Lebanon: deep lows that form off the coasts of the Carolinas and low pressure disturbances that form in the Mississippi Valley. The first storm normally occurs in December and is usually less than 10 inches.

Lebanon's rainfall is distributed fairly evenly throughout the year, with spring and summer accounting for 55% of the year's total. Lebanon's average annual precipitation is 37 inches.

PROPOSED MONITOR LOCATION:

Latitude and Longitude of Monitor: Lat 40 deg 22 min 4 sec
Long 76 deg 29 min 36 sec

1.3 Equipment: Instruments appropriate for collection of temperature data, barometric data, wind speed, wind direction and rainfall will be installed on a 10 meter tower.

1.4 Data Processing: Equipment functionality and data will be reviewed and summarized. Instrument readings and sitings will be in compliance with both the manufacturer's instructions and EPA guidelines.

1.5 QA Program Review and Organization: The program will be maintained by the engineering staff with cooperation from the Executive Director and Superintendent. The program will be reviewed for effectiveness at least annually or as needed.

2.0 Calibrations

2.1 Wind Speed Sensor: The unit can be returned to the manufacturer on an annual basis. A verification of generated rotation rate by comparison to a

phototachometer of frequency counter may be performed on a quarterly basis. Any motors or drives may be returned to the manufacturer on an annual basis for certification. All certifications/recalibrations will be performed using manufacturer's recommendations.

- 2.2 Wind Direction Sensor: Various methods exist for verifying/calibrating wind direction sensors. Instrument will be verified/calibrated per manufacture's recommendation.
- 2.3 Air Temperature Sensor: The thermometer and thermocouple shall be certified annually by an independent certification process.
- 2.4 Barometer: The barometer shall be certified annually by an independent certification process.
- 2.5 Precipitation Gauge: The gauge will be certified annually or in accordance with the manufacture's recommendations by an independent certification process.
- 2.6 Relative Humidity Sensor: The gauge will be certified annually or in accordance with the manufacture's recommendations by an independent certification process.

3.0 Quality Control/Quality Assurance

- 3.1 Wind Speed Sensor: The unit purchased will be factory certified to the referenced standards. Immediately following installation an independent firm capable of assuring operation of the Wind Speed Sensor on the tower will test the instrument in place and provide documentation of operation. The unit will then be placed in operation. Prior to removal from the tower the instrument will again be tested in place to provide assurance for the data collected.
- 3.2 Wind Direction Sensor: The unit purchased will be factory certified to the referenced standards. Immediately following installation an independent firm capable of assuring operation of the Wind Direction Sensor on the tower will test the instrument in place and provide documentation of operation. The unit will then be placed in operation. Prior to removal from the tower the instrument will again be tested in place to provide assurance for the data collected.
- 3.3 Air Temperature Sensor: Sensor will be checked against a certified thermometer by an independent firm prior to being placed in operation and before being removed from operation.
- 3.4 Barometer: Barometer will be verified prior to being placed in operation and before being removed from operation against certified equipment by an independent firm.
- 3.5 Precipitation Gauge: The unit purchased will be factory certified to the referenced standards. Immediately following installation an independent firm capable of assuring operation of the Precipitation Gauge on the tower will test the instrument in place and provide documentation of operation. The unit will then be placed in operation. Prior to removal from the tower the instrument will again be tested in place to provide assurance for the data collected.
- 3.6 Relative Humidity Sensor: Relative Humidity Sensor will be verified against certified equipment by an independent firm prior to being placed in operation and before being removed from operation.
- 3.7 Data Verification

- 3.7.1 Data will be verified for quality and anomalies. Should data not appear to be correct, Routine Station Checks will be performed by facility personnel in accordance with manufacturer's recommendations.

4.0 Preventative Maintenance

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- 4.3 Temperature Sensor: Per manufacturer's recommendations.
- 4.4 Barometer: Per manufacturer's requirements.
- 4.5 Precipitation Gauge: Per manufacturer's recommendations.
- 4.6 Relative Humidity Sensor: Per manufacturer's recommendations.
- 4.7 Naturally Aspirated Shield: Per manufacturer's recommendations.

5.0 Routine Station Checks

- 5.1 Wind Speed Sensor: Check to see the cups are turning.
- 5.2 Wind Direction Sensor: Check to see that the data appears reasonable.
- 5.3 Air Temperature Sensor: Check to see that data appears reasonable. If necessary check sensor against NIST certified thermometer.
- 5.4 Barometer: Check readings against facility barometer.
- 5.5 Precipitation Gauge: Check funnel and screen, and remove any debris.
- 5.6 Relative Humidity Sensor: Check to see that data appears reasonable. Check sensor filter for dirt/dust. If necessary check sensor against sling psychrometer. Clean or replace as necessary.
- 5.7 Naturally Aspirated Shield: Check for unobstructed air flow.