Golder Associates Inc.

1951 Old Cuthbert Road, Suite 301
Cherry Hill, NJ 08034
Telephone (856) 616-8166
Fax (856) 616-1874

15.4
10/18/00

Golder Associates

FINAL CAP DESIGN REPORT
LEMON LANE LANDFILL
BLOOMINGTON, INDIANA

Prepared for:

CBS Corporation
Bloomington Project
11 Stanwix Street
Pittsburgh, Pennsylvania 15222

Prepared by:

Golder Associates Inc.
1951 Old Cuthbert Road, Suite 301
Cherry Hill, New Jersey 08034

DISTRIBUTION:

2 Copies	USEPA
5 Copies	CBS Corporation
2 Copies	Indiana Dept. of Environmental Management
1 Copy	Monroe County Health Department
1 Copy	City of Bloomington
1 Copy	Tetra Tech EM Inc.
1 Copy	Earth Tech
2 Copy	PSARA Technologies, Inc.
2 Copies	WRS Infrastructure & Environment, Inc.
2 Copies	Golder Associates

October 18, 2000

Project No.: 993-6573

TABLE OF CONTENTS

1.0 INTRODUCTION

CBS Corporation (formerly known as Westinghouse Electric Corporation) has retained Golder Associates Inc. (Golder Associates) to design a RCRA Subtitle C landfill cap for the Lemon Lane Landfill (Site). The cap system has been designed to comply with the substantive requirements of RCRA Subtitle C as specified in 40 CFR 264.310(a) and is a component of the proposed remedial action at the Site, which also involves waste excavation, off-Site disposal and on-Site waste consolidation.

The Remedial Design/Remedial Action (RD/RA) Work Plan (Work Plan) for the Site was submitted for Agency review by CBS Corporation on March 10, 2000. The Work Plan contained a conceptual design of the proposed landfill cap system including preliminary design drawings and design calculations, technical specifications and drawings relating to the waste excavation. Following receipt of Agency review comments, a revised Work Plan was submitted on May 3, 2000. The revised work plan contained no significant modifications to the proposed landfill cap system cross section and conceptual design. On May 17, 2000 the approved Final RD/RA Work Plan was issued by CBS.

This report serves as the Final Design submittal for the landfill cap system and presents detailed design calculations, technical specifications and design drawings. No significant modifications have been made to the cap design approach since the Work Plan was submitted. It should be noted that the proposed footprint of the cap system has been modified from that contained within the Work Plan submittal as described in the Section 3.0, Cap Limits.

This report comprises Volume I of the Final Design submittal. The following sections provide a brief summary of the information presented in the Work Plan relating to the cap design and provides a description of the site specific design calculations that have been performed for the Pre-Final design submittal. The detailed design calculations are contained within Appendices A through F. The Construction Quality Assurance (CQA) Plan is presented in Appendix F and the Technical Specifications are presented in Appendix G. The design drawings are presented in Volume II of this report.

2.0 CAP SECTION

The proposed landfill cap cross section was presented in the Work Plan and has not been modified in the Final Design. A cross section of the cap system is presented on Drawing 6, Cap Section and Transition Details, and consists of the following components (from top to bottom):

- A 24-inch protective cover and vegetative support layer consisting of 6 inches of topsoil and 18 inches of general soil fill;
- A prefabricated geocomposite drainage material consisting of geonet drainage media sandwiched between two layers of geotextile; and,
- A composite barrier layer consisting of a geomembrane and geosynthetic clay liner (GCL) with a maximum permeability of 1×10^{-8} cm/sec. A 40-mil flexible polyethylene membrane liner or equivalent will be used as the geomembrane component.

Consolidated waste material will be placed in controlled lifts and compacted to minimize post-construction settlement and achieve a firm surface for the geosynthetic cap as described in the Work Plan. Following compaction of the consolidated waste material, a soil layer with a minimum thickness of 12 inches will be placed and compacted above the waste surface to provide a cushion soil layer for the geosynthetic materials. This soil layer may be increased in thickness in localized areas to enhance site grading for drainage purposes. Soil used for the cushion layer may be obtained from an offsite borrow area, from the borrow area adjacent to the Site or from the bedding soil layer that currently lies below the existing Hypalon geomembrane.

Prior to placing the cushion soil and geosynthetic materials, the surface of the waste material will be graded to facilitate positive drainage from the cap system and to achieve the final required grades. The final waste surface will be inspected for objects that may damage the geosynthetics and if encountered, such material will be removed and buried within the waste at an appropriate depth.

3.0 CAP LIMITS

The anticipated limits of waste consolidation are presented on Drawing 2, Limit of Waste Consolidation. Waste outside the limits of consolidation will be excavated and disposed off-Site or consolidated within these limits in accordance with the Work Plan. The limits of waste consolidation have been modified from those presented in the approved final RD/RA Work Plan, resulting in a reduced waste consolidation area and associated cap area.

The cap system has been designed to encapsulate all waste material remaining on-site following waste excavation and waste consolidation. The limits of waste consolidation and associated cap grading presented on Drawings 2 and 4, respectively, are the currently estimated limits for these boundaries. It is likely that some modification to these proposed grades will occur during construction based on actual quantities of waste to be consolidated. Following field delineation of the final limits of waste consolidation, the RCRA cap will be constructed to encapsulate the waste material. No groundwater monitoring wells will be located within the limits of waste consolidation. The final as-built surveyed limits of waste and cap will be presented in the Construction Completion Report.

4.0 CAP GRADING

In accordance with the criteria outlined in the Work Plan, waste material will be excavated and either permanently disposed of off-Site or consolidated onsite within the defined limits of waste consolidation, as presented on Drawing 2, Limit of Waste Consolidation. The final landfill configuration will be largely dependent on the volume of waste material to be consolidated under the RCRA cap and as such cannot be ultimately determined until excavation and consolidation of the waste material is complete. However, it is anticipated that the final cap slopes will not exceed 25% and will be no flatter than 5%.

In order to develop proposed cap grades, it was necessary to prepare a preliminary estimate of the volume of waste material to be excavated and consolidated onsite. The total estimated volume of excavation is approximately 75,000 cubic yards (c.y.) which includes hot-spot excavation, non hot-spot excavation and excavation of the Hypalon bedding soil that currently lies between the Hypalon liner and the waste material. To estimate the volume of waste material to be consolidated onsite, it was assumed that all waste generated from the hot-spot excavation would be disposed offsite. In addition, it was assumed that the Hypalon bedding soil will be carefully excavated and stockpiled for use below the proposed geosynthetic cap, allowing six inches of this soil material to remain in-place above the waste material. Based on these assumptions, a volume of waste material to be consolidated onsite of approximately 24,000 c.y has been estimated. The actual depths of excavation and the levels of contamination of the excavated materials will ultimately determine the volume of waste material that will be consolidated.

A cap grading plan was developed to accommodate the estimated volume of waste material to be consolidated on-site and is presented as Drawing 3, Cap Subgrade Plan. This grading plan shows a 15% sideslope on the majority of the cap perimeter with a 9% plateau and provides a storage volume of approximately 25,000 c.y. above the proposed excavation grades within the limits of waste consolidation. This volume accommodates the estimated 24,000 c.y. of waste to be consolidated on-site. The grades presented on Drawing 3 include a 12-inch thick soil layer placed above the waste material, however, the storage volumes presented above apply to consolidated waste material only.

As the final waste volume to be consolidated onsite will not be known until excavation is completed, the proposed grading plan provides sufficient flexibility to accommodate a range of waste volumes that could potentially be generated. Several other cap grades were evaluated using the same cap footprint based on the anticipated need for flexibility to accommodate varying waste volumes. By varying the slope of the plateau area from 5% to 10%, corresponding storage volumes ranging from approximately 1,000 c.y. to 30,500 c.y. can be achieved above the proposed excavation grades within the limits of consolidation. Therefore, the proposed grading plan affords the flexibility that is essential in order to reconcile cut and fill volumes during construction.

The area beyond the cap will be graded to accommodate drainage of cap runoff and run-on of offsite surface water. Backfill required to grade beyond the limits of consolidation will be obtained from the onsite borrow area. The restoration of the borrow area is described on page 7 of Technical Specification 02220.

Upon completion of waste excavation, consolidation and cap grading, the final constructed grades will be surveyed and presented in the as-built record drawings as a part of the Construction Completion Report.

5.0 STORMWATER MANAGEMENT

5.1 Proposed Conditions

An overview of the proposed Site drainage features is shown on Drawing 7, Stormwater Management Plan. The final cap grading pattern features a drainage divide running east-west in the middle of the reduced cap footprint. The stormwater runoff from the cap footprint is intercepted at the edge of the landfill cap by a perimeter channel. The perimeter channel also intercepts run-on to the Site from Lemon Lane Road and the drainage area east of the Site. The perimeter channel is rip-rap lined and trapezoidal in shape with a minimum depth of 2 feet and a base width of 6 feet around the majority of the perimeter. The rip-rap is underlain by a non-woven geotextile and the cap geomembrane is extended under the channel. The perimeter channel base width may be reduced to 4 feet over a portion of the eastern perimeter of the site, where the flows are reduced. If this adjustment is made during construction the final location and dimensions of the perimeter channel will be recorded on the as-built drawings. A typical perimeter channel detail is shown on Drawing 10 and a typical transition detail with the cap is shown on Drawing 6.

The perimeter channel discharges surface water to the expanded southwest basin (basin) at two locations via a rip-rap energy dissipator. The basin will be lined with a low permeability geosynthetic liner system. The liner system will have an 18 inch thick cover consisting of a 12 inch thick soil layer overlain by a 6 inch thick vegetated soil layer on basin sideslopes or a 6 inch thick rip-rap surface armoring layer on the basin bottom. Corresponding calculations for the basin liner are attached in Appendix C. The stormwater from the basin discharges via a concrete storm inlet and a 24-inch reinforced concrete pipe to Sargent's Pond. A reno mattress lined channel is provided as the discharge point to Sargent's Pond. Details for the basin and associated outlet structures are shown on Drawings 8, 9, and 10.

At two locations along the perimeter channel, access roads are proposed to allow future access to the capped area for inspections and maintenance. Stormwater in the perimeter channel traverses the crossings via reinforced concrete culverts, as shown on Drawings 4 and 7. Details of culvert crossings are presented on Drawing 9. The capacity of the existing 24 inch culvert that currently drains runoff from a portion of the site towards Sargent's Pond was checked with respect to the proposed condition. Appendix A.8 presents calculations indicating that this culvert conveys the peak flow from the 10 year and 25 year, 24 hour design storm events, without over topping the site access road.

A perimeter drainage V-ditch will be constructed on the east side of the site along the boundary to the Griffin property and also along the extreme south edge of the site parallel to the railroad tracks. This V-ditch will intercept the flow of run-on water across the southeast portion of the site and will drain towards and merge with the perimeter channel on the southern perimeter of the Site. Drawing 10 contains a cross section of the V-ditch and Appendix A5 presents corresponding design calculations.

The final location and routing of the stormwater drainage features may vary based on additional information obtained during remediation and subsurface investigation. The final location of the stormwater drainage features will be recorded on the as-built drawings.

5.2 Surface Water Analysis

In order to determine the size of the proposed channels, culverts, and basins, the design flow for each proposed feature was developed using methods outlined in Technical Release 55 (TR-55) entitled, "Urban Hydrology for Small Watersheds," developed by the Soil Conservation Service in 1987. This method included developing the runoff curve number, time of concentration and contributing drainage area (or watershed) for the proposed conditions. This information is provided to the corresponding computer program along with the rainfall depth for the storm event being simulated. For this project, the 25-year, 24-hour design storm event with a rainfall depth of 5.0 inches was used. The results of the TR-55 analyses, provided in Appendix A, include the peak runoff rate, as well as a complete runoff hydrograph for each watershed. The peak runoff rate for each watershed was used to determine the minimum size of the proposed channels. This rate and a desired channel geometry were input into an Excel Spreadsheet which implements Manning's equation for open channel flow. The designed channel capacity was further checked for the 100-year, 24-hour storm event. The channel was not overtopped by this critical storm event. These analyses can be found in Appendix A.

The expanded southwestern basin was designed to be a retention basin after completion of construction (i.e., when all permanent erosion control measures are in place/established). The runoff hydrographs for the watersheds were routed through the Basin using the computer software

"POND2" developed by Haestad Methods, Inc. in 1989. POND2 implements the Storage Indication Method of hydrologic routing. The size of the outlet structure for the Basin was selected such that the Basin would retain the approximately 82% of 10-year, 24-hour storm event. For conservatism, the runoff hydrographs for the 100-year, 24-hour storm event was routed through the Basin, as well. The results of these additional routings indicate that the top of basin bank is not overtopped during the 100-year, 24-hour storm event. These analyses can be found in Appendix A.

The RD/RA Workplan evaluated peak runoff rates for the 25-year 24-hour storm event in the Sargent's Pond watershed for existing and proposed conditions. As the area of the cap footprint has been modified since the Work Plan submittal, the proposed condition peak runoff rate was recalculated. Appendix A presents the calculation with a corresponding peak flow rate in the Sargent's Pond watershed for proposed condition of 102 cfs. The proposed condition represents a 30% reduction in peak flow rates from the 147 cfs previously calculated in the Work Plan for existing conditions. Therefore, upon construction of the proposed cap, the peak discharge for the watershed will be reduced from the existing condition, and further reduced by the installation of the Basin.

5.3 Soil Erosion Analysis

The potential for soil loss was evaluated for the proposed condition shown on Figure 4, Final Cap Grading Plan. In addition to the analysis of the currently proposed slopes, two additional slopes were analyzed to examine the impact on potential soil loss for a range of slopes that may result due to varying fill quantities. The two additional slopes analyzed were 25% and 5% over maximum slope lengths of 100 and 200 feet, respectively. The results of all three case analyzed are presented in Appendix A and in each case analyzed the potential soil loss calculated is less than maximum 2 ton/acre/year recommended by USEPA.

6.0 CAP DRAINAGE LAYER

The Work Plan presented a preliminary evaluation of the proposed cap system drainage layer using HELP analysis, a water balance model developed by the U.S. Army Corps of Engineers. In the Final Design, the preliminary design analysis has been refined utilizing site specific design parameters, including anticipated cap slopes and construction materials to assess the drainage performance of the proposed cap system. As the final cap configuration and constructed grades will depend on the volume of waste material to be consolidated onsite, a range of potential cap slopes were considered in our analysis, ranging from the minimum allowable slope of 5% to the maximum allowable slope of 25%.

The HELP model has recently been shown to underestimate the impacts of short duration peak rain events on cap drainage systems (References 1,2 and 4 in Appendix B). The HELP model cannot analyze such short duration peak storm events and actually models such storm events by spreading the infiltration over a 24-hour period. As a result, a unit gradient water balance analysis was also utilized to design the cap drainage system which assumes that the cap cover system will become fully saturated as a result of a short term peak storm event. By utilizing the additional method of calculation presented in Appendix B, design of the cap drainage system accounts for both long term and short term worst case storm events.

Appendix B presents the analysis, assumptions and conclusions. The slopes of 9% and 15% considered in our analysis reflect those presented on the Drawing 4, Final Cap Grading Plan, and maximum slope lengths for each case have been analyzed. In summary, the analysis showed that the longest and flattest proposed slope, i.e. 9% over 200 feet, provides the governing design transmissivity requirement of 8.2×10^{-4} m^2/sec for the cap drainage layer.

As capping grades may be modified during construction based on the volume of material to be consolidated onsite, the drainage requirements of the cover system will be evaluated and may need to be modified, by adjusting the maximum slope lengths or providing intermediate slope drainage piping, if necessary.

Appendix B also presents design calculations for the required Apparent Opening Size (AOS) of the geocomposites' upper geotextile to prevent clogging and provide retention of the soil.

7.0 CAP VENEER STABILITY

A preliminary analysis of the proposed cap system veneer stability was provided in the RD/RA Workplan. The preliminary analysis concluded that a minimum residual interface friction angle of 20.5° would be required to satisfy the minimum acceptable factory of safety of 1.5 for cap stability, assuming a maximum cap slope of 25%.

Site specific interface friction testing was conducted during the Pre-Final design phase using the actual geosynthetic materials and soil materials proposed for construction. This testing was performed in accordance with ASTM D5321, using site specific test conditions. The residual friction angles measured were 36.7 degrees, 27.2 degrees and 36.8 degrees for the geocomposite-cover soil interface, GCL-onsite borrow soil interface and GCL-imported soil interface respectively. All interfaces tested exceeded the minimum residual angle of 20.5 degrees indicating that the geosynthetic-soil interfaces tested will provide sufficient frictional resistance to maintain a factor of safety greater than 1.5. Interface friction testing was also performed on the interfaces between the proposed geosynthetic materials and a minimum residual friction angle of 23.3 degrees was reported, again exceeding the minimum required residual friction angle of 20.5 degrees. Interface friction test summary reports are presented in Appendix C. If soil or geosynthetic materials proposed for use in construction vary from those tested in the design, additional interface testing will be conducted as necessary to provide site specific test data.

The proposed stormwater retention basin will be lined with a 40-mil flexible polyethylene geomembrane. The geomembrane will terminate in an anchor trench at the top of the basin slopes on each side and will be connected to the cap geomembrane on a transition bench at the top of the eastern pond slope, as shown on Drawing 6. An 18-inch cover layer will be placed above the geomembrane and a non-woven geotextile will be placed above and below the geomembrane, as shown on Drawing 8, Basin Details. Calculations for the geosynthetic design of the lined basin are also presented in Appendix C. The proposed basin sideslopes are 5H:1V and design calculations indicate that a minimum residual friction angle of 19.1 degrees will be required between the lower geosynthetic component of the pond liner and the prepared soil subgrade to achieve a suitable factor of safety for liner stability. Prior to construction, site specific interface friction testing will be conducted to verify that the proposed materials of construction will provide the required frictional characteristics for stability of the pond liner system.

8.0 GLOBAL SLOPE STABILITY

The global stability of the landfill mass was evaluated by a limiting equilibrium method of analysis, using the SLOPE/W slope stability software. The analysis was performed to evaluate the minimum factor of safety for stability using an assumed worst case slope configuration corresponding to the steepest allowable final cover slopes of 25% over a 100 foot slope length. Calculations are presented in Appendix D and a brief summary is presented below.

The analysis was performed on this worst case slope configuration for both static and seismic conditions using material properties for native soil, waste material and cap cover material as presented in Appendix D. The unit weight of the waste material is considered to be the most variable parameter in the analysis and as a result, a sensitivity analysis was performed by varying the waste unit weight from 60 pcf to 85 pcf. The native soil properties were conservatively derived by combining information from blow counts, soil classifications of samples obtained from the site subsurface and geotechnical references for similar soil materials. Appendix D provides details of material property selection for this analysis.

The results of our analysis indicate that the slopes will be stable under both static and seismic conditions for both of the assumed waste unit weights. The static factors of safety range from 2.0 to 2.8 and the seismic factors of safety range from 1.3 to 1.6. These factors of safety exceed minimum required factors of safety of 1.5 and 1.2 for static and seismic conditions, respectively.

9.0 SETTLEMENT

An analysis for localized subsidence presented in the RD/RA workplan concluded that the proposed geomembrane could safely withstand the induced tensile stresses resulting from the assumed deformation. To complete the settlement analysis, the total long-term settlement of the newly consolidated waste material, has been estimated. Calculations are presented in Appendix E. Potential impact of sinkhole subsidence on final cap grades will be addressed under separate cover.

It has been assumed that the compaction efforts applied to the lifts of consolidated waste material will cause the majority of primary mechanical settlement to occur rapidly and that this initial settlement will be complete before cap construction is completed. It has further been assumed that the undisturbed waste material that was placed between 1933 and 1964 will not contribute significantly to future settlement. The long-term secondary settlement of the newly consolidated waste material that is anticipated to occur following completion of the cap construction has been estimated and it's impact on the performance of the cap system has been evaluated.

Based on our proposed grading plan, the maximum thickness of consolidated waste material will be approximately 11.5 feet in the vicinity of the proposed newly created high point. The proposed high point is located away from the known significant sinkhole depressions. In order to provide flexibility to accommodate a potentially thicker maximum fill, we have conservatively assumed a total waste thickness of 15 feet in our settlement calculation. The resulting post capping settlement of the waste material has been estimated as approximately 1.5 feet. This degree of settlement can be accommodated by the current cap grading plan and will not cause significant strain in the geomembrane. Assuming this settlement occurs at the current landfill high point, the proposed 9% slope would be reduced to a post settlement slope of 8.2%. This slope reduction would not negatively impact the positive drainage from the cap.

10.0 PIEZOMETERS

Following waste excavation and consolidation, piezometers will be installed at selected locations to monitor groundwater levels at the site. Piezometers will be used to monitor groundwater levels in the general vicinity area of the sinkholes, where the abandoned piezometers PZ-1A and PZ-2A were originally located. Piezometers will also be installed beyond the western edge of the limits of waste consolidation at the locations of two infiltration galleries that were established during waste excavation. The locations of all proposed piezometers are shown on Drawings 3 and 4.

As the landfill excavation is completed and geophysical data is evaluated, locations may be identified beyond the limits of the cap for installation of additional piezometers. These piezometers can be installed after the cap is completed without impacting the cap system.

10.1 Sinkhole Piezometers

Paired piezometers will be installed at the two sinkhole areas. One piezometer will be located in the deepest part of the fill and another piezometer will be located at the deepest bedrock location of each sinkhole area. Prior to waste excavation PZ-1A was located in the area of the south sinkhole and in the deepest portion of the fill. At the direction of the EPA consultants, a fill piezometer will be installed at location 30 feet west of SB16. SB-16 can be located on Figure 3 of the May 17, 2000 Lemon Lane Work Plan. This proposed piezometer will be identified as PZ-A(S). The location of the bedrock piezometer has been selected based on bedrock elevation data gathered by CBS. A location identified as DTB-52 (approximately 1429690 Northing and 3100880 Easting) will be the site for the installation of PZ-A(D), the bedrock elevation piezometer.

The originally location of PZ-2A was chosen to monitor the deepest fill location of the northern sinkhole. Piezometer PZ-B(S) will be located at this same point and will be used to measure water at the deepest point of fill at that location. The deepest bedrock point associated with this sinkhole is located at boring B-8 shown on Figure 3 of the May 17, 2000 Lemon Lane Work Plan. The bedrock elevation piezometer of this pair, PZ-B(D), will be installed at the location of located boring B-8.

10.2 Infiltration Gallery Piezometers

Two infiltration galleries were constructed at locations just west of the limits of consolidation and east of the retention pond northeast inlet. These locations were established based on observations during excavations to bedrock that were performed to remove PCB contaminated soils in these areas. At the bedrock elevation some ground water was observed. A layer of pea gravel approximately 3 to 4 feet thick was placed over the exposed bedrock, covering an area of approximately 150 to 200 square feet. in each of these two areas. A layer of non-woven geotextile was placed over the surface of the pea gravel prior to placement of soil backfill. Each location was surveyed in case of a future need to access these areas. Drawings 3 and 4 show the locations of these two infiltration gallery piezometers, PZ-C and PZ-D.

10.3 Piezometer Construction

Typical construction details for the proposed piezometers are shown in Drawing 11. The casings used for the piezometers located in the infiltration galleries will be of sufficient diameter to accommodate the requirements of a recovery well, if one is needed in the future. Data will be taken and recorded to identify the final elevations of the screened portions of these piezometers as well as the exact survey coordinates of each location. This information will be presented in the final report and shown on the as-built drawings. The frequency and method of monitoring water level measurements will be discussed in the Operation and Maintenance Plan to be submitted after construction has been completed. In the event that recovery wells are required, the design, installation, operation and maintenance will be presented in the O & M Plan.

G:\PROJECTS\993-6573\FINALDESIGN\FINALREPORT2.DOC

APPENDIX A

STORMWATER CALCULATIONS

APPENDIX A1
STORMWATER RUNOFF RATES – PROPOSED CONDITION

GOLDER ASSOCIATES	Subject: DRAINAGE AREA CALCULATIONS - PROPOSED		
	Job No: 993-6573	Made by: VEF	Date: 5/23/00
	Ref: Lemon Lane 95%	Check by: MPD/KAB	Sheet: 1 of 3
		Review by: BWJ	

OBJECTIVE: To determine the limits and the areas of the on-site and off-site, upgradient drainage areas associated with the Lemon Lane Landfill.

METHOD: Using a topographic map showing the landfill and surrounding area (Ref. 1, attached), select the downstream points of interest and connect the topographic ridges to find the limits of the drainage area which drain through the selected points. Then, using a digital planimeter, trace the limits of each drainage area to find the areas.

REFERENCES:

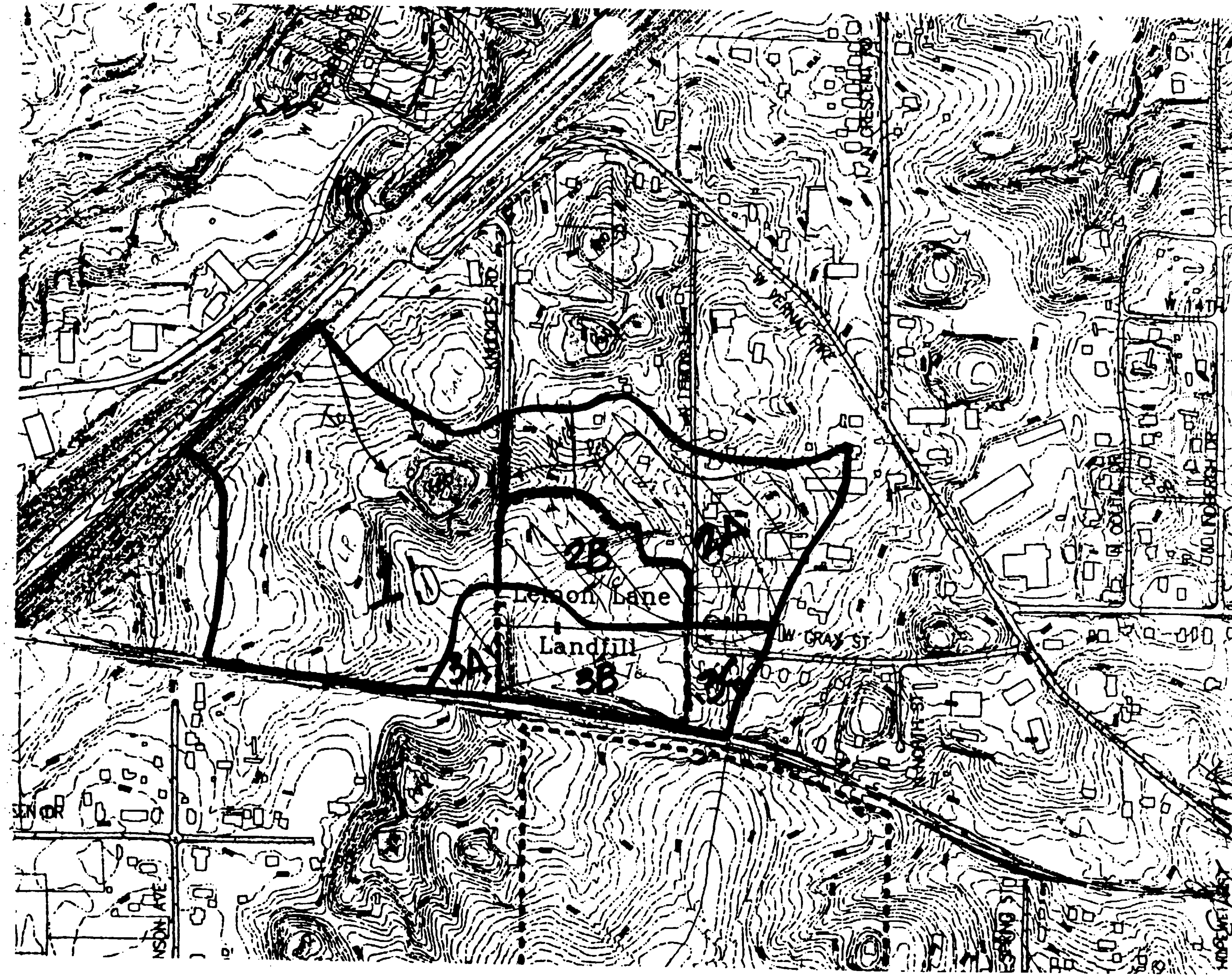
1) City of Bloomington, "Illinois Central Basin," Drawing OillCenBas, dated 10-8-97.

CALCULATION: See the attached topographic map (Ref. 1) for the off-site drainage area limits, names, and downstream points of interest for the existing conditions.

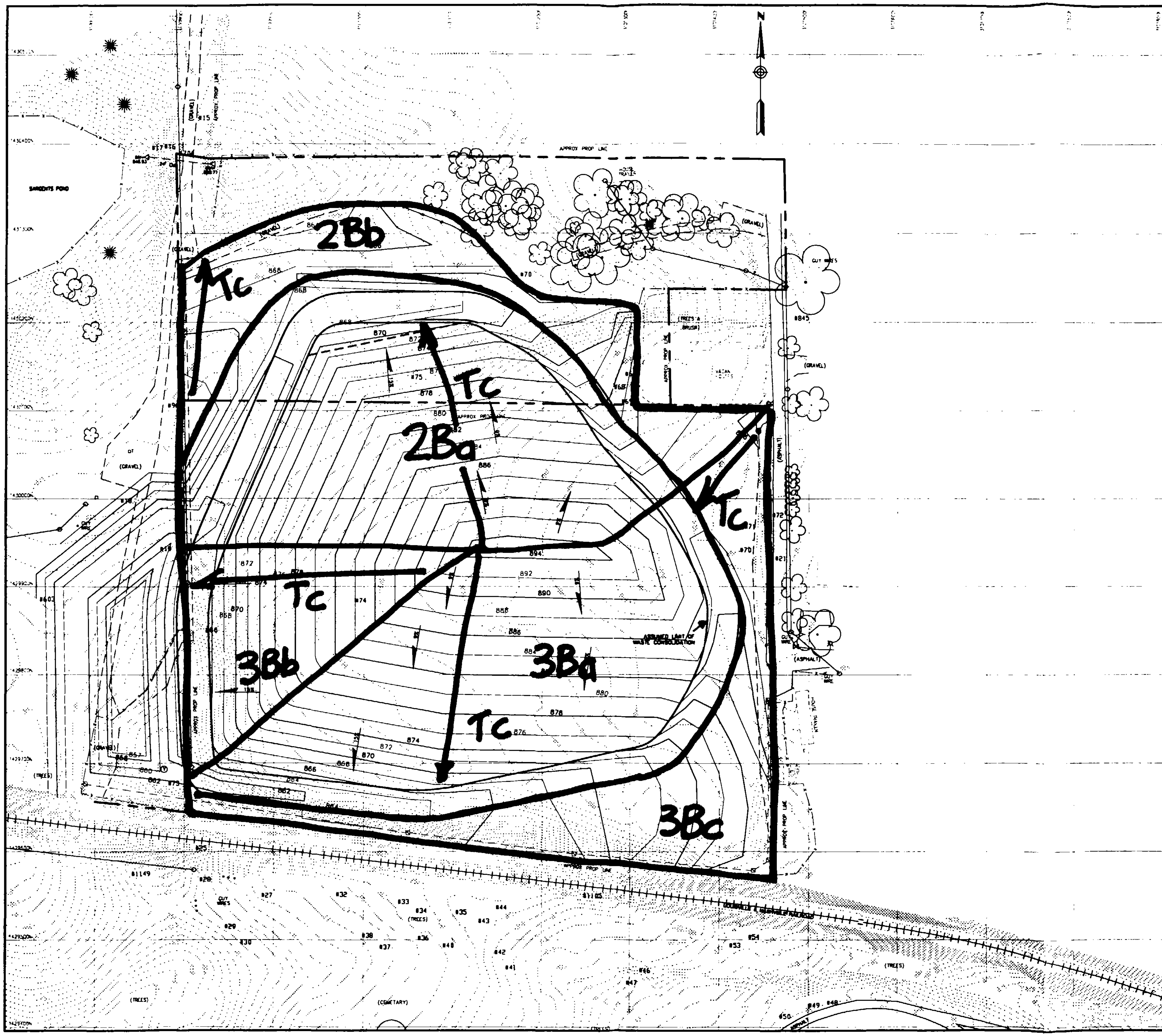
The results of tracing the areas discharging to channels or basins are as follows:

Drainage Area Name	Area (s.f.)	Area (acres)	Area (sq.mi.)	Description
1	877,920	20.2	0.0315	Brush/Meadow
2A	471,200	10.8	0.0169	Residential/Brush
2Ba	126,058	2.9	0.0045	Proposed Cap
2Bb	91,737	2.1	0.0033	Brush/Meadow
3A	59,520	1.4	0.0021	Brush/Meadow
3Ba	131,986	3.0	0.0047	Proposed Cap
3Bb	39,457	0.9	0.0014	Proposed Cap
3Bc	34,842	0.8	0.0013	Brush/Meadow
3C	79,360	1.8	0.0028	Residential

As a result of regrading the Landfill, the high point has shifted south. Subsequently, a portion (approximately 21,000 sf) of the watershed area that was part of 3B has shifted to 2B.


Lemon Lane
Landfill
1
2A
2B
3A
3B
W GRAY ST

Sheet 3 of 3



LEGEND

	WASTE THICKNESS CONTOUR (1 FT)
	WASTE THICKNESS CONTOUR (5 FT)
	ASSUMED LIMIT OF CAP GEOMEMBRANE
	GROUND SURFACE CONTOUR (1 FT)
	GROUND SURFACE CONTOUR (5 FT)
	PROPERTY LINE
	BRUSHLINE
	FENCELINE
	BUILDING FOOTPRINT
	POWER LINE
	GAS LINE
	ROAD
	RAILROAD
	INDIVIDUAL TREE
	SUMP
	UTILITY POLE
876.38 DTNS-23	SOIL BORING LOCATION AND ELEVATION

NOTES

1.) WASTE THICKNESS CONTOURS PRESENTED ARE DERIVED FROM SUBSURFACE INFORMATION OBTAINED FROM BORINGS CATALOGUED BELOW IN NOTES 2 THROUGH 6.

2.) BORINGS B-1 THROUGH B-8: LOCATIONS OBTAINED FROM BLASLAND & BOUCK ENGINEERS, PHASE 1 REPORT, ENTITLED, "SUPPLEMENTAL HYDROGEOLOGIC INVESTIGATION", DATED NOVEMBER [illegible]. BORING LOGS, DATED MAY [illegible], WERE PROVIDED BY CBS.

3.) BORINGS SB-1 THROUGH SB-25: LOCATIONS AND BORING LOGS OBTAINED FROM PSARA TECHNOLOGIES, INC. SUMMARY REPORT FOR LEMON LANE LANDFILL, DATED MARCH 7, [illegible].

4.) BORINGS DTNS-1 THROUGH DTNS- 27: LOCATIONS WERE OBTAINED FROM SMITH, NEUBECKER AND ASSOCIATES, INC. BASE MAP ENTITLED, "TOPOGRAPHIC SURVEY", DATED OCTOBER [illegible]. DEPTHS TO NATURAL SOIL WERE PROVIDED BY CBS.

5.) BORINGS DTB-1 THROUGH DTB-[illegible]: LOCATIONS WERE OBTAINED FROM SMITH, NEUBECKER AND ASSOCIATES, INC. BASE MAP ENTITLED, "TOPOGRAPHIC SURVEY", DATED OCTOBER [illegible]. DEPTHS TO BEDROCK WERE PROVIDED BY CBS.

6.) LOCATION AND SUBSURFACE INFORMATION FOR N-SERIES, E-SERIES AND W-SERIES BORINGS AS SHOWN WERE OBTAINED FROM PSARA TECHNOLOGY.

7.) WASTE THICKNESS INCLUDE THICKNESS OF HYPALON BEDDING SOIL.

REFERENCE

1.) BASE MAP AND PROPERTY LINE TAKEN FROM CADD FILE PROVIDED BY SMITH, NEUBECKER AND ASSOCIATES INC., TITLED "TOPOGRAPHIC SURVEY", DATED DECEMBER [illegible].

40 0 40 80
scale feet

REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY

PROJECT:
CBS
LEMON LANE LANDFILL PRE-FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE:
TOP OF CAP GRADES

Golder Associates
Philadelphia USA

PROJECT No.	993-6573		FILE No.	WSTPLS3
CLIENT PROJ. No.			DRAFTING SUBTITLE:	03
DES BY	VCF	05/02/00	SCALE:	AS SHOWN
CAD BY	MJS	05/19/00	FIGURE	
CHK BY				
RVW BY				

GOLDER ASSOCIATES	Subject: SELECTION OF MANNING'S N VALUES - PROPOSED		
	Job No: 993-6573	Made by: VEF	Date: 5/23/00
	Ref: Lemon Lane	Check by: MW/RAB	Sheet: 1 of 3
	95%	Review by: EW	

OBJECTIVE: To determine the n-values to be used in the storm water design for evaluating channel roughness and time of concentration.

METHOD: Review the applicable guidance documents in Indiana, or similar guidance in other jurisdictions, for the n-values which are recommended for the existing or proposed conditions.

REFERENCES:

1) USDA, Soil Conservation Service, "Technical Release No. 55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

2) Simon, Andrew L., "Hydraulics," 1986.

CALCULATION: Consider the proposed vegetation as dense grass, for conservatism. Therefore, for overland flow for proposed conditions, 'n' is 0.24 (Ref. 1, see attached sheet 2 of 3).

For grass lined channels, 'n' is 0.04 (Ref. 2, see attached sheet 3 of 3).

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning Eqn

TABLE 8.2 (*continued*)

Description of Channel	n	$\frac{1.49}{n}$
Small, man-made earth channels in well-kept condition; straight natural streams with rather clean, uniform bottoms without pools and flow barriers, cavings, and scours of the banks	0.025	59.60
Ditches; below average man-made channels with scattered cobbles in bed	0.028	53.21
Well-maintained large floodway; unkept artificial channels with scours, slides, considerable aquatic growth; natural stream with good alignment and fairly constant cross section	0.030	49.66
Permanent alluvial rivers with moderate changes in cross section, average stage; slightly curving intermittent streams in very good condition	0.033	45.15
Small, deteriorated artificial channels, half choked with aquatic growth; winding river with clean bed, but with pools and shallows	0.035	42.57
Irregularly curving permanent alluvial stream with smooth bed; straight natural channels with uneven bottom, sand bars, dunes, few rocks and underwater ditches; lower section of mountainous streams with well-developed channel with sediment deposits; intermittent streams in good condition; rather deteriorated artificial channels, with moss and reeds, rocks, and slides	0.040	37.25
Artificial earth channels partially obstructed with debris, roots, and weeds; irregularly meandering rivers with partly grown-in or rocky bed; developed floodplains with high grass and bushes	0.067	22.24
Mountain ravines; fully ingrown small artificial channel; flat floodplains crossed by deep ditches (slow flow)	0.080	18.62
Mountain creeks with waterfalls and steep ravines; very irregular floodplains; weedy and sluggish natural channels obstructed with trees	0.10	14.9
Very rough mountain creeks; swampy, heavily vegetated rivers with logs and driftwood on the bottom; floodplain forest with pools	0.133	11.2
Mudflows; very dense floodplain forests; watershed slopes	0.22	6.77

3 of 3

GOLDER ASSOCIATES	Subject: SELECTION OF CN VALUES - PROPOSED		
	Job No: 993-6573	Made by: VEF	Date: 5/23/00
	Ref: Lemon Lane 95%	Check by:	Sheet: 1 of 3
		Review by:	

OBJECTIVE: To determine relevant CN values for the soils and surface conditions for the site.

METHOD: After evaluating the vegetation type, vegetation density, and the soil characteristics, select CN values which accurately represent the conditions.

REFERENCES:

1) USDA, Soil Conservation Service, "Technical Release No. 55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

2) Based upon the proposed soil to be used as cover (Loam), assume hydrologic soil Type C.

CALCULATION: From TR-55 (ref. 1) (see attached).

For conservatism, the proposed condition will be evaluated immediately after the establishment of vegetation.

Condition	CN value	Description
Existing	79	1-acre Residential, fair, Type C
Existing	70	Brush, fair, Type C
Proposed	79	Open space, fair, Type C

Watershed	CN Value	Watershed	CN value
1	70	3A	70
2A	79	3C	79
2Ba	79	3Ba	79
2Bb	70	3Bb	79
		3Bc	70

Sheet 2 of 3

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.
[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5] mposite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, ased on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Sheet 3 of

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3] *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

OBJECTIVE: To determine the times of concentration (T_C) for the off-site drainage areas associated with the Lemon Lane Landfill.

METHOD: Using methods outlined in TR-55, determine the time of concentration for each off-site drainage area. For conservatism, the travel time in the perimeter channels was not computed because it is negligible.

REFERENCES:

1) Golder Associates Inc., Calculations entitled "Run-on Drainage Area Calculations," dated 5/23/00.

CALCULATION: See the topographic maps included in Ref. 1 for the drainage area limits, names, and downstream points of interest for the conditions.

A summary of the times of concentration for the watersheds is as follows:

Watershed Name	T_C (hr)
1	0.42
2A	0.43
2Ba	0.30
2Bb	0.21
3A	0.31
3Ba	0.30
3Bb	0.27
3Bc	0.23
3C	0.44

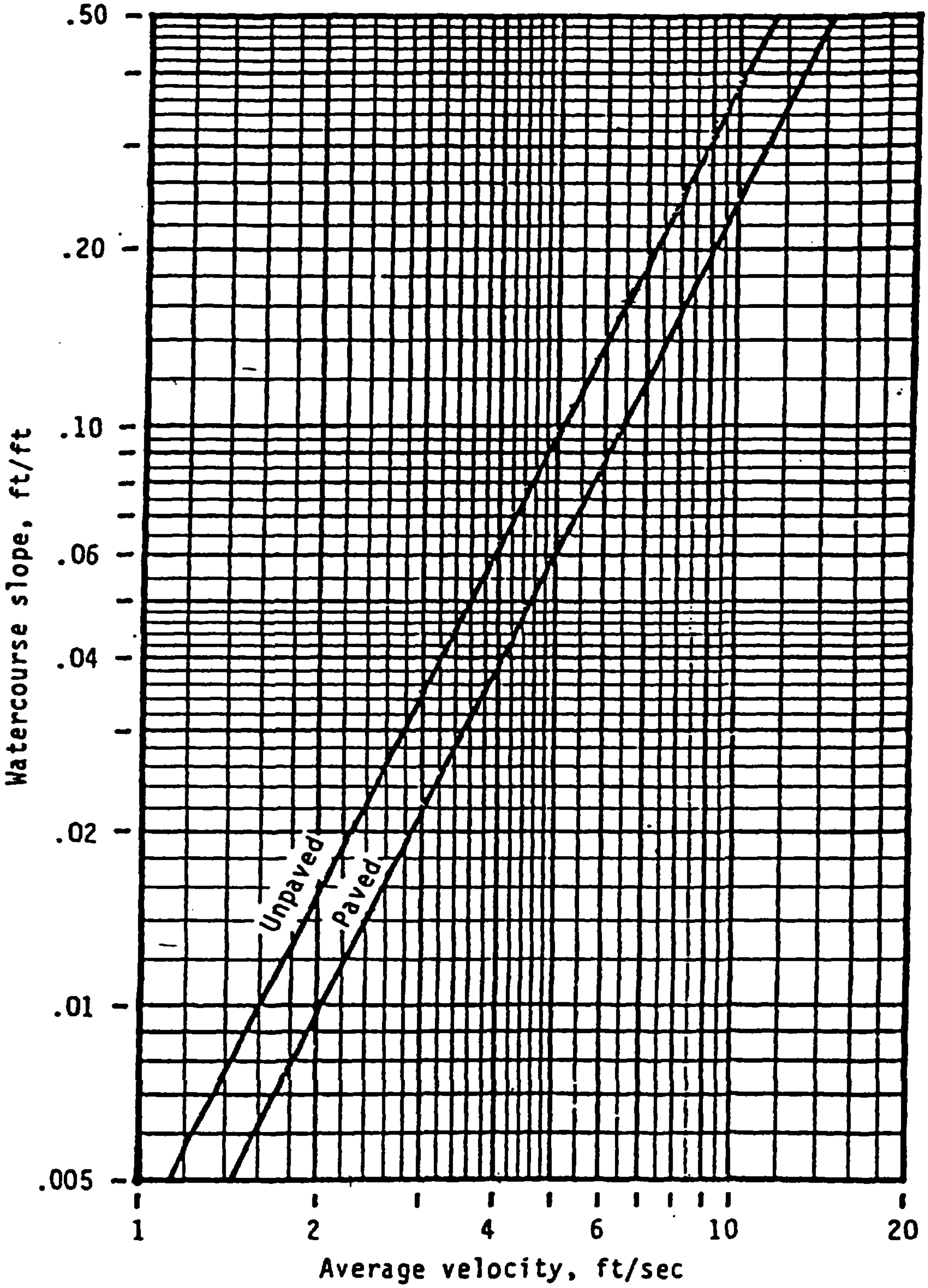


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Sheet 3 of 11

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Lemon Lane Landfill By [illegible] Date 2-29-00

Location 1 Checked ____ Date ____

Circle one: Present Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID: 1	Segment ID:	Total
1. Surface description (table 3-1)		GRASS		
2. Manning's roughness coeff., n (table 3-1)		0.24		
3. Flow length, L (total L $\leq$ 300 ft)	ft	300		
4. Two-yr 24-hr rainfall, P_2	in	3.1		
5. Land slope, s (14/300)	ft/ft	0.047		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.415	+	= 0.42

Shallow concentrated flow

	Unit	Segment ID	Segment ID	Total
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

Channel flow

	Unit	Segment ID	Segment ID	Total
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.42

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Lemon Lane Landfill By VE7 Date 2-29-00

Location 2A Checked ____ Date ____

Circle one: Present Developed

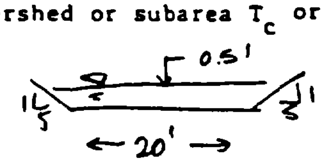
Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID	1			
1. Surface description (table 3-1)		Grass			
2. Manning's roughness coeff., n (table 3-1) ..		0.24			
3. Flow length, L (total L $\leq$ 300 ft)	ft	300			
4. Two-yr 24-hr rainfall, P_2	in	3.1			
5. Land slope, s	ft/ft	0.053			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.39 ✓	+		= 0.39 ✓
Shallow concentrated flow	Segment ID	2			
7. Surface description (paved or unpaved)		Unpaved			
8. Flow length, L	ft	380			
9. Watercourse slope, s	ft/ft	0.042			
10. Average velocity, V (figure 3-1)	ft/s	3.4			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.03 ✓	+		= 0.03 ✓
Channel flow	Segment ID	3			
12. Cross sectional flow area, a	ft^2	11.25*			
13. Wetted perimeter, p_w	ft	25.1*			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	0.45* ✓			
15. Channel slope, s ....14/280............	ft/ft	0.05			
16. Manning's roughness coeff., n		0.04			
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s	4.88 ✓			
18. Flow length, L	ft	240			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.01 ✓	+		= 0.01 ✓
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr				0.43 ✓

*assume



Area = 22.5×0.5 = 11.25 ✓

P_w = 20 + 2×0.5×√26 = 25.1

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Sheet 5 of 11

Project Lemon Lane Landfill By VEJ Date 5-23-2000

Location 2Ba Checked RAD Date

Circle one: Present Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Segment ID		1	2	
1.	Surface description (table 3-1)		Grass	Grass	
2.	Manning's roughness coeff., n (table 3-1)		0.24	0.24	
3.	Flow length, L (total L $\leq$ 300 ft)	ft	235	30	
4.	Two-yr 24-hr rainfall, P_2	in	3.1	3.1	
5.	Land slope, s	ft/ft	0.09	0.15	
6.	$T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.26	+ 0.04	= 0.30

Shallow concentrated flow

	Segment ID				
7.	Surface description (paved or unpaved)				
8.	Flow length, L	ft			
9.	Watercourse slope, s	ft/ft			
10.	Average velocity, V (figure 3-1)	ft/s			
11.	$T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

Channel flow

	Segment ID				
12.	Cross sectional flow area, a	ft^2			
13.	Wetted perimeter, p_w	ft			
14.	Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15.	Channel slope, s	ft/ft			
16.	Manning's roughness coeff., n				
17.	$V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V	ft/s			
18.	Flow length, L	ft			
19.	$T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.30

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Lemon Lane Landfill By VEJ Date 5-23-2000

Location 2Eb Checked PAD Date 5/24/00

Circle one: Present **Developed**

Circle one: **T_c** T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)		Segment ID	1		
1. Surface description (table 3-1)			Grass		
2. Manning's roughness coeff., n (table 3-1) ..			0.24		
3. Flow length, L (total L $\leq$ 300 ft)		ft	140 ✓		
4. Two-yr 24-hr rainfall, P_2		in	3.1		
5. Land slope, s		ft/ft	0.057 ✓		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$	Compute T_t	hr	0.21 ✓	+	= 0.21 ✓

Shallow concentrated flow		Segment ID			
7. Surface description (paved or unpaved)					
8. Flow length, L		ft			
9. Watercourse slope, s		ft/ft			
10. Average velocity, V (figure 3-1)		ft/s			
11. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr		+	=

Channel flow		Segment ID			
12. Cross sectional flow area, a		ft^2			
13. Wetted perimeter, p_w		ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$	Compute r	ft			
15. Channel slope, s		ft/ft			
16. Manning's roughness coeff., n					
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$	Compute V	ft/s			
18. Flow length, L		ft			
19. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.21 ✓

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Lemon Lane Landfill By UGT Date 2/29/00

Location 3A Checked ____ Date ____

Circle one: Present Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

		Segment ID	1			
1.	Surface description (table 3-1)		Grass			
2.	Manning's roughness coeff., n (table 3-1) ..		0.24			
3.	Flow length, L (total L ≤ 300 ft)	ft	210			
4.	Two-yr 24-hr rainfall, P_2	in	3.1			
5.	Land slope, s 10/210	ft/ft	0.048			
6.	$T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.31	+		= 0.31

Shallow concentrated flow

		Segment ID				
7.	Surface description (paved or unpaved)					
8.	Flow length, L	ft				
9.	Watercourse slope, s	ft/ft				
10.	Average velocity, V (figure 3-1)	ft/s				
11.	$T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

Channel flow

		Segment ID				
12.	Cross sectional flow area, a	ft^2				
13.	Wetted perimeter, p_w	ft				
14.	Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft				
15.	Channel slope, s	ft/ft				
16.	Manning's roughness coeff., n					
17.	$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s				
18.	Flow length, L	ft				
19.	$T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.31

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Sheet 8 of 11

Project Lemon Lane Landfill By UF7 Date 5-23-200_

Location 3Ra Checked RAD Date ________

Circle one: Present Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID 1	Segment ID 2	Total
1. Surface description (table 3-1)		Grass	Grass	
2. Manning's roughness coeff., n (table 3-1) ..		0.24 ✓	0.24 ✓	
3. Flow length, L (total L ≤ 300 ft)	ft	220 ✓	40 ✓	
4. Two-yr 24-hr rainfall, P_2	in	3.1 ✓	3.1 ✓	
5. Land slope, s	ft/ft	0.09 ✓	0.15 ✓	
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.25 ✓	+ 0.05 ✓	= 0.30 ✓

Shallow concentrated flow

	Unit	Segment ID		Total
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

Channel flow

	Unit	Segment ID		Total
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.30 ✓

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Lemon Lane Landfill By [illegible] Date 5-23-2000

Location 3Bb Checked RAO Date 5/24/00

Circle one: Present Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID 1	Segment ID 2	Total
1. Surface description (table 3-1)		Grass	Grass	
2. Manning's roughness coeff., n (table 3-1)		0.24	0.24	
3. Flow length, L (total L ≤ 300 ft)	ft	180 ✓	50 ✓	
4. Two-yr 24-hr rainfall, P_2	in	3.1	3.1	
5. Land slope, s	ft/ft	0.09	0.15 ✓	
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{\,0.5}\, s^{0.4}}$ Compute T_t	hr	0.21 ✓	+ 0.06 ✓	= 0.27 ✓

Shallow concentrated flow

	Unit	Segment ID		Total
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

Channel flow

	Unit	Segment ID		Total
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.27 ✓

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Sheet 10 of 11

Project Lemon Lane Landfill   By JEF   Date 5-23-2000

Location 3Bc   Checked RAO   Date ______

Circle one: Present **Developed**

Circle one: **T_c** T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) — Segment ID		1		
1. Surface description (table 3-1)		Grass		
2. Manning's roughness coeff., n (table 3-1) ..		0.24		
3. Flow length, L (total L $\leq$ 300 ft)	ft	95		
4. Two-yr 24-hr rainfall, P_2	in	3.1		
5. Land slope, s 2/95	ft/ft	0.021 ✓		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.23 ✓	+	= 0.23 ✓
Shallow concentrated flow — Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
Channel flow — Segment ID				
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			0.23

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Lemon Lane Landfill By VEJ Date 2/29/00

Location 3C Checked ____ Date ____

Circle one: Present Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

Segment ID		1			
1. Surface description (table 3-1)		Grass			
2. Manning's roughness coeff., n (table 3-1) ..		0.24			
3. Flow length, L (total L ≤ 300 ft)	ft	300			
4. Two-yr 24-hr rainfall, P_2	in	3.1			
5. Land slope, s ....12/300..........	ft/ft	0.04			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.44	+		= 0.44

Shallow concentrated flow

Segment ID					
7. Surface description (paved or unpaved)					
8. Flow length, L	ft				
9. Watercourse slope, s	ft/ft				
10. Average velocity, V (figure 3-1)	ft/s				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

Channel flow

Segment ID					
12. Cross sectional flow area, a	ft^2				
13. Wetted perimeter, p_w	ft				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft				
15. Channel slope, s	ft/ft				
16. Manning's roughness coeff., n					
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s				
18. Flow length, L	ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.44

GOLDER ASSOCIATES	Subject: RUN-ON HYDROGRAPHS – PROPOSED		
	Job No: 993-6573	Made by: VEF	Date: 5/23/00
	Ref: Lemon Lane 95%	Check by: RM	Sheet: 1 of 5
		Review by: AJ	

OBJECTIVE: To develop runoff hydrographs for the drainage areas related to the Lemon Lane Landfill.

METHOD:

1) Use the times of concentration, area and curve numbers developed under separate calculations (Refs. 1, 2, and 3) to determine the peak stormwater runoff for the 25 year, 24 hour storm event (5.0 inches of precipitation) by methods described in TR-55 (Ref. 5). AS the site is located in Indiana, the storm will be Type II as classified in Reference 5.

2) Based upon the peak runoff values generated using TR-55, determine the peak flow for the channels, benches, and downchutes.

3) Repeat for the 100 year storm event which represents (6.0 inches of precipitation).

REFERENCES:

1) Golder Associates Inc., Calculations entitled "Selection of CN Values," dated 5/23/00.

2) Golder Associates Inc., Calculations entitled "Run-on Drainage Area Calculations," dated 5/23/00.

3) Golder Associates Inc., Calculations entitled "Run-on T_C Calculations," dated 5/23/00.

4) Golder Associates Inc., Calculations entitled "Selection of Manning's N Values," dated 5/23/00.

5) USDA, Soil Conservation Service, "TR-55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

6) Indiana Department of Natural Resources, Division of Soil Conservation, "Indiana Handbook for Erosion Control in Developing Areas," dated October 1992.

7) Golder Associates, Drawing "Anticipated Top of Cover Grades," File No. IN01-072, dated 5/19/00.

CONCLUSION: See attached TR-55 computer generated output.

Watershed Name	Peak Q – 25 yr (cfs)	Peak Q – 100 yr (cfs)
1	38	52
2A	28	37
2Ba	9	11
2Bb	5	7
3A	3	4
3Ba	9	12
3Bb	3	3
3Bc	2	3
3C	5	6

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAO Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 25 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	5.0	5.0
Curve number	70	79
Runoff(in)	2.04	2.80
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.17	0.11
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	2	1	1
11.3	3	2	1
11.6	4	2	2
11.9	9	5	4
12.0	16	9	7
12.1	30	17	13
12.2	52	30	22
12.3	66P	38P	28P
12.4	64	37	27
12.5	48	28	20
12.6	33	19	14
12.7	24	14	10
12.8	18	10	8
13.0	12	7	5
13.2	9	5	4
13.4	7	4	3
13.6	7	4	3
13.8	5	3	2
14.0	5	3	2
14.3	4	2	2
14.6	4	2	2
15.0	3	2	1
15.5	3	2	1
16.0	3	2	1
16.5	2	1	1
17.0	2	1	1
17.5	2	1	1
18.0	2	1	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000
County : BLOOMINGTON State: IN Checked: RAW Date: 6/7/00
Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 25 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	2.80	2.04	2.04	2.04	2.80	2.80	2.80
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.11	0.17	0.17	0.17	0.11	0.11	0.11
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
		Subarea Contribution to Total Flow (cfs)						
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	7	1	1	1	1	2	0	1
12.0	13	3	3	1	1	3	1	1
12.1	25	6	5P	2P	2	6	2	2
12.2	35P	9P	5	2	3P	9P	3P	4
12.3	33	9	3	1	3	9	3	5P
12.4	24	6	2	1	2	6	2	5
12.5	14	4	1	0	1	4	1	3
12.6	10	2	1	0	1	3	1	2
12.7	9	2	1	0	1	2	1	2
12.8	5	1	1	0	0	2	0	1
13.0	3	1	0	0	0	1	0	1
13.2	3	1	0	0	0	1	0	1
13.4	2	1	0	0	0	1	0	0
13.6	2	1	0	0	0	1	0	0
13.8	2	1	0	0	0	1	0	0
14.0	2	1	0	0	0	1	0	0
14.3	0	0	0	0	0	0	0	0
14.6	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAO Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 100 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	6.0	6.0
Curve number	70	79
Runoff(in)	2.81	3.68
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.14	0.09
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	3	2	1
11.3	4	2	2
11.6	5	3	2
11.9	12	7	5
12.0	21	12	9
12.1	41	24	17
12.2	70	41	29
12.3	89P	52P	37P
12.4	87	51	36
12.5	65	38	27
12.6	45	26	19
12.7	32	19	13
12.8	24	14	10
13.0	15	9	6
13.2	12	7	5
13.4	10	6	4
13.6	8	5	3
13.8	7	4	3
14.0	7	4	3
14.3	5	3	2
14.6	5	3	2
15.0	5	3	2
15.5	4	2	2
16.0	4	2	2
16.5	3	2	1
17.0	3	2	1
17.5	3	2	1
18.0	3	2	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAD Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 100 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	3.68	2.81	2.81	2.81	3.68	3.68	3.68
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.09	0.14	0.14	0.14	0.09	0.09	0.09
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	10	2	2	1	1	2	1	1
12.0	16	4	4	1	1	4	1	1
12.1	33	7	7P	3P	3	8	2	3
12.2	45P	11P	7	3	4P	12P	3P	5
12.3	42	11	4	2	4	12	3	6P
12.4	30	8	2	1	3	8	2	6
12.5	20	5	2	1	2	5	1	4
12.6	12	3	1	0	1	3	1	3
12.7	10	2	1	0	1	3	1	2
12.8	9	2	1	0	1	2	1	2
13.0	4	1	1	0	0	1	0	1
13.2	4	1	1	0	0	1	0	1
13.4	3	1	0	0	0	1	0	1
13.6	3	1	0	0	0	1	0	1
13.8	3	1	0	0	0	1	0	1
14.0	2	1	0	0	0	1	0	0
14.3	2	1	0	0	0	1	0	0
14.6	2	1	0	0	0	1	0	0
15.0	2	1	0	0	0	1	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

APPENDIX A2
CULVERT A DESIGN

GOLDER ASSOCIATES	Subject: DESIGN FOR CULVERT A		
	Job No: 993-6573	Made by: BRB	Date: 5/23/00
	Ref: Lemon Lane	Check by:	Sheet: 1 of 11
		Review by:	

OBJECTIVE: To select the pipe diameter (D) for peak flow rates, for the 25 and 100 year design storms, with a headwater depth (HW) of less than 2 ft for the Lemon Lane Landfill. The perimeter channel that discharges into the culverts has a depth of 2 ft, therefore a headwater depth of less than 2 ft would prevent the water from overflowing the outer banks, and overtopping the access road.

METHOD:

1) Use the attached maps (Reference 2) of the site to determine the portion each of the delineated watersheds discharging to culvert A.

2) Based upon the peak runoff values from the hydrographs for the 25, and 100 year design storms, determine the peak flow using the equations found from Method 1.

3) Using the nomograph (Figure 33, Reference 1), determine the required HW by aligning a straight edge through alternate pipe diameters and calculated flow rate (from Method 2) to intersect scale 1, (HW/D for square edge). Since we will use a flared end section (comparable to a groove end with headwall), use scale 2. To find HW/D value for the design condition, draw a horizontal line to scale 2, from the point on scale 1. This will provide the required HW/D. To obtain the HW, multiply the value determined from scale 2 by the diameter. The diameters we are considering are 12, 15, and 18 inches. The ideal HW is approximately 1.5 ft, to provide 0.5 ft of freeboard on the upgradient end of the culvert.

REFERENCES:

1) American Concrete Pipe Association, "Concrete Pipe Design Manual," dated 1985.

2) Golder Associates Inc., Calculations entitled "Run-on Hydrographs – Proposed," dated 5/23/00.

CALCULATION: As stated in Method 1, the pipe discharge is determined first. From map estimation, the discharge in culvert A is the sum of 40% of watershed 3Bc, 10% of watershed 3Ba and 50% of watershed 3C. The equation for discharge in culvert A is,

$$Q_A = 0.4\ (3Bc) + 0.1\ (3Ba) + 0.5\ (3C).$$

Watershed 3C is an off-site upgradient watershed and half of the flow will be intercepted by the perimeter channel and diverted south, via culvert A.

GOLDER ASSOCIATES	Subject: DESIGN FOR CULVERT A		
	Job No: 993-6573	Made by: BRB	Date: 5/23/00
	Ref: Lemon Lane	Check by: VE7	Sheet: 2 of 11
		Review by: DW	

The values of each watershed vary per design storm event, the table below gives peak values of runoff rates (in cfs) for each watershed for the 25 and 100 year design storms from the tabular hydrographs.

Peak Runoff Rates (cfs) (from Reference 2, see copy attached sheets 6-9 of 11) ✓		
Watershed	25 year	100 year
3Ba	9 ✓	12 ✓
3Bc	2 ✓	3 ✓
3C	5 ✓	6 ✓

From the discharge equations and peak runoff rates, the discharge for culvert A can be calculated for each storm event. The equations are displayed on sheet 1 of 11. ✓ The table below summarizes the discharge (Q).

Culvert Design Q (cfs)		
Culvert	25 year	100 year
Q_A	4.2 ✓	5.4 ✓

The attached sheets 3-5 of 11 ✓ (Reference 1), provide the nomographs with the calculated discharge for each pipe for each design storm, for each of the three evaluated diameter pipes. From the nomographs, the HW/D is obtained, then HW is calculated, as described in Method 3.

Headwater Depths (ft)			
Culvert	Pipe Diameter (in)	25 year	100 year
A	12	1.50	2.00
A	15	1.21	1.41
A	18	1.09	1.26

RESULTS: Both the 15 inch and 18 inch diameter pipes provide the ideal HW with free board requirement, for each storm event. ✓

CONCLUSION: Use the 18 inch diameter pipe so contractor is able to order just one culvert pipe diameter for the landfill. ✓

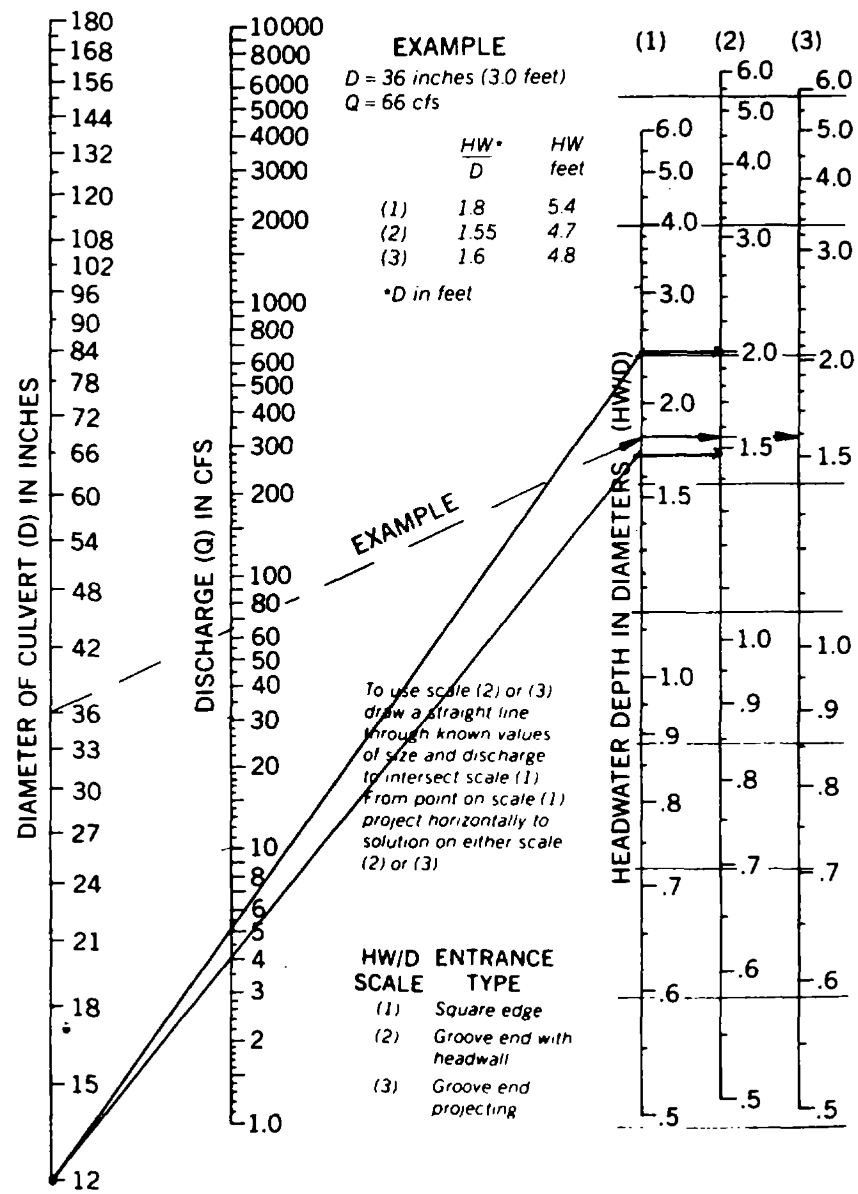
SHEET 3 OF 11

12" DIA. PIPE

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL

		HW (ft)
– $Q_{25\,YR}$ = 4.2 cf		1.50
– $Q_{100\,YR}$ = 5.4 cf		2.00



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

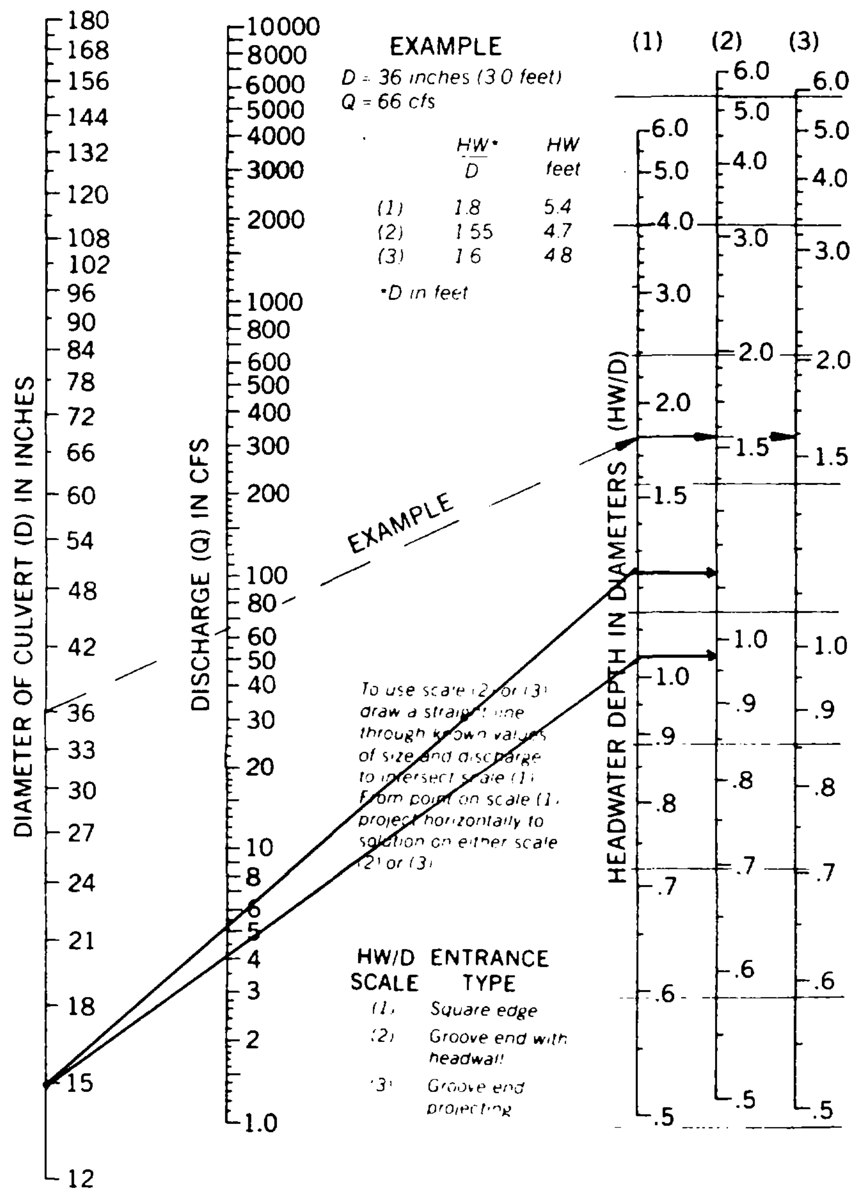
SHEET 4 OF 11

15" DIA. PIPE

FIGURE 33

		HW (ft)
— $Q_{25\,YR}$ = 4.2 cf		1.21
— $Q_{100\,YR}$ = 5.4 cf		1.41

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

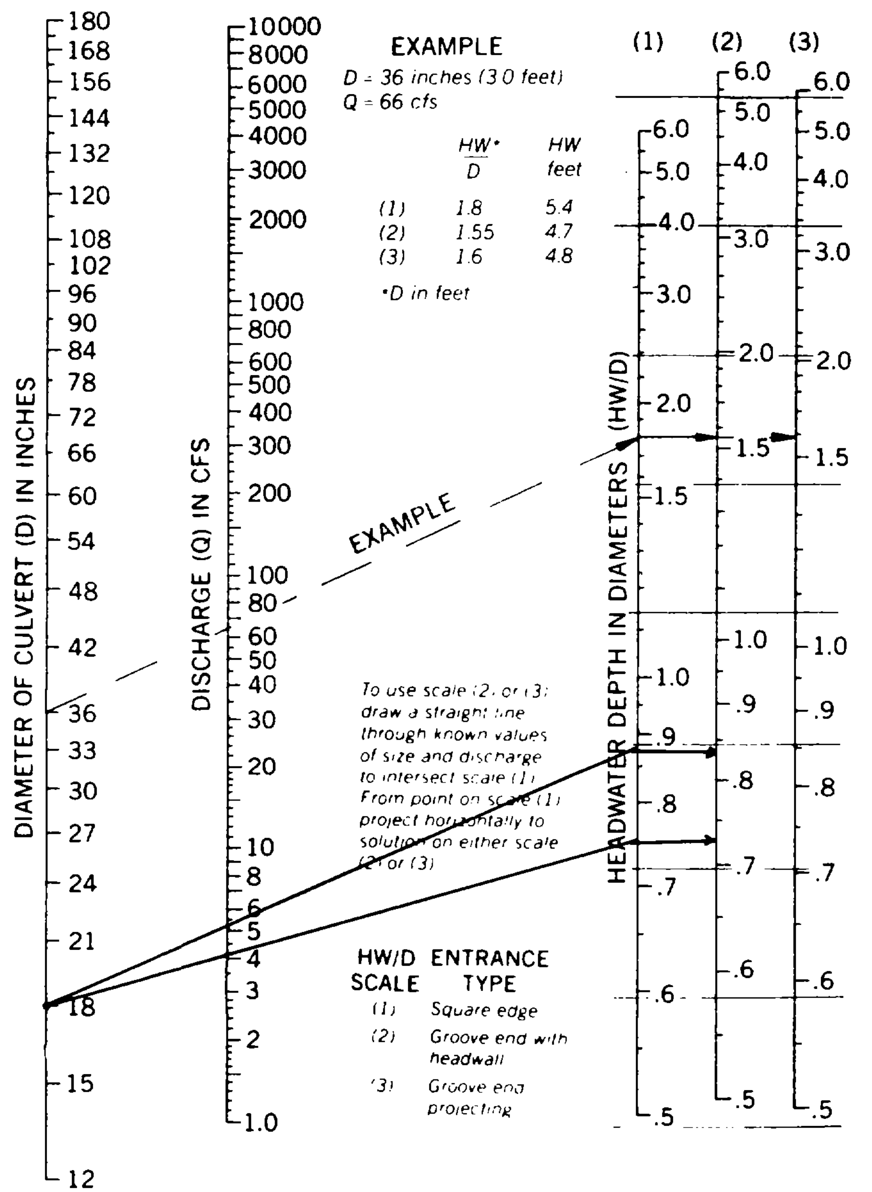
18" DIA. PIPE

FIGURE 33

— Q_{25YR} = 4.2 cf   HW(ft) 1.09

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL

— Q_{100YR} = 5.4 cf   1.26



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3 REVISED MAY 1964

Sheet 6 of 11

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAO Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 25 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	5.0	5.0
Curve number	70	79
Runoff(in)	2.04	2.80
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.17	0.11
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	2	1	1
11.3	3	2	1
11.6	4	2	2
11.9	9	5	4
12.0	16	9	7
12.1	30	17	13
12.2	52	30	22
12.3	66P	38P	28P
12.4	64	37	27
12.5	48	28	20
12.6	33	19	14
12.7	24	14	10
12.8	18	10	8
13.0	12	7	5
13.2	9	5	4
13.4	7	4	3
13.6	7	4	3
13.8	5	3	2
14.0	5	3	2
14.3	4	2	2
14.6	4	2	2
15.0	3	2	1
15.5	3	2	1
16.0	3	2	1
16.5	2	1	1
17.0	2	1	1
17.5	2	1	1
18.0	2	1	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

Sheet 7 of 11

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAW Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 25 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	2.80	2.04	2.04	2.04	2.80	2.80	2.80
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.11	0.17	0.17	0.17	0.11	0.11	0.11
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	7	1	1	1	1	2	0	1
12.0	13	3	3	1	1	3	1	1
12.1	25	6	5P	2P	2	6	2	2
12.2	35P	9P	5	2	3P	9P	3P	4
12.3	33	9	3	1	3	9	3	5P
12.4	24	6	2	1	2	6	2	5
12.5	14	4	1	0	1	4	1	3
12.6	10	2	1	0	1	3	1	2
12.7	9	2	1	0	1	2	1	2
12.8	5	1	1	0	0	2	0	1
13.0	3	1	0	0	0	1	0	1
13.2	3	1	0	0	0	1	0	1
13.4	2	1	0	0	0	1	0	0
13.6	2	1	0	0	0	1	0	0
13.8	2	1	0	0	0	1	0	0
14.0	2	1	0	0	0	1	0	0
14.3	0	0	0	0	0	0	0	0
14.6	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAD Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 100 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	6.0	6.0
Curve number	70	79
Runoff(in)	2.81	3.68
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.14	0.09
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	3	2	1
11.3	4	2	2
11.6	5	3	2
11.9	12	7	5
12.0	21	12	9
12.1	41	24	17
12.2	70	41	29
12.3	89P	52P	37P
12.4	87	51	36
12.5	65	38	27
12.6	45	26	19
12.7	32	19	13
12.8	24	14	10
13.0	15	9	6
13.2	12	7	5
13.4	10	6	4
13.6	8	5	3
13.8	7	4	3
14.0	7	4	3
14.3	5	3	2
14.6	5	3	2
15.0	5	3	2
15.5	4	2	2
16.0	4	2	2
16.5	3	2	1
17.0	3	2	1
17.5	3	2	1
18.0	3	2	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

Sheet 9 of 11

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: DAD Date: 6/7/00

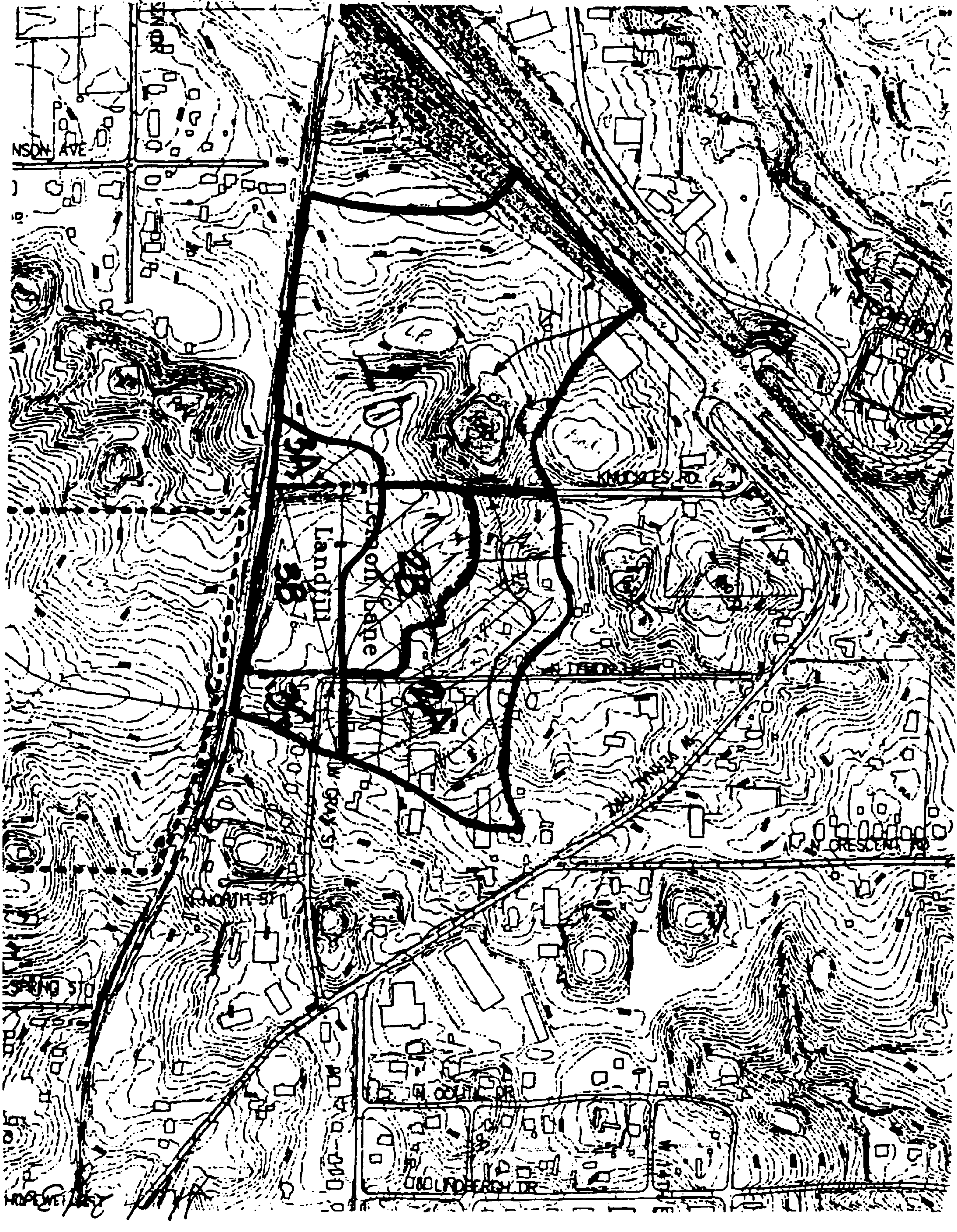
Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 100 years

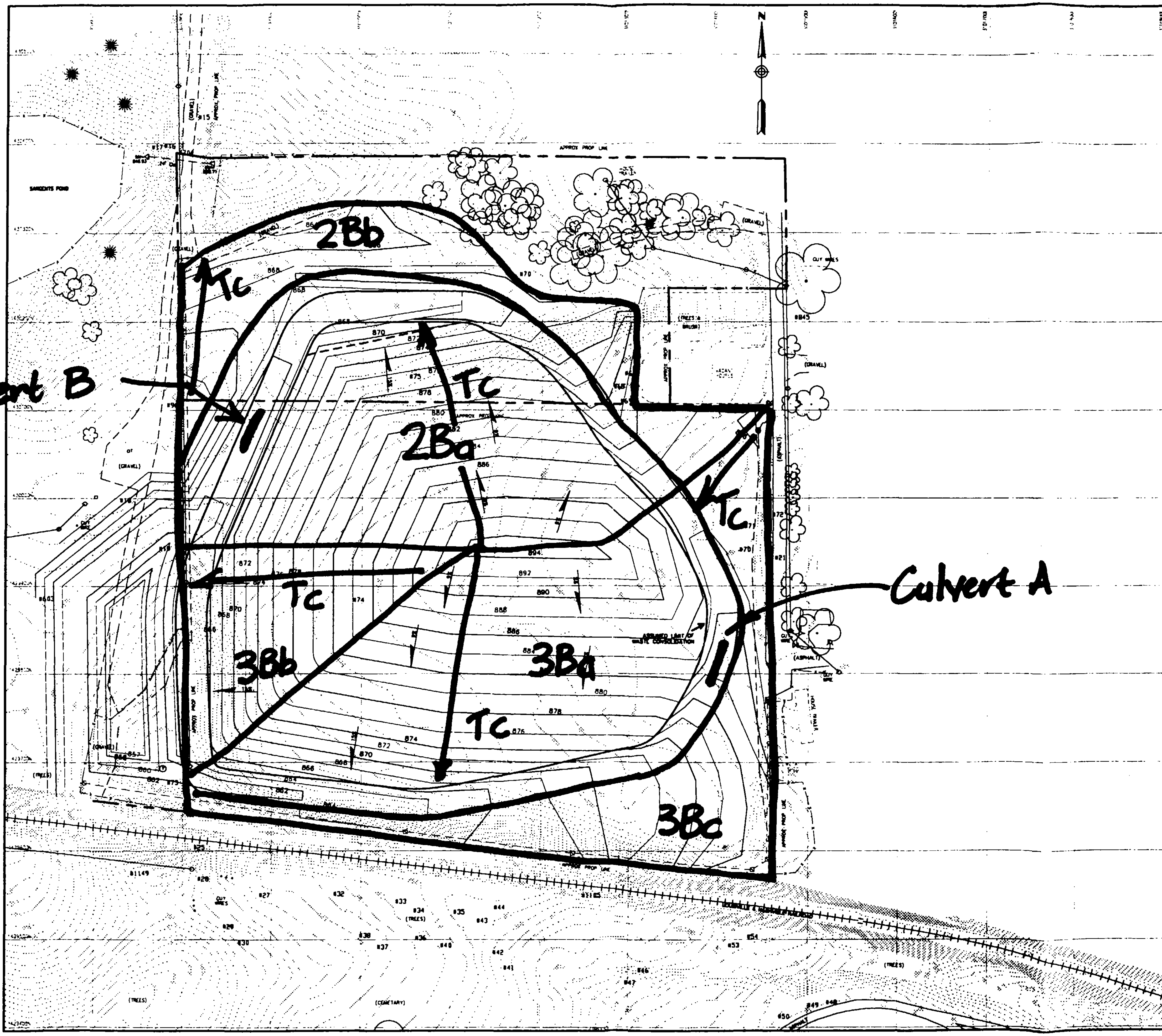
	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	3.68	2.81	2.81	2.81	3.68	3.68	3.68
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.09	0.14	0.14	0.14	0.09	0.09	0.09
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time	Total	Subarea Contribution to Total Flow (cfs)					
(hr)	Flow	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	10	2	2	1	1	2	1	1
12.0	16	4	4	1	1	4	1	1
12.1	33	7	7P	3P	3	8	2	3
12.2	45P	11P	7	3	4P	12P	3P	5
12.3	42	11	4	2	4	12	3	6P
12.4	30	8	2	1	3	8	2	6
12.5	20	5	2	1	2	5	1	4
12.6	12	3	1	0	1	3	1	3
12.7	10	2	1	0	1	3	1	2
12.8	9	2	1	0	1	2	1	2
13.0	4	1	1	0	0	1	0	1
13.2	4	1	1	0	0	1	0	1
13.4	3	1	0	0	0	1	0	1
13.6	3	1	0	0	0	1	0	1
13.8	3	1	0	0	0	1	0	1
14.0	2	1	0	0	0	1	0	0
14.3	2	1	0	0	0	1	0	0
14.6	2	1	0	0	0	1	0	0
15.0	2	1	0	0	0	1	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow


NSON AVE
KNOCKLES RD
3A
3B
2B
2A
Landfill
Lemon Lane
W GRAY ST
N NORTH ST
SPRING ST

Sheet 11 of 11



LEGEND

	WASTE THICKNESS CONTOUR (1 FT)
	WASTE THICKNESS CONTOUR (5 FT)
	ASSUMED LIMIT OF CAP GEOMEMBRANE
	GROUND SURFACE CONTOUR (1 FT)
	GROUND SURFACE CONTOUR (5 FT)
	PROPERTY LINE
	BRUSHLINE
	FENCELINE
	BUILDING FOOTPRINT
	POWER LINE
	GAS LINE
	ROAD
	RAILROAD
	INDIVIDUAL TREE
	SUMP
	UTILITY POLE
876.08 DTWS-23	SOIL BORING LOCATION AND ELEVATION

NOTES

1.) WASTE THICKNESS CONTOURS PRESENTED ARE DERIVED FROM SUBSURFACE INFORMATION OBTAINED FROM BORINGS CATALOGUED BELOW IN NOTES 2 THROUGH 6.

2.) BORINGS B-1 THROUGH B-8: LOCATIONS OBTAINED FROM BLASLAND & BOUCK ENGINEERS, PHASE 1 REPORT, ENTITLED, "SUPPLEMENTAL HYDROGEOLOGIC INVESTIGATION", DATED NOVEMBER 1986. BORING LOGS, DATED MAY 1984, WERE PROVIDED BY CBS.

3.) BORINGS SB-1 THROUGH SB-25: LOCATIONS AND BORING LOGS OBTAINED FROM PEARA TECHNOLOGIES, INC. SUMMARY REPORT FOR LEMON LANE LANDFILL, DATED MARCH 7, 1997.

4.) BORINGS DTWS-1 THROUGH DTWS-27: LOCATIONS WERE OBTAINED FROM SMITH, NEUBECKER AND ASSOCIATES, INC. BASE MAP ENTITLED, "TOPOGRAPHIC SURVEY", DATED OCTOBER 28, 1998. DEPTHS TO NATURAL SOIL WERE PROVIDED BY CBS.

5.) BORINGS DTB-1 THROUGH DTB-36: LOCATIONS WERE OBTAINED FROM SMITH, NEUBECKER AND ASSOCIATES, INC. BASE MAP ENTITLED, "TOPOGRAPHIC SURVEY", DATED OCTOBER 28, 1998. DEPTHS TO BEDROCK WERE PROVIDED BY CBS.

6.) LOCATION AND SUBSURFACE INFORMATION FOR N-SERIES, E-SERIES AND W-SERIES BORINGS AS SHOWN WERE OBTAINED FROM PEARA TECHNOLOGY.

7.) WASTE THICKNESS INCLUDE THICKNESS OF HYPALON BEDDING SOIL.

REFERENCE

1.) BASE MAP AND PROPERTY LINE TAKEN FROM CADD FILE PROVIDED BY SMITH, NEUBECKER AND ASSOCIATES INC., TITLED "TOPOGRAPHIC SURVEY", DATED DECEMBER 9, 1998.

40 0 40 80
scale feet

REV	DATE	DESCRIPTION	CADD BY	CHK BY	RVW BY

PROJECT:
CBS
LEMON LANE LANDFILL PRE-FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE:
TOP OF CAP GRADES

Golder Associates
Philadelphia USA

PROJECT No.	993-6373		FILE No.	USTPLS3
CLIENT PROJ. No.			DRAFTING SUBMITTAL	03
DES BY	VEF	05/02/00	SCALE	AS SHOWN
DRN BY	MJS	05/19/00	FIGURE	
CHK BY				
RVW BY				

APPENDIX A3
CULVERT B DESIGN

GOLDER ASSOCIATES	Subject: DESIGN FOR CULVERT B		
	Job No: 993-6573	Made by: BRB	Date: 5/23/00
	Ref: Lemon Lane	Check by: WT	Sheet: 1 of 14
		Review by: DW	

OBJECTIVE: To select the pipe diameter (D) for peak flow rates, for the 25 and 100 year design storm, with a headwater depth (HW) of less than 2 ft for the Lemon Lane Landfill. The perimeter channel that discharges into the culverts has a depth of 2 ft, therefore a headwater depth of less than 2 ft would prevent the water from overflowing the outer banks, and overtopping the access road.

METHOD:

1) Use the attached maps (Reference 2) of the site to determine the portion of the delineated watershed discharging to culvert B.

2) Based upon the peak runoff values from the hydrographs for the 25 and 100 year design storms, determine the peak flow using the equation found from Method 1. The 100 year design storms are checked for overtopping of access road under more critical events.

3) Using the nomograph (Figure 33, Reference 1), determine the required HW by aligning a straight edge through alternate pipe diameters and calculated flow rate (from Method 2) to intersect scale 1, (HW/D for square edge). Since we will use a flared end section (comparable to a groove end with headwall), use scale 2. To find HW/D value for the design condition, draw a horizontal line to scale 2, from the point on scale 1. This will provide the required HW/D. To obtain the HW, multiply the value determined from scale 2 by the diameter. The diameters we are considering are 12, 15, and 18 inches. The ideal HW is approximately 1.5 ft, to provide 0.5 ft of freeboard on the upgradient end of the culvert.

REFERENCES:

1) American Concrete Pipe Association, "Concrete Pipe Design Manual," dated 1985.

2) Golder Associates Inc., Calculations entitled "Run-on Hydrographs – Proposed," dated 5/23/00.

CALCULATION: As stated in Method 1, the pipe discharge is determined first. From map estimation, the discharge in culvert B is the sum of all of watershed 2Ba and 50% of watershed 2Bb. The equation for discharge in culvert B is,

$$Q_B = 2Ba + 0.5\,(2Bb).$$

The values of each watershed vary per design storm event, the table below gives peak values of runoff rates (in cfs) for each watershed for the 25 and 100 year design storms from the tabular hydrographs.

Peak Runoff Rates (cfs) (from Reference 2, see copy attached sheets 9-12 of 14)		
Watershed	25 year	100 year
2Ba	9	11
2Bb	5	7

From the discharge equation and peak runoff rate, the discharge for culvert B can be calculated for each storm event. The equations are displayed on sheet 1 of 14. The table below summarizes the discharge (Q).

Culvert Design Q (cfs)		
Culvert	25 year	100 year
Q_B	11.5	14.5

The attached sheets 3-8 of 14 (Reference 1), provide the nomographs with the calculated discharge for each pipe for each design storm, for each of the three evaluated diameter pipes. From the nomographs the HW/D is obtained, then HW is calculated, as described in Method 3.

Headwater Depths (ft)			
Culvert	Pipe Diameter (in)	25 year	100 year
B	12	NA	NA
B	15	3.25	4.50
B	18	2.22	3.00
B*	12	2.20	3.00
B*	15	1.50	1.81
B*	18	1.34	1.55
NA means the HW could not be determined from the nomograph.			
* Denotes the use of two pipes.			

RESULTS: The results for the discharge in culvert B were off the charts for the 12 inch diameter pipe and much too high for the 15 inch and 18 inch pipes for both design storms. Through further evaluation 2-18 inch pipes would be ideal for the 25 year storm discharge, and convey the flow for the 100 year storm discharge, as well.

CONCLUSION: The two 18 inch diameter pipes are the best choice for the culvert design for culvert B. For culvert B, two 18 inch diameter pipes will obtain a headwater depth of less than 1.5 feet for the 25 design storm, which is ideal, and obtain a headwater depth of a little more than 1.5, which is sufficient.

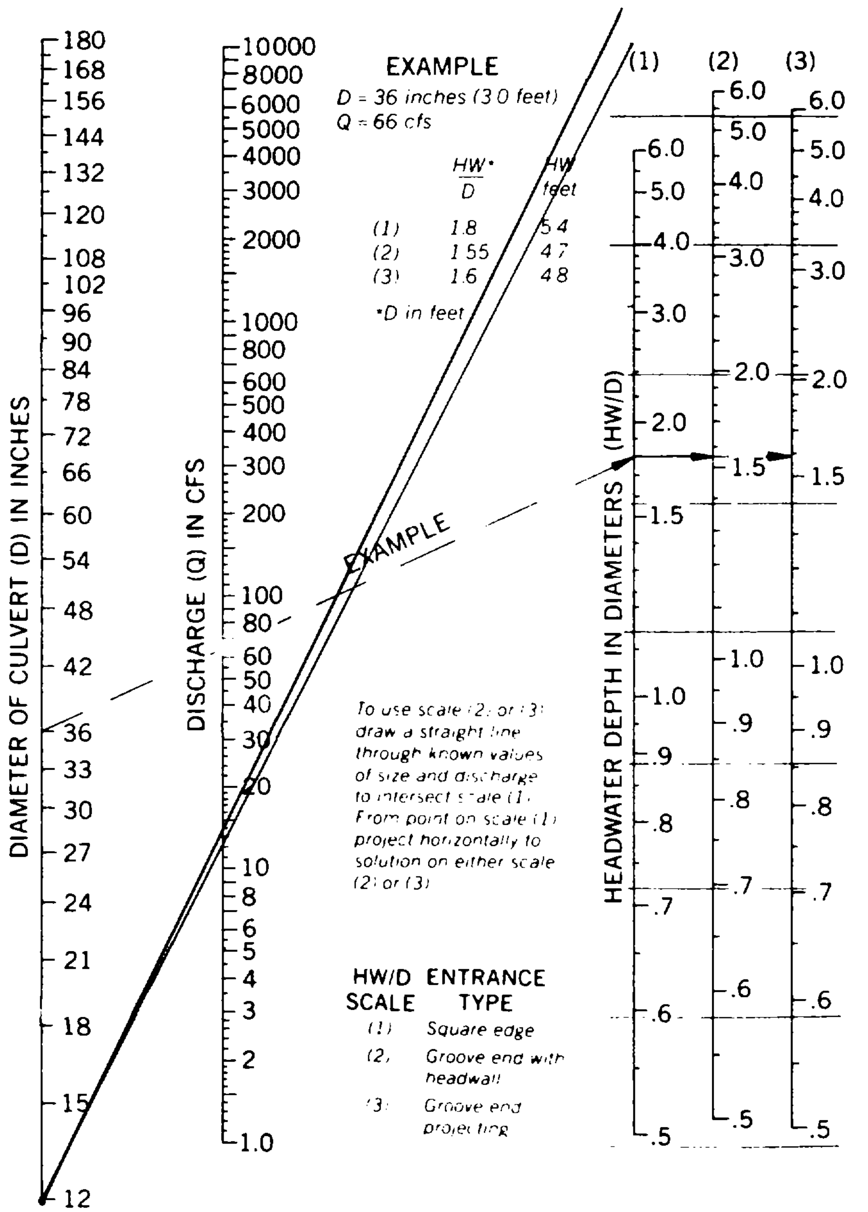
SHEET 3 OF 14

12" DIA. PIPE

		HW (ft)
—	$Q_{25\,YR}$ = 11.5 cf	NA
—	$Q_{100\,YR}$ = 14.5 cf	NA

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

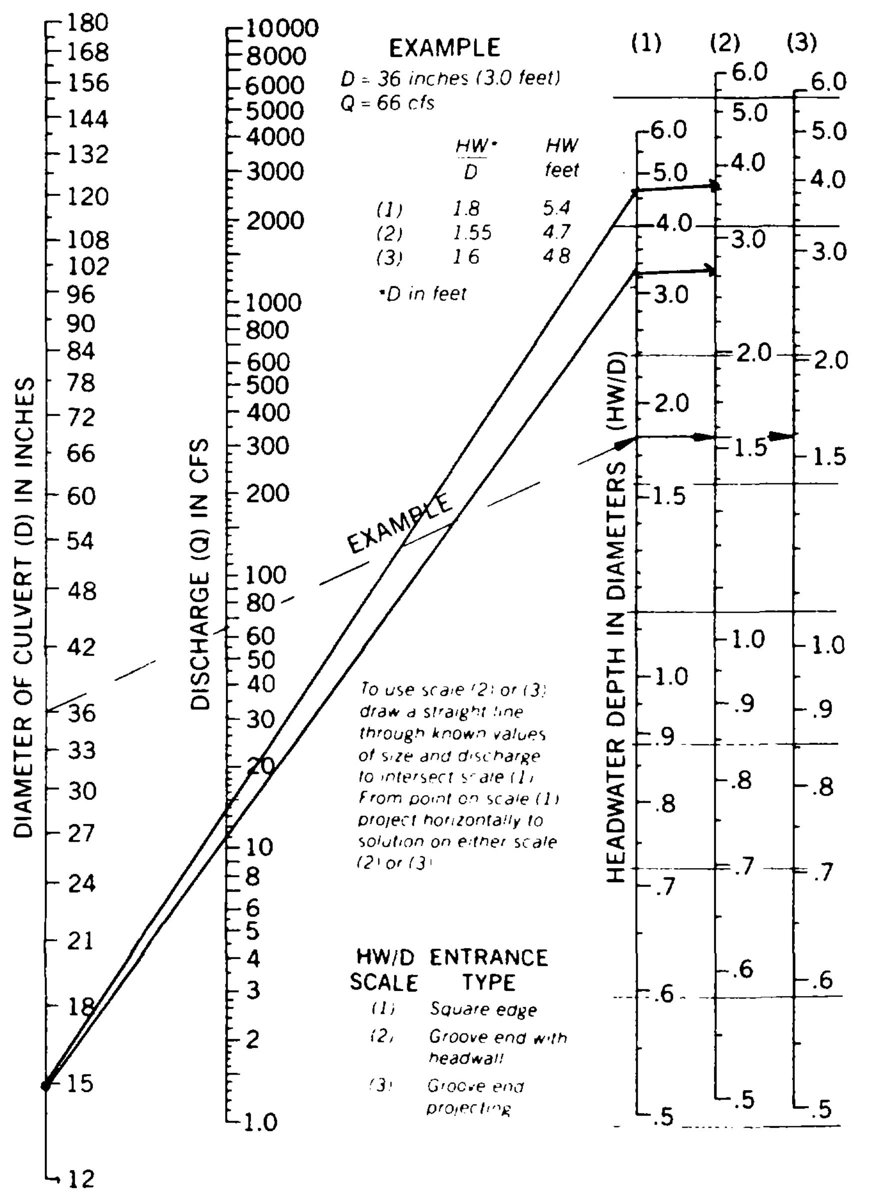
SHEET 4 OF 14

15" DIA. PIPE

FIGURE 33

		HW(ft)
— $Q_{25\,YR}$ = 11.5 cf		3.25
— $Q_{100\,YR}$ = 14.5 cf		4.50

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

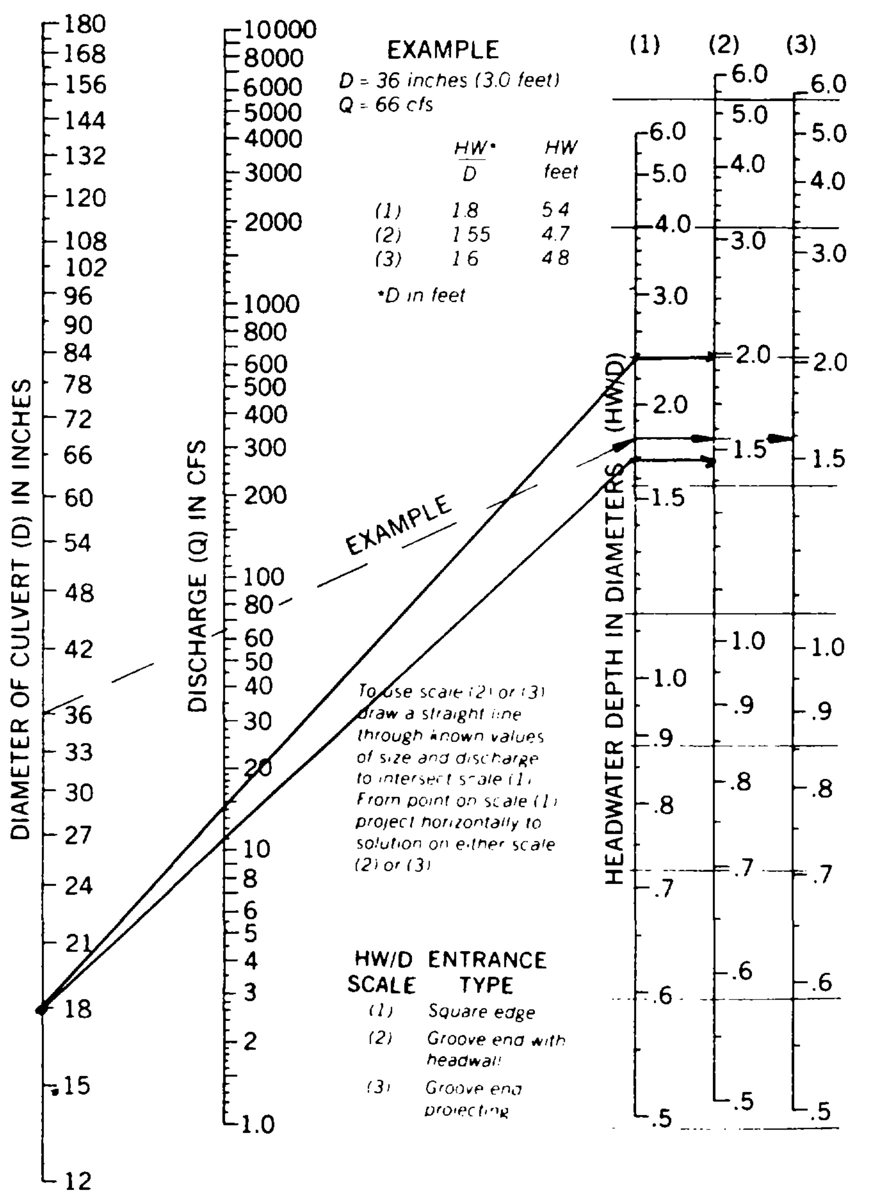
SHEET 5 OF 14

18" DIA. PIPE

		HW (ft)
$-Q_{25\text{-}YR}$	= 11.5 cf	2.22
$-Q_{100\text{-}YR}$	= 14.5 cf	3.00

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

SHEET 6 OF 14

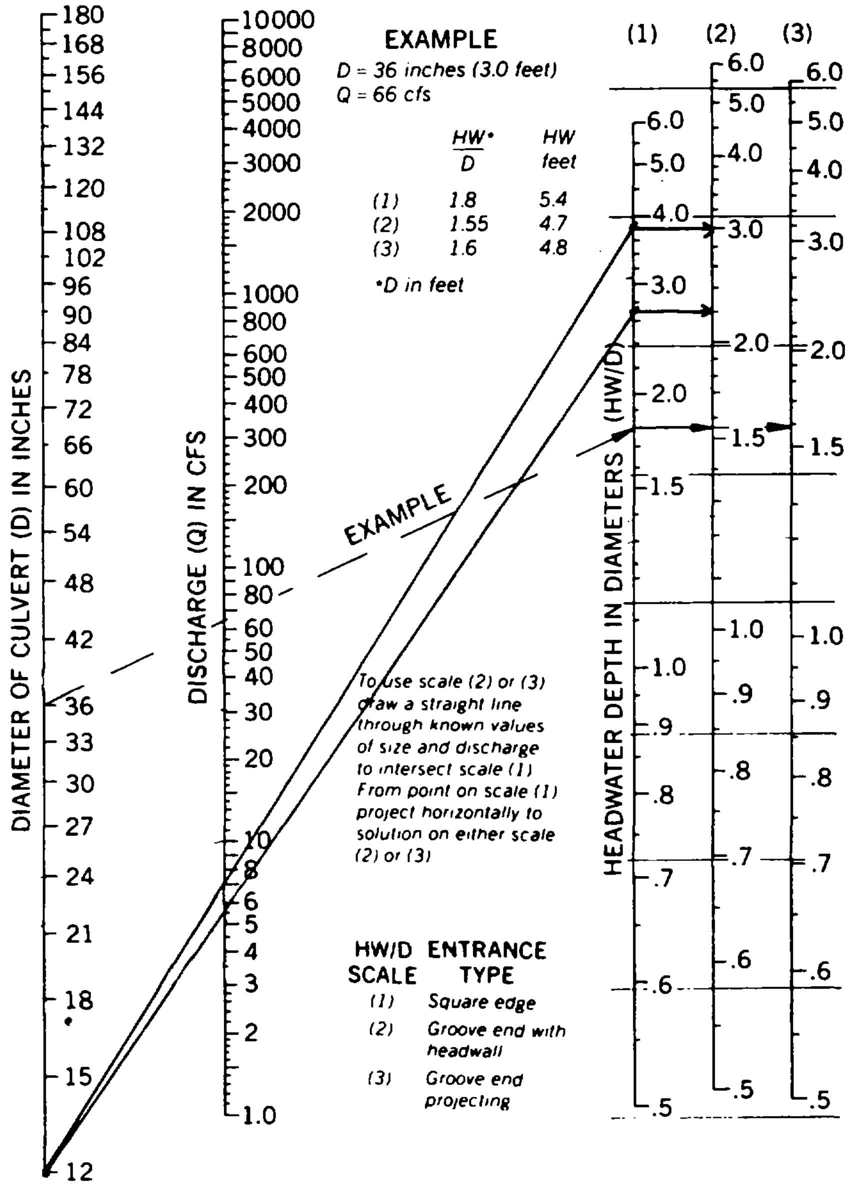
2-12" DIA. PIPES

– $Q_{25\text{-}R}$ = 5.75 cf $\frac{HW(ft)}{2.20}$

– $Q_{100\text{-}R}$ = 7.25 cf 3.00

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL

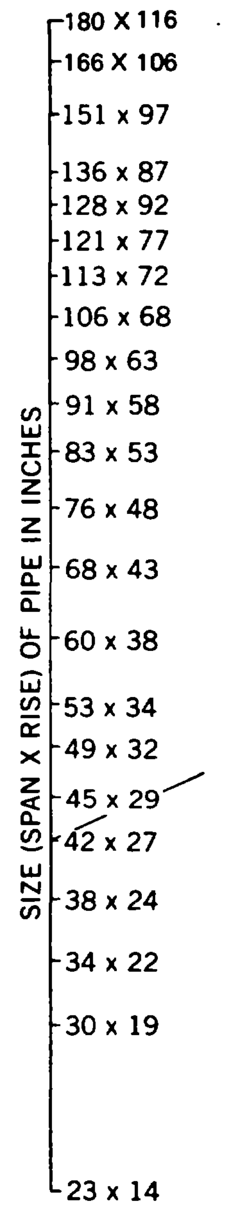


BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

FIGURE 34

HEA
CO



BUREAU OF PUBL

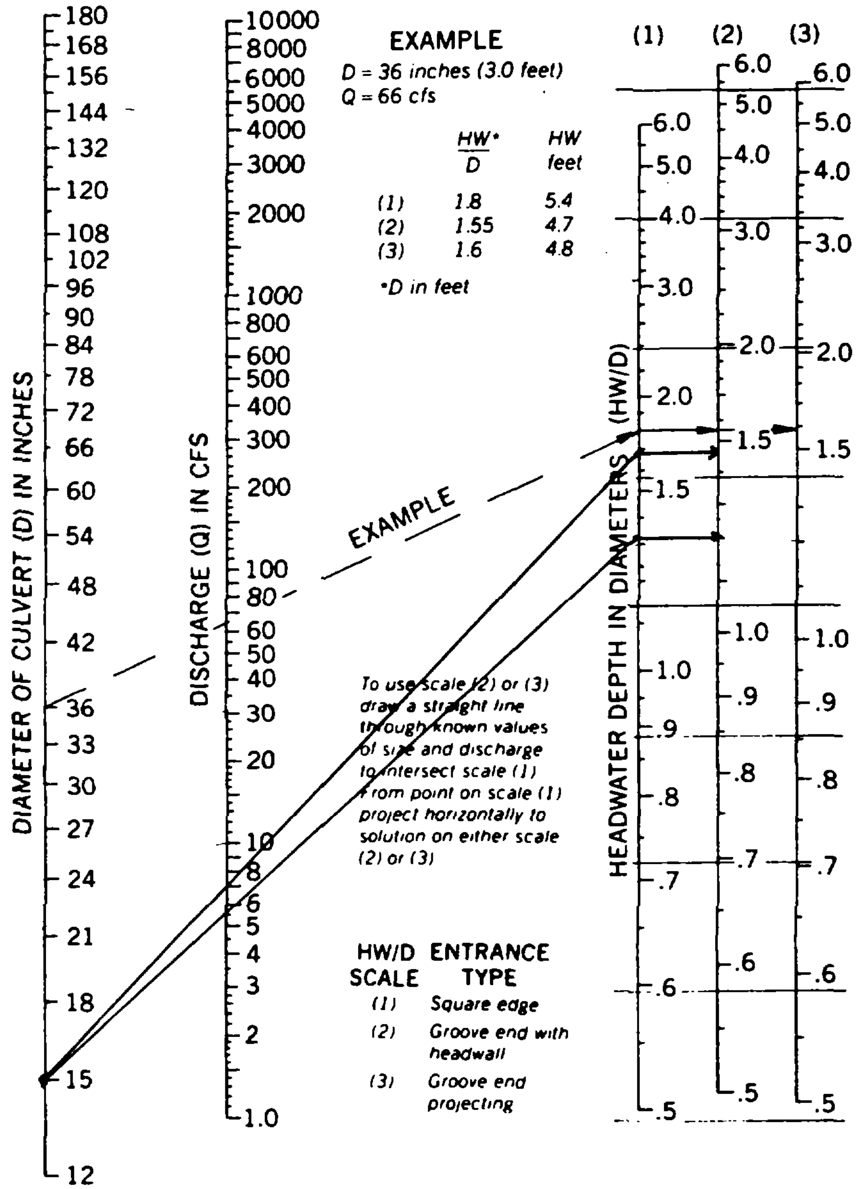
Z-15" DIA. PIPES

FIGURE 33

— $Q_{25\text{-}R}$ = 5.75 cf HW (ft) 1.50

— $Q_{100\text{-}R}$ = 7.25 cf 1.81

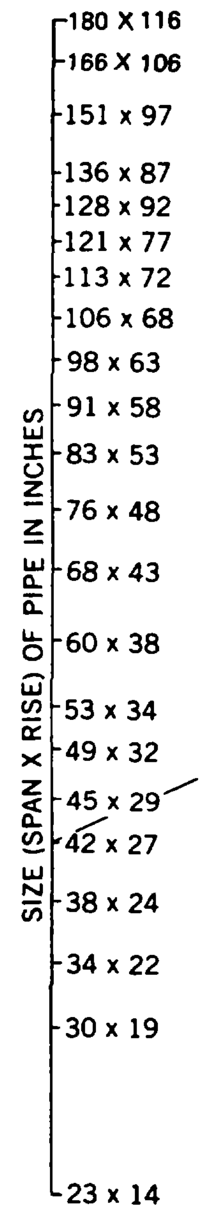
HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



HEADWATER SCALES 2&3
REVISED MAY 1964

FIGURE 34

H
C



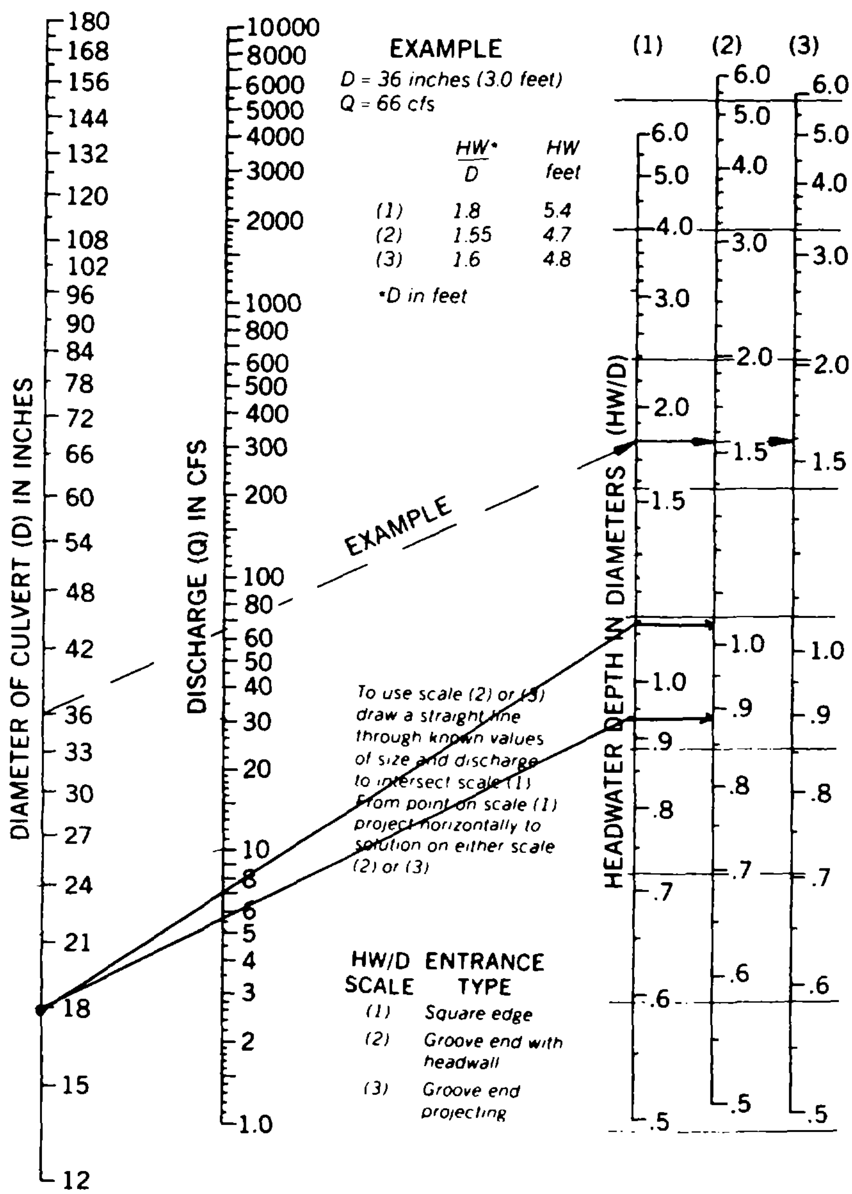
SHEET 8 OF 14

2-18" DIA. PIPES

		HW(ft)
$-Q_{25yr}$	= 5.75 cf	1.34
$-Q_{100yr}$	= 7.25 cf	1.55

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

Sheet 9 of 14

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAO Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 25 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	5.0	5.0
Curve number	70	79
Runoff(in)	2.04	2.80
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.17	0.11
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	2	1	1
11.3	3	2	1
11.6	4	2	2
11.9	9	5	4
12.0	16	9	7
12.1	30	17	13
12.2	52	30	22
12.3	66P	38P	28P
12.4	64	37	27
12.5	48	28	20
12.6	33	19	14
12.7	24	14	10
12.8	18	10	8
13.0	12	7	5
13.2	9	5	4
13.4	7	4	3
13.6	7	4	3
13.8	5	3	2
14.0	5	3	2
14.3	4	2	2
14.6	4	2	2
15.0	3	2	1
15.5	3	2	1
16.0	3	2	1
16.5	2	1	1
17.0	2	1	1
17.5	2	1	1
18.0	2	1	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

Sheet 10 of 14

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAN Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 25 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	2.80	2.04	2.04	2.04	2.80	2.80	2.80
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.11	0.17	0.17	0.17	0.11	0.11	0.11
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	7	1	1	1	1	2	0	1
12.0	13	3	3	1	1	3	1	1
12.1	25	6	5P	2P	2	6	2	2
12.2	35P	9P	5	2	3P	9P	3P	4
12.3	33	9	3	1	3	9	3	5P
12.4	24	6	2	1	2	6	2	5
12.5	14	4	1	0	1	4	1	3
12.6	10	2	1	0	1	3	1	2
12.7	9	2	1	0	1	2	1	2
12.8	5	1	1	0	0	2	0	1
13.0	3	1	0	0	0	1	0	1
13.2	3	1	0	0	0	1	0	1
13.4	2	1	0	0	0	1	0	0
13.6	2	1	0	0	0	1	0	0
13.8	2	1	0	0	0	1	0	0
14.0	2	1	0	0	0	1	0	0
14.3	0	0	0	0	0	0	0	0
14.6	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAD Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 100 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	6.0	6.0
Curve number	70	79
Runoff(in)	2.81	3.68
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.14	0.09
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	3	2	1
11.3	4	2	2
11.6	5	3	2
11.9	12	7	5
12.0	21	12	9
12.1	41	24	17
12.2	70	41	29
12.3	89P	52P	37P
12.4	87	51	36
12.5	65	38	27
12.6	45	26	19
12.7	32	19	13
12.8	24	14	10
13.0	15	9	6
13.2	12	7	5
13.4	10	6	4
13.6	8	5	3
13.8	7	4	3
14.0	7	4	3
14.3	5	3	2
14.6	5	3	2
15.0	5	3	2
15.5	4	2	2
16.0	4	2	2
16.5	3	2	1
17.0	3	2	1
17.5	3	2	1
18.0	3	2	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: [illegible] Date: 6/7/00

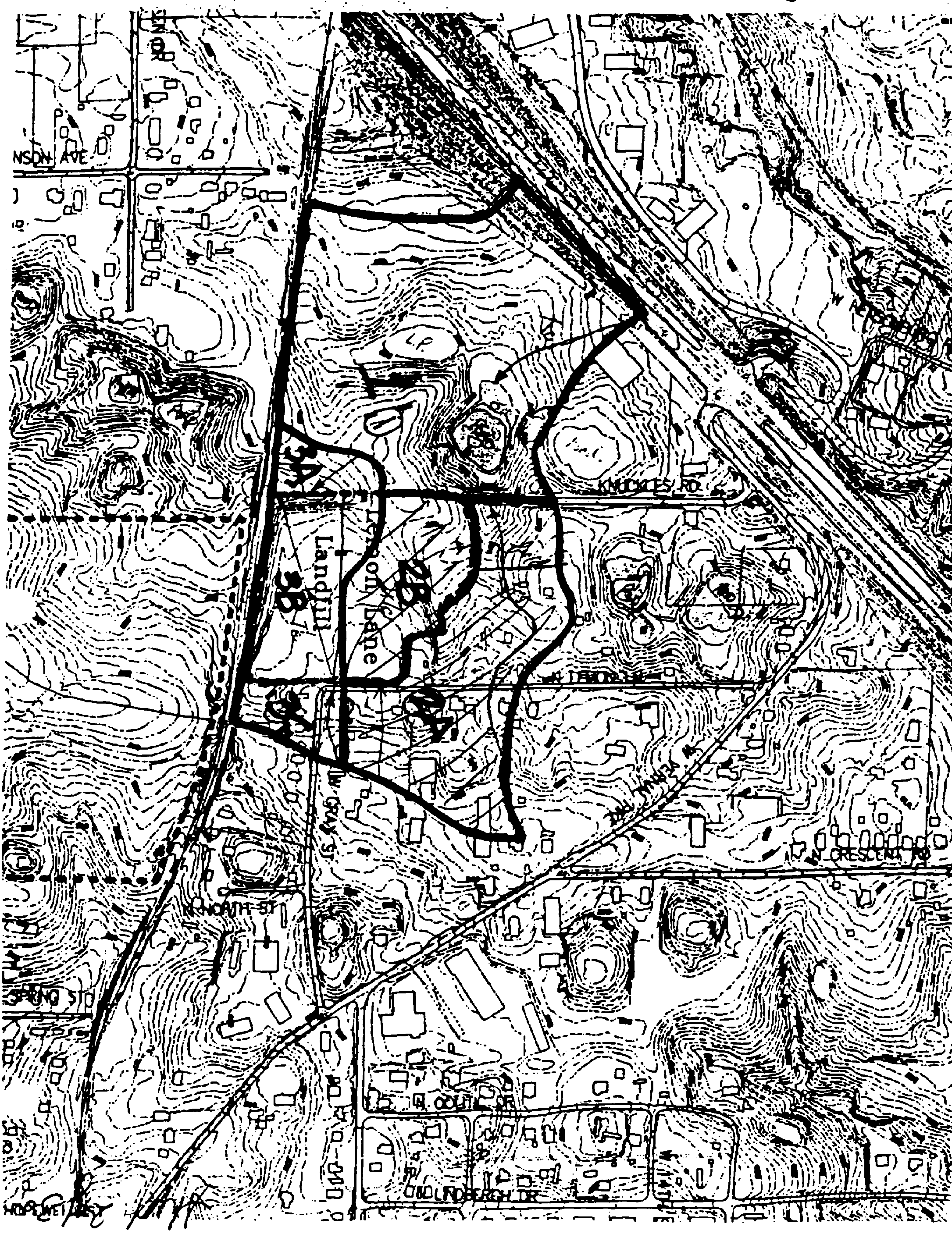
Subtitle: PROPOSED CONDITIONS

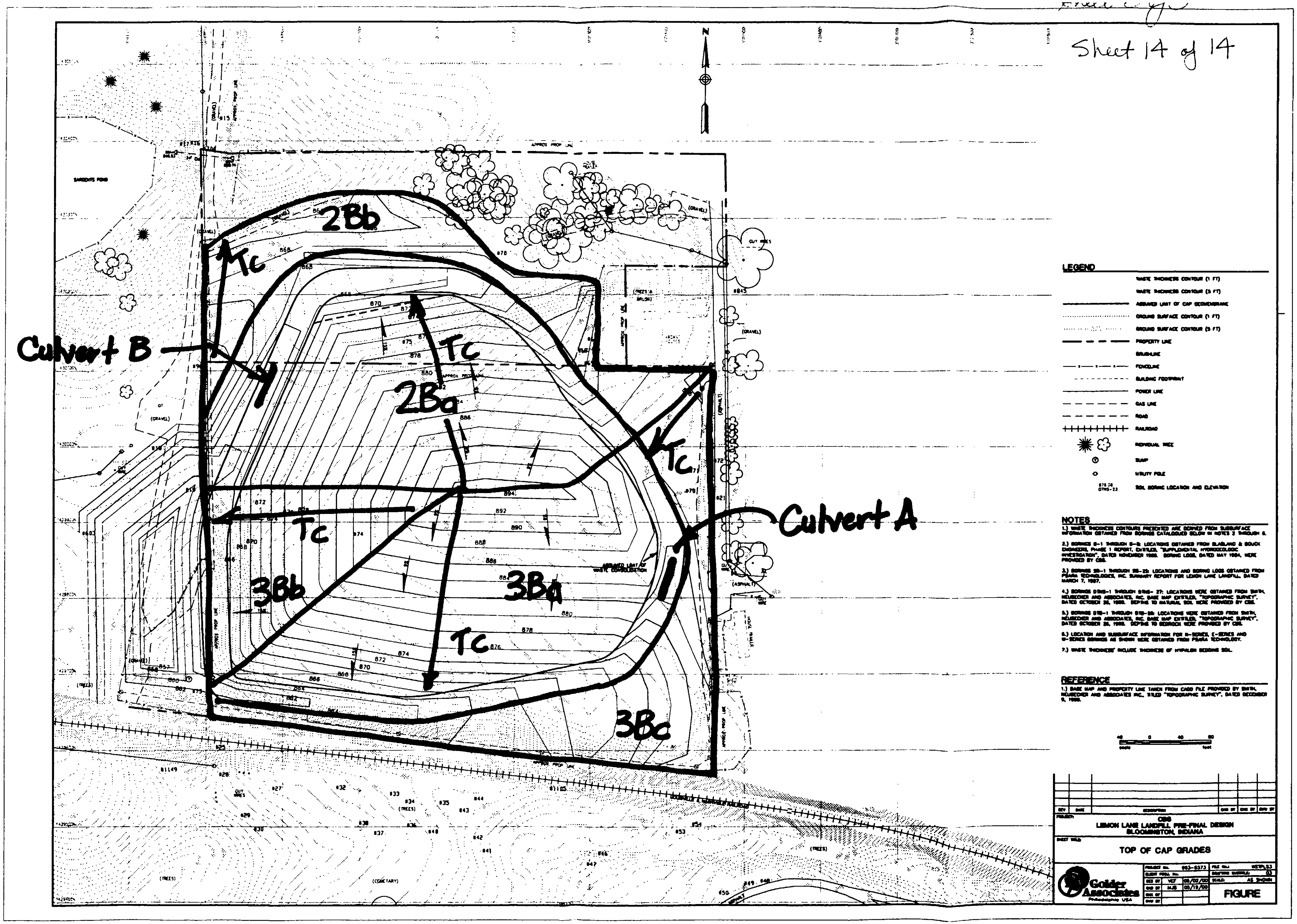
Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 100 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	3.68	2.81	2.81	2.81	3.68	3.68	3.68
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.09	0.14	0.14	0.14	0.09	0.09	0.09
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time	Total	Subarea Contribution to Total Flow (cfs)						
(hr)	Flow	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	10	2	2	1	1	2	1	1
12.0	16	4	4	1	1	4	1	1
12.1	33	7	7P	3P	3	8	2	3
12.2	45P	11P	7	3	4P	12P	3P	5
12.3	42	11	4	2	4	12	3	6P
12.4	30	8	2	1	3	8	2	6
12.5	20	5	2	1	2	5	1	4
12.6	12	3	1	0	1	3	1	3
12.7	10	2	1	0	1	3	1	2
12.8	9	2	1	0	1	2	1	2
13.0	4	1	1	0	0	1	0	1
13.2	4	1	1	0	0	1	0	1
13.4	3	1	0	0	0	1	0	1
13.6	3	1	0	0	0	1	0	1
13.8	3	1	0	0	0	1	0	1
14.0	2	1	0	0	0	1	0	0
14.3	2	1	0	0	0	1	0	0
14.6	2	1	0	0	0	1	0	0
15.0	2	1	0	0	0	1	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow


NSON AVE
KNUCKLES RD
Landfill
Lemon Lane
3A
3B
2B
2A
N CRESCENT RD
N NORTH ST
SPRING ST
W GRAY ST
N COLLINS DR
LINDBERGH DR
HOPEWELL DR



Sheet 14 of 14
N
2Bb
2Ba
3Bb
3Ba
3Bc
Tc
Culvert B
Culvert A
SARGENTS POND
(GRAVEL)
APPROX. PROP. LINE
ASSUMED LIMIT OF WASTE CONSOLIDATION
(ASPHALT)
(TREES)
(CEMETARY)
CUT WIRES
LEGEND
WASTE THICKNESS CONTOUR (1 FT)
WASTE THICKNESS CONTOUR (5 FT)
ASSUMED LIMIT OF CAP GEOMEMBRANE
GROUND SURFACE CONTOUR (1 FT)
GROUND SURFACE CONTOUR (5 FT)
PROPERTY LINE
BRUSHLINE
FENCELINE
BUILDING FOOTPRINT
POWER LINE
GAS LINE
ROAD
RAILROAD
INDIVIDUAL TREE
SUMP
UTILITY POLE
SOIL BORING LOCATION AND ELEVATION
NOTES
REFERENCE
scale feet
CBS
LEMON LANE LANDFILL PRE-FINAL DESIGN
BLOOMINGTON, INDIANA
TOP OF CAP GRADES
Golder Associates
Philadelphia USA
PROJECT No. 993-6373
SCALE AS SHOWN
FIGURE

APPENDIX A4
PERIMETER CHANNEL DESIGN

GOLDER ASSOCIATES	Subject: PERIMETER CHANNEL DESIGN		
	Job No: 993-6573	Made by: VEF	Date: 8/9/00
	Ref: Lemon Lane	Check by: BPB	Sheet: 1 of 11
		Review by: DJ	

OBJECTIVE: To determine the flow rates in each channel and design a new channel.

METHOD:

1) Based upon the peak runoff rates developed for each watershed, add the peak rates discharging into each channel.

2) Select the most critical channel flow rate for like channels and design all like channels to convey the peak runoff rate.

REFERENCES:

1) Golder Associates Inc., Calculations entitled "Run-On Hydrographs – Proposed," dated 5/23/00.

ASSUMPTIONS:

1) For channels with a rip rap lining and a d_{50} of 0.5 feet, $n = 0.0395 d_{50}^{(1/6)}$, where d_{50} is expressed in feet. Therefore, 'n' is 0.0352.

2) Alternatively, use the riprap n-values vs. flow depth chart (see attached as Sheet 10 of 10) to also check for critical velocity and flow depth for the peak design Q.

CALCULATION: The values of each watershed vary per design storm event, the table below gives peak values of runoff rates (in cfs) for each watershed for the 25 and 100 year design storms from the tabular hydrographs. Attached is a map which displays the watersheds contributions to the perimeters.

Peak Runoff Rates (cfs) (from Reference 1, see copy attached sheets 5-8 of 11)		
Watershed	25 year	100 year
2Ba	9	11
2Bb	5	7
3Ba	9	12
3Bc	2	3
3C	5	6

From map estimation, the discharge, (Q), for the perimeter channels can be obtained. The table below summarizes the discharge values.

Flow rates for Perimeter Channels (cfs)			
Channels	Q_{25}	Q_{100}	$Q_{equation}$
South	16	21	3Ba + 3Bc + 3C
North	11.5	14.5	0.5 (2Bb) + 2Ba
Maximum Q	16	21	---

The most critical channel flow rate per storm event is the maximum value of discharge, displayed on the bottom of the chart.

Use an Excel Spreadsheet that implements Manning's equation, where

$Q = (1.49 \times R_h^{2/3} \times A \times S^{1/2})/n$, such that

Q = channel flow rate (cfs)
R_h = hydrualic radius of channel = A/P
A = cross-sectional area of flow
P = wetted perimeter of flow
S = channel slope
n = Manning's coefficient

RESULTS: For perimeter channels, use a rip rap lined channel, trapezoidal channel cross-section, with bottom width of 6 ft, and a channel depth of 2 ft. The riprap (d_{50} = 6 inches) has a maximum permissible velocity of 9 fps. The critical discharges are 16 cfs for the 25 year storm event and 21 cfs for the 100 year storm event.

1) Using Manning's n = 0.0352: For the 25 year storm peak flow rate, the peak velocities are 2.96 fps for 1% slope and 6.19 fps for 9% slope. For the 100 year storm peak flow rate, the peak velocities are 3.23 fps for 1% slope and 6.73 fps for 9% slope.
2) Using riprap n-values vs. flow depth curves: For the 25 year design storm peak flow rate, the critical flow depth is 0.91 feet for a 1% slope. The critical velocity is 4.16 fps with a corresponding flow depth of 0.55 feet at 9% slope.
3) Using riprap n-values vs. flow depth curves: For the 100 year design storm peak flow rate, the critical flow depth is 1.02 feet for a 1% slope. The critical velocity is 4.83 fps with a corresponding flow depth of 0.60 feet at 9% slope.

CONCLUSION: The specified channel geometry and lining are adequate to convey flow and withstand anticipated design velocities.

Disk: G:\Projects 6573 Client: CBS Date: 08/10/00
File: 100%\100perim Project: 993-6573 Time: 11:24

Title: Surface Water Calc.-Perimeter Channel	Site: Lemon Lane		
Prepared by: V.E.FOSTER	Telephone Number:		Sheet 3 of 11

Design Calculations: PROPOSED PERIMETER CHANNEL DESIGN

Channel Name	Design Storm (years)	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Freeboard (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Actual Q (cfs)	With Freeboard Channel Depth (ft)	Top Channel Width (ft)	Q Available (cfs)
1	25	16	0.010	1.27	Riprap	0.035	6.00	2.00	2.00	5.45	0.73	8.92	2.96	16.1	2.00	14.0	102.5
1	25	16	0.090	1.61	Riprap	0.035	6.00	2.00	2.00	2.64	0.39	7.56	6.19	16.4	2.00	14.0	307.6
1	25	16	0.010	1.09	Riprap	0.052	6.00	2.00	2.00	7.12	0.91	9.64	2.27	16.1	2.00	14.0	69.4
1	25	16	0.090	1.45	Riprap	0.064	6.00	2.00	2.00	3.91	0.55	8.20	4.16	16.2	2.00	14.0	169.2
1	100	21	0.010	1.15	Riprap	0.035	6.00	2.00	2.00	6.55	0.85	9.40	3.23	21.1	2.00	14.0	102.5
1	100	21	0.090	1.55	Riprap	0.035	6.00	2.00	2.00	3.11	0.45	7.80	6.73	20.9	2.00	14.0	307.6
1	100	21	0.010	0.98	Riprap	0.049	6.00	2.00	2.00	8.20	1.02	10.08	2.56	21.0	2.00	14.0	73.7
1	100	21	0.090	1.40	Riprap	0.058	6.00	2.00	2.00	4.32	0.60	8.40	4.83	20.8	2.00	14.0	186.7

SHEET 3 OF 11

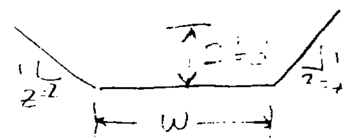
Golder Associates	SUBJECT Perimeter Channel - DESIGN		
	Job No. 993-6573 Ref. LLL/CBS	Made by VEA Checked BRB Reviewed RW	Date 7/31/2000 Sheet 4 of 11

Example calculation:

$Q = 16$ cfs

$S = 1\% = 0.01$ ft/ft

$n = 0.0352$ (Riprap)



$A = \frac{(w + w + 2zd)}{2} d = (w + dz)d = (w + 2d)d$

$P = w + 2d\sqrt{z^2+1} = w + 2 \times d \times \sqrt{5} = w + 2d\sqrt{5}$

$R_h = \frac{A}{P}$

Determine the flow depth (d) required to convey the design flow (Q) if $w = 6$ ft, try $d = 0.73$ ft (allowing 1.27 feet freeboard)

$A = [6 + (2 \times 0.73)]\, 0.73 = 5.45$ s.f.

$P = 6 + (2 \times 0.73 \times \sqrt{5}) = 9.26$ ft

$R_h = \frac{A}{P} = \frac{5.45}{9.26} = 0.59$ ft

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

$Q = \frac{1.49}{0.0352}(0.01)^{1/2}(0.59)^{2/3}(5.45)$

$Q = 16.1 \text{ cfs} \overset{?}{=} 16$ OK

The velocity corresponding to this depth is

$Q = VA \rightarrow V = Q/A = \frac{16.1}{5.45} = 2.95$ fps < 9 fps OK (max. allow for $d_{50} = 6''$)

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAD Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 25 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	5.0	5.0
Curve number	70	79
Runoff(in)	2.04	2.80
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.17	0.11
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	2	1	1
11.3	3	2	1
11.6	4	2	2
11.9	9	5	4
12.0	16	9	7
12.1	30	17	13
12.2	52	30	22
12.3	66P	38P	28P
12.4	64	37	27
12.5	48	28	20
12.6	33	19	14
12.7	24	14	10
12.8	18	10	8
13.0	12	7	5
13.2	9	5	4
13.4	7	4	3
13.6	7	4	3
13.8	5	3	2
14.0	5	3	2
14.3	4	2	2
14.6	4	2	2
15.0	3	2	1
15.5	3	2	1
16.0	3	2	1
16.5	2	1	1
17.0	2	1	1
17.5	2	1	1
18.0	2	1	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

Sheet 6 of 11

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAW Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 25 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	2.80	2.04	2.04	2.04	2.80	2.80	2.80
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.11	0.17	0.17	0.17	0.11	0.11	0.11
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	7	1	1	1	1	2	0	1
12.0	13	3	3	1	1	3	1	1
12.1	25	6	5P	2P	2	6	2	2
12.2	35P	9P	5	2	3P	9P	3P	4
12.3	33	9	3	1	3	9	3	5P
12.4	24	6	2	1	2	6	2	5
12.5	14	4	1	0	1	4	1	3
12.6	10	2	1	0	1	3	1	2
12.7	9	2	1	0	1	2	1	2
12.8	5	1	1	0	0	2	0	1
13.0	3	1	0	0	0	1	0	1
13.2	3	1	0	0	0	1	0	1
13.4	2	1	0	0	0	1	0	0
13.6	2	1	0	0	0	1	0	0
13.8	2	1	0	0	0	1	0	0
14.0	2	1	0	0	0	1	0	0
14.3	0	0	0	0	0	0	0	0
14.6	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAD Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 100 years

	Subareas	
	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	6.0	6.0
Curve number	70	79
Runoff(in)	2.81	3.68
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.14	0.09
(Used)	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2A
11.0	3	2	1
11.3	4	2	2
11.6	5	3	2
11.9	12	7	5
12.0	21	12	9
12.1	41	24	17
12.2	70	41	29
12.3	89P	52P	37P
12.4	87	51	36
12.5	65	38	27
12.6	45	26	19
12.7	32	19	13
12.8	24	14	10
13.0	15	9	6
13.2	12	7	5
13.4	10	6	4
13.6	8	5	3
13.8	7	4	3
14.0	7	4	3
14.3	5	3	2
14.6	5	3	2
15.0	5	3	2
15.5	4	2	2
16.0	4	2	2
16.5	3	2	1
17.0	3	2	1
17.5	3	2	1
18.0	3	2	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: [signature] Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 100 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	3.68	2.81	2.81	2.81	3.68	3.68	3.68
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.09	0.14	0.14	0.14	0.09	0.09	0.09
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time	Total	Subarea Contribution to Total Flow (cfs)						
(hr)	Flow	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	10	2	2	1	1	2	1	1
12.0	16	4	4	1	1	4	1	1
12.1	33	7	7P	3P	3	8	2	3
12.2	45P	11P	7	3	4P	12P	3P	5
12.3	42	11	4	2	4	12	3	6P
12.4	30	8	2	1	3	8	2	6
12.5	20	5	2	1	2	5	1	4
12.6	12	3	1	0	1	3	1	3
12.7	10	2	1	0	1	3	1	2
12.8	9	2	1	0	1	2	1	2
13.0	4	1	1	0	0	1	0	1
13.2	4	1	1	0	0	1	0	1
13.4	3	1	0	0	0	1	0	1
13.6	3	1	0	0	0	1	0	1
13.8	3	1	0	0	0	1	0	1
14.0	2	1	0	0	0	1	0	0
14.3	2	1	0	0	0	1	0	0
14.6	2	1	0	0	0	1	0	0
15.0	2	1	0	0	0	1	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

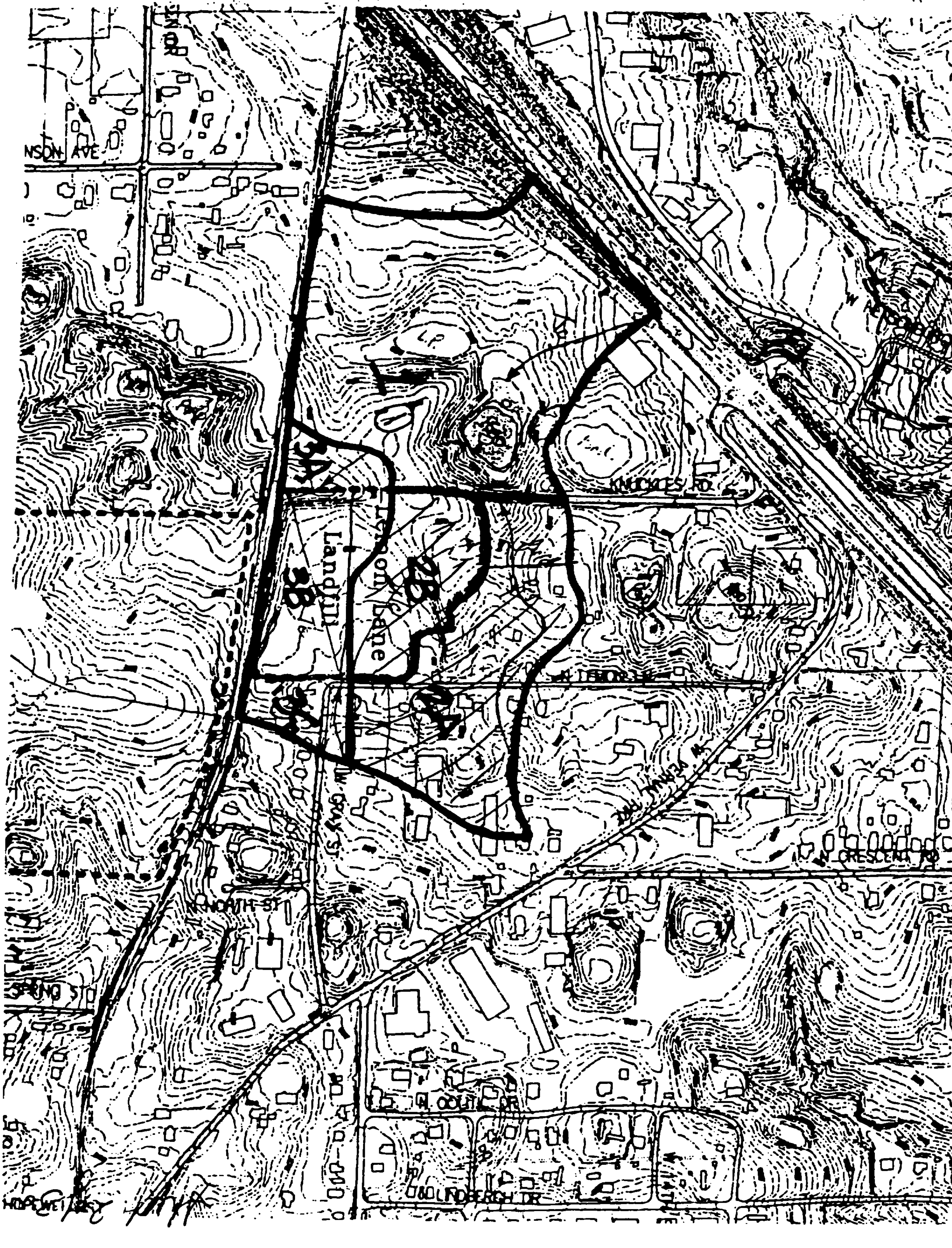
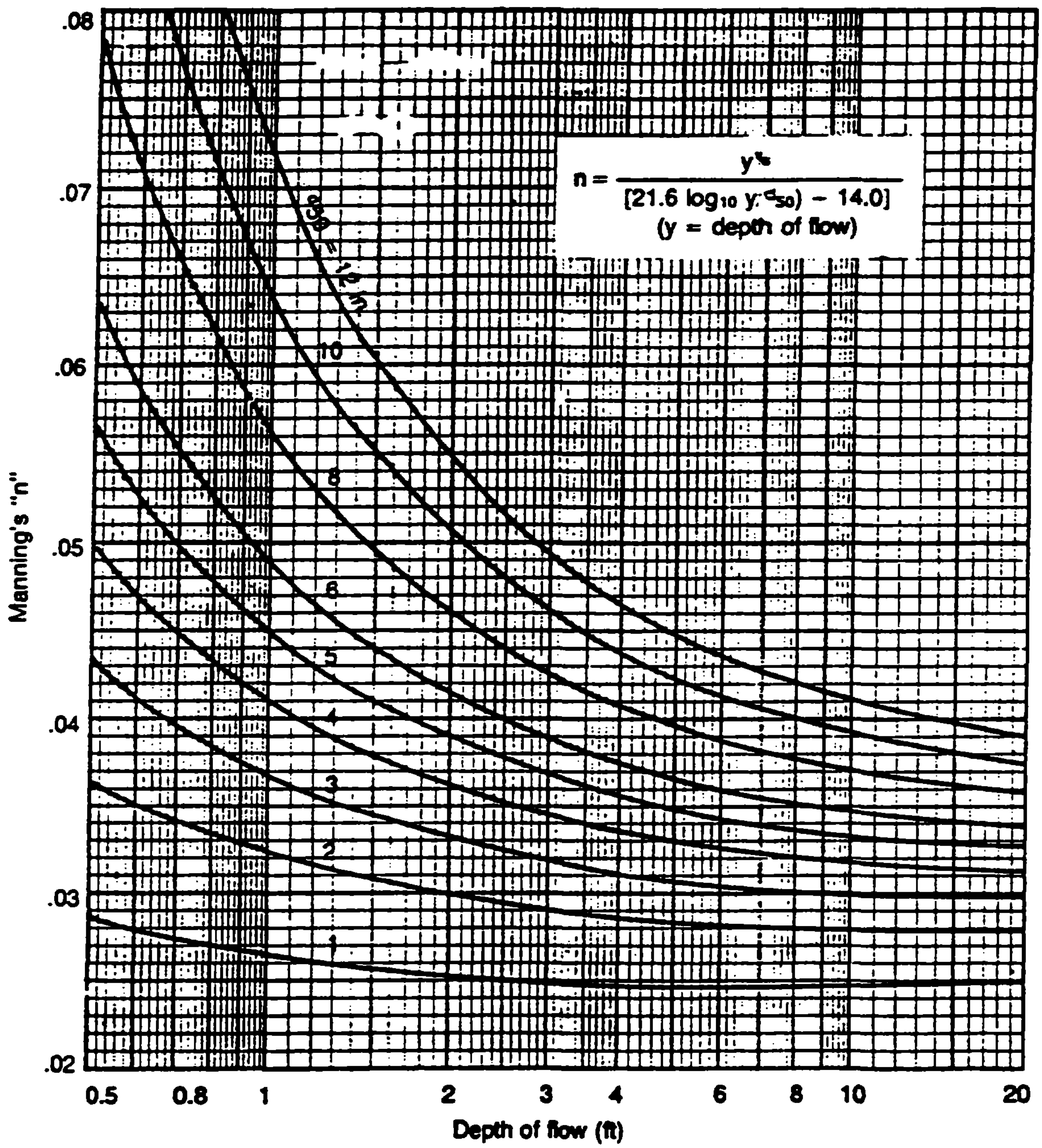
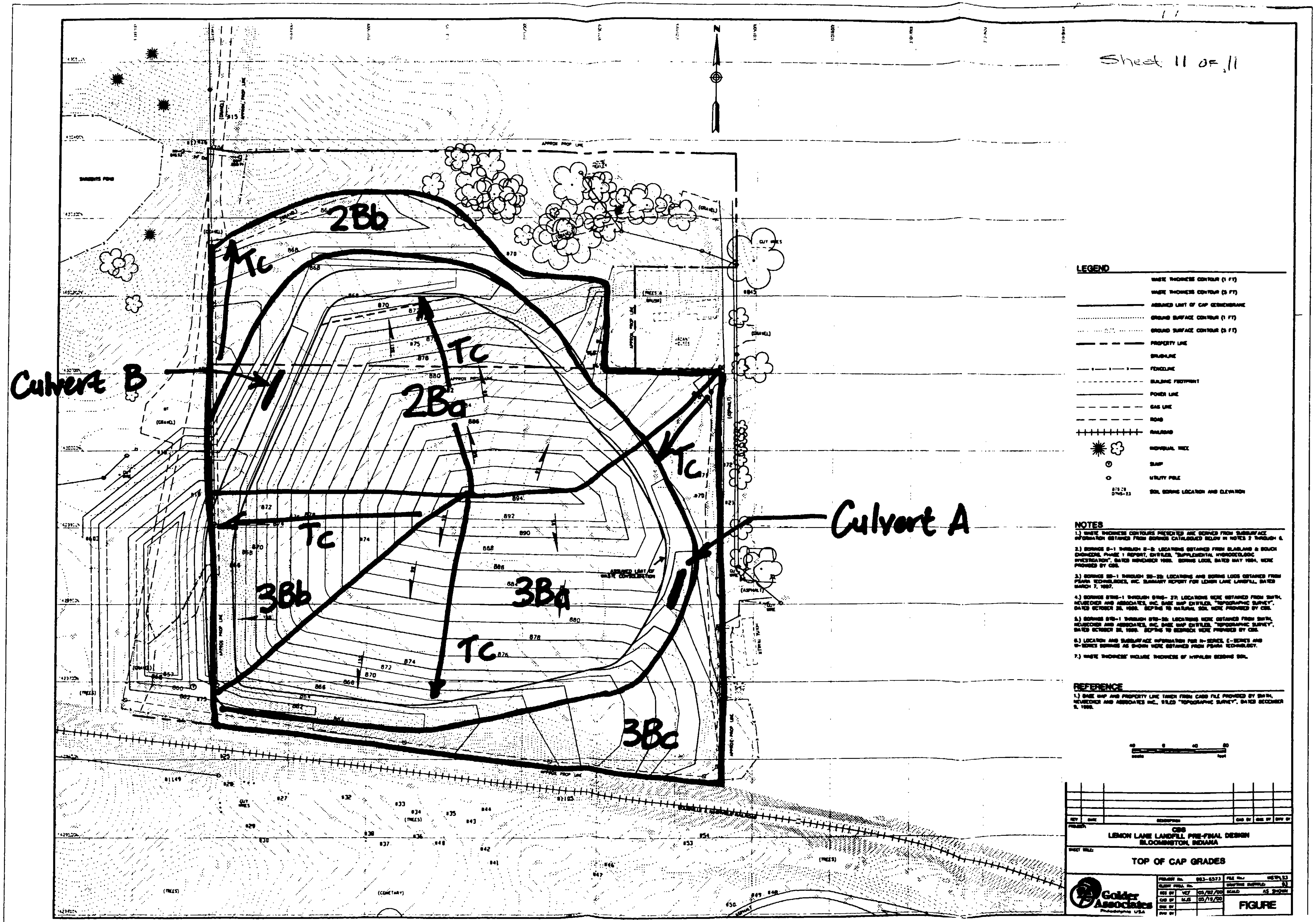

NSON AVE
KNICKLES RD
Landfill
Lane
3A
3B
2B
N GRAY ST
N CRESCENT RD
N NORTH ST
SPRING ST
LINDBERGH DR

FIGURE 4.5 n Values for Riprap Lined Channels





Sheet 11 of 11
N
2Bb
Tc
Culvert B
2Ba
Tc
Tc
Culvert A
3Bb
3Ba
Tc
Tc
3Bc
LEGEND
NOTES
REFERENCE
CBS
LEMON LANE LANDFILL PRE-FINAL DESIGN
BLOOMINGTON, INDIANA
TOP OF CAP GRADES
Golder Associates
Philadelphia USA
FIGURE

APPENDIX A5
V-DITCH DESIGN

GOLDER ASSOCIATES	Subject: PROPOSED V-DITCH DESIGN		
	Job No: 993-6573	Made by: VEF	Date: 8/9/00
	Ref: Lemon Lane	Check by: BCB	Sheet: 1 of 5
		Review by: DL	

OBJECTIVE: To determine the flow rates in the v-ditch and design the v-ditch.

METHOD:

1) Based upon the peak runoff rates developed for each watershed, add the peak rates discharging into each bench.

2) Select the most critical flow rate and design the v-ditch to convey the peak runoff rate using Manning's Equation for open channel flow.

REFERENCES:

1) Golder Associates Inc., Calculations entitled "Runoff Rates - Proposed," dated 5/23/00.

2) Simon, Andrew L., "Hydraulics", Third Edition, dated 1986.

CALCULATION: The values of each watershed vary per design storm event, the table below gives peak values of runoff rates (in cfs) for each watershed for the 25 and 100 year design storms from the tabular hydrographs.

Peak Runoff Rates (cfs) (from Reference 1, see copy attached sheets 3-4 of 5)		
Watershed	25 year	100 year
3Bc	2	3
3C	5	6

From map estimation, the discharge, (Q), for the proposed benches can be obtained. The table below summarizes the discharge values.

Flow Rates for Proposed Benches (cfs)			
Channel	$Q_{25\ year}$	$Q_{100\ year}$	$Q_{equation}$
V-Ditch	2.25	3	0.5 (3Bc) + 0.25 (3C)

Use an Excel Spreadsheet that implements Manning's equation, where

$Q = (1.49 \times R_h^{2/3} \times A \times S^{1/2})/n$, such that

Q = bench flow rate (cfs)
R_h = hydrualic radius of bench = A/P
A = cross-sectional area of flow
P = wetted perimeter of flow
S = bench slope
n = Mannings coefficient

RESULTS/
CONCLUSIONS: For v-ditch, assume Mannings coefficient to be 0.035 (taken from Reference 2), a riprap lined ditch, and minimum and maximum slopes slope of 2% (0.02 ft/ft) and 13.3 % (0.133 ft/ft), respectively. The proposed channel configuration triangular, with a left and right side slopes of 2H:1V and 1.5 foot deep in the center. This depth will provide for the lower 12-inches area to be lined with the geosynthetics to minimize infiltration from surface water, while providing 6-inch cover over the geosynthetics in the anchor trench.

Disk:	G:/Projects/993-6573	Client: CBS		Date:	08/10/00
File:	100%RD\v-ditch	Project: 993-6573		Time:	11:24

Title: Surface Water Calculations - Channel A Surface Water Calc.-Bench	Site: Lemon Lane		
Prepared by: V E FOSTER	Telephone Number:		Sheet 2 of 5

Design Calculations: PROPOSED V-DITCH DESIGN

Channel Name	Contributing Watersheds	Design Storm (years)	Curve Number Number	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Freeboard (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Actual Q (cfs)	With Freeboard Channel Depth (ft)	Top Channel Width (ft)	Q Available (cfs)
V-DITCH	0.5 3Bc + 0.25 3C	25	79	2.25	0.020	0.84	Riprap	0.035	0.00	2.00	2.00	0.87	0.66	2.64	2.66	2.3	1.50	6.0	20.7
V-DITCH	0.5 3Bc + 0.25 3C	25	79	2.25	0.133	1.04	Riprap	0.035	0.00	2.00	2.00	0.42	0.46	1.84	5.40	2.3	1.50	6.0	53.5
V-DITCH	0.5 3Bc + 0.25 3C	100	79	3	0.020	0.77	Riprap	0.035	0.00	2.00	2.00	1.07	0.73	2.92	2.85	3.0	1.50	6.0	20.7
V-DITCH	0.5 3Bc + 0.25 3C	100	79	3	0.133	0.99	Riprap	0.035	0.00	2.00	2.00	0.52	0.51	2.04	5.79	3.0	1.50	6.0	53.5

Sheet 3 of 5

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: RAW Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 25 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	2.80	2.04	2.04	2.04	2.80	2.80	2.80
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.11	0.17	0.17	0.17	0.11	0.11	0.11
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	7	1	1	1	1	2	0	1
12.0	13	3	3	1	1	3	1	1
12.1	25	6	5P	2P	2	6	2	2
12.2	35P	9P	5	2	3P	9P	3P	4
12.3	33	9	3	1	3	9	3	5P
12.4	24	6	2	1	2	6	2	5
12.5	14	4	1	0	1	4	1	3
12.6	10	2	1	0	1	3	1	2
12.7	9	2	1	0	1	2	1	2
12.8	5	1	1	0	0	2	0	1
13.0	3	1	0	0	0	1	0	1
13.2	3	1	0	0	0	1	0	1
13.4	2	1	0	0	0	1	0	0
13.6	2	1	0	0	0	1	0	0
13.8	2	1	0	0	0	1	0	0
14.0	2	1	0	0	0	1	0	0
14.3	0	0	0	0	0	0	0	0
14.6	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

Sheet 4 of 5

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: [illegible] Date: 6/7/00

Subtitle: PROPOSED CONDITIONS

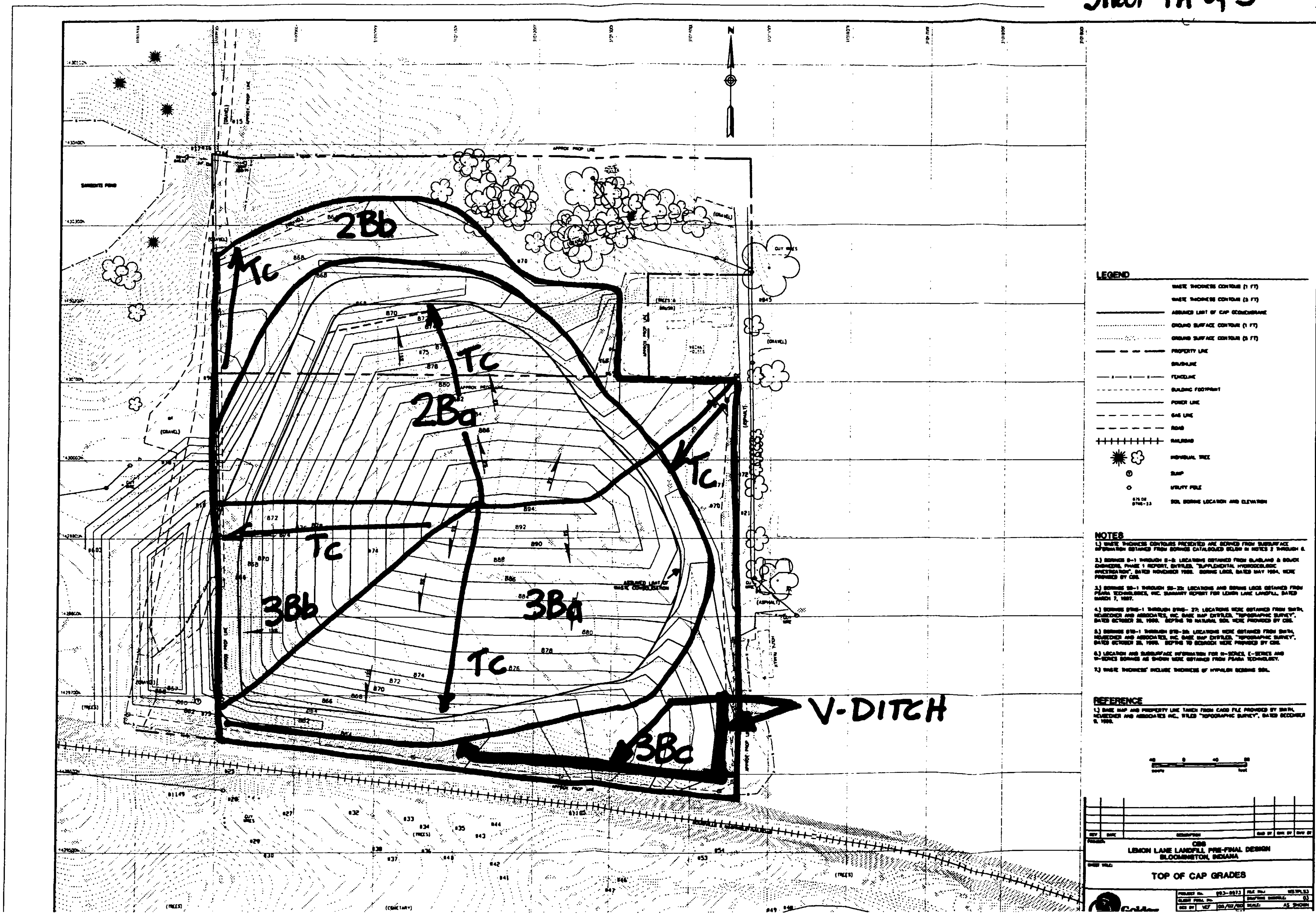
Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 100 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	3.68	2.81	2.81	2.81	3.68	3.68	3.68
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.09	0.14	0.14	0.14	0.09	0.09	0.09
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	10	2	2	1	1	2	1	1
12.0	16	4	4	1	1	4	1	1
12.1	33	7	7P	3P	3	8	2	3
12.2	45P	11P	7	3	4P	12P	3P	5
12.3	42	11	4	2	4	12	3	6P
12.4	30	8	2	1	3	8	2	6
12.5	20	5	2	1	2	5	1	4
12.6	12	3	1	0	1	3	1	3
12.7	10	2	1	0	1	3	1	2
12.8	9	2	1	0	1	2	1	2
13.0	4	1	1	0	0	1	0	1
13.2	4	1	1	0	0	1	0	1
13.4	3	1	0	0	0	1	0	1
13.6	3	1	0	0	0	1	0	1
13.8	3	1	0	0	0	1	0	1
14.0	2	1	0	0	0	1	0	0
14.3	2	1	0	0	0	1	0	0
14.6	2	1	0	0	0	1	0	0
15.0	2	1	0	0	0	1	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

Sheet 4A of 5



N
2Bb
Tc
2Ba
Tc
Tc
Tc
3Bb
3Ba
Tc
3Bc
V-DITCH
LEGEND
NOTES
REFERENCE
CBS
LEMON LANE LANDFILL PRE-FINAL DESIGN
BLOOMINGTON, INDIANA
TOP OF CAP GRADES
AS SHOWN

APPENDIX A6
BASIN DESIGN

GOLDER ASSOCIATES	Subject: BASIN DESIGN		
	Job No: 993-6573	Made by: VEF	Date: 9/6/00
	Ref: Lemon Lane 100%	Check by: FRG	Sheet: 1 of 33
		Review by:	

OBJECTIVE: Size Basin in southwest corner and the corresponding outflow structures.

METHOD: Use Pond2 to route the runoff hydrograph from the 10, 25 and 100 year storm events (reference 1) through the design basin. The 25 and 100 year storm events are routed to verify that the basin is not overtopped during these more critical events.

REFERENCES:

1) Golder Associates Inc., "Peak Runoff Rates – Proposed," dated 5/23/00.

2) Haestad Methods, Inc., "Pond2: Detention Pond Analysis," dated 1989

SUMMARY: The pond has a minimum elevation of 857 and a maximum elevation of 862, finished grades. The outflow structure is a catch basin/storm inlet with a 3x4 foot grate at elevation 861, and 3-3" dewatering holes at elevation 857. The outflow pipe from the catch basin is a 24 inch diameter, approximately 360 foot long, reinforced concrete pipe that discharges at elevation 850, into Sargent's Pond via a reno mattress lined channel.

Attached sheets 2 through 33 of 33 provide the printouts of the POND2 modeling. The maximum peak inflow, peak outflow and maximum surface water elevation for the proposed pond, assuming that the 3-3"dewatering holes (at elevation 857) are not clogged, are summarized in the table below.

Storm Event	With dewatering holes engaged		
	Peak Inflow (cfs)	Peak Outflow (cfs)	Max. Water Elevation
10 year	27	4.82	861.17
25 year	35	13.65	861.45
100 year	45	24.88	861.70

CONCLUSION: In summary, the basin will perform adequately with the dewatering holes engaged. It should be noted that the geosynthetic liner extends to an elevation of 862, with an additional 18-inches of cover soil, for a top of bank elevation for the pond of 863.5.

POND-2 Version: 5.21
S/N:

south pond - 100%

CALCULATED 08-15-2000 11:35:29
DISK FILE: LPOND .VOL

Planimeter scale: 1 inch = 1 ft.

Elevation (ft)	Planimeter (sq.in.)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	* Volume (acre-ft)	Volume Sum (acre-ft)
857.00	324.00	0.01	0.00	0.00	0.00
858.00	5,457.00	0.13	0.16	0.05	0.05
859.00	11,417.00	0.26	0.57	0.19	0.24
860.00	14,700.00	0.34	0.90	0.30	0.54
862.00	21,672.00	0.50	1.24	0.83	1.37

$$IA = (sq.rt(Area1) + ((Ei-E1)/(E2-E1))*(sq.rt(Area2)-sq.rt(Area1)))^2$$

where: E1, E2 = Closest two elevations with planimeter data
Ei = Elevation at which to interpolate area
Area1,Area2 = Areas computed for E1, E2, respectively
IA = Interpolated area for Ei

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

***** COMPOSITE OUTFLOW SUMMARY ****

Elevation (ft)	Q (cfs)	Contributing Structures
857.00	0.0	
857.25	0.4	4 +3 +2
857.50	0.5	4 +3 +2
857.75	0.6	4 +3 +2
858.00	0.7	4 +3 +2
858.25	0.8	4 +3 +2
858.50	0.9	4 +3 +2
858.75	0.9	4 +3 +2
859.00	1.0	4 +3 +2
859.25	1.1	4 +3 +2
859.50	1.1	4 +3 +2
859.75	1.2	4 +3 +2
860.00	1.2	4 +3 +2
860.25	1.3	4 +3 +2
860.50	1.3	4 +3 +2
860.75	1.4	4 +3 +2
861.00	1.4	4 +3 +2 +1
861.25	6.4	4 +3 +2 +1
861.50	15.4	4 +3 +2 +1
861.75	27.0	4 +3 +2 +1
862.00	40.8	4 +3 +2 +1

Sheet 47 of 35

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

Outlet Structure File: LPOND .STR
Planimeter Input File: LLL .VOL
Rating Table Output File: LPONDDW .PND

Min. Elev.(ft) = 857 Max. Elev.(ft) = 862 Incr.(ft) = .25

Additional elevations (ft) to be included in table:
* *

****
SYSTEM CONNECTIVITY
****

Structure	No.	Q Table	Q Table
ORIFICE-VC	4		-> 4
ORIFICE-VC	3		-> 3
ORIFICE-VC	2		-> 2
INLET BOX	1		-> 1

Outflow rating table summary was stored in file:
LPONDDW .PND

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

>>>>>> Structure No. 4 <<<<<<
(Input Data)

ORIFICE-VC
Orifice - Vertical Circular

E1 elev.(ft)?	857.25
E2 elev.(ft)?	862.1
Orifice coeff.?	.6
Invert elev.(ft)?	857.0
Datum elev.(ft)?	857.0
Diameter (ft)?	.25

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

>>>>>> Structure No. 3 <<<<<<
(Input Data)

ORIFICE-VC
Orifice - Vertical Circular

E1 elev.(ft)?	857.25
E2 elev.(ft)?	862.1
Orifice coeff.?	.6
Invert elev.(ft)?	857.0
Datum elev.(ft)?	857.0
Diameter (ft)?	.25

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21   S/N:
Date Executed: Time Executed:

****

OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

>>>>>> Structure No. 2 <<<<<<
(Input Data)

ORIFICE-VC
Orifice - Vertical Circular

E1 elev.(ft)?	857.25
E2 elev.(ft)?	862.1
Orifice coeff.?	0.6
Invert elev.(ft)?	857.0
Datum elev.(ft)?	857.0
Diameter (ft)?	.25

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

>>>>>> Structure No. 1 <<<<<<
(Input Data)

INLET BOX
Weir & Orifice defined by length and area

E1 elev.(ft)?	861.0
E2 elev.(ft)?	862.1
Crest elev.(ft)?	861.0
Weir length (ft)?	14
Weir coefficient?	2.8
Orifice area (sq.ft)?	12
Orifice coefficient?	0.6
Start transition elev.(ft) @ ?	
Transition height (ft)?	

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

Outflow Rating Table for Structure #4
ORIFICE-VC Orifice - Vertical Circular

Elevation (ft)	Q (cfs)	Computation Messages
857.00	0.0	E < E1=857.25
857.25	0.1	H =.25
857.50	0.2	H =.5
857.75	0.2	H =.750
858.00	0.2	H =1.0
858.25	0.3	H =1.25
858.50	0.3	H =1.5
858.75	0.3	H =1.75
859.00	0.3	H =2.0
859.25	0.4	H =2.25
859.50	0.4	H =2.5
859.75	0.4	H =2.75
860.00	0.4	H =3.0
860.25	0.4	H =3.25
860.50	0.4	H =3.5
860.75	0.5	H =3.75
861.00	0.5	H =4.0
861.25	0.5	H =4.25
861.50	0.5	H =4.5
861.75	0.5	H =4.75
862.00	0.5	H =5.0

C = .6 A = 4.908739E-02 sq.ft.
H (ft) = Table elev. - Datum elev. (857 ft)
Q (cfs) = C * A * sqr(2g * H)

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****

OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

Outflow Rating Table for Structure #3
ORIFICE-VC Orifice - Vertical Circular

Elevation (ft)	Q (cfs)	Computation Messages
857.00	0.0	E < E1=857.25
857.25	0.1	H =.25
857.50	0.2	H =.5
857.75	0.2	H =.750
858.00	0.2	H =1.0
858.25	0.3	H =1.25
858.50	0.3	H =1.5
858.75	0.3	H =1.75
859.00	0.3	H =2.0
859.25	0.4	H =2.25
859.50	0.4	H =2.5
859.75	0.4	H =2.75
860.00	0.4	H =3.0
860.25	0.4	H =3.25
860.50	0.4	H =3.5
860.75	0.5	H =3.75
861.00	0.5	H =4.0
861.25	0.5	H =4.25
861.50	0.5	H =4.5
861.75	0.5	H =4.75
862.00	0.5	H =5.0

C = .6 A = 4.908739E-02 sq.ft.
H (ft) = Table elev. - Datum elev. (857 ft)
Q (cfs) = C * A * sqr(2g * H)

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

Outflow Rating Table for Structure #2
ORIFICE-VC Orifice - Vertical Circular

Elevation (ft)	Q (cfs)	Computation Messages
857.00	0.0	E < E1=857.25
857.25	0.1	H =.25
857.50	0.2	H =.5
857.75	0.2	H =.750
858.00	0.2	H =1.0
858.25	0.3	H =1.25
858.50	0.3	H =1.5
858.75	0.3	H =1.75
859.00	0.3	H =2.0
859.25	0.4	H =2.25
859.50	0.4	H =2.5
859.75	0.4	H =2.75
860.00	0.4	H =3.0
860.25	0.4	H =3.25
860.50	0.4	H =3.5
860.75	0.5	H =3.75
861.00	0.5	H =4.0
861.25	0.5	H =4.25
861.50	0.5	H =4.5
861.75	0.5	H =4.75
862.00	0.5	H =5.0

C = .6 A = 4.908739E-02 sq.ft.
H (ft) = Table elev. - Datum elev. (857 ft)
Q (cfs) = C * A * sqr(2g * H)

Outlet Structure File: LPOND .STR

POND-2 Version: 5.21 S/N:
Date Executed: Time Executed:

****
OUTFLOW STRUCTURE FOR POND
catch basin with rim elevation at 861
3 - 3" dewatering holes

****

Outflow Rating Table for Structure #1
INLET BOX Weir & Orifice defined by length and area

***** INLET CONTROL ASSUMED *****

Elevation (ft)	Q (cfs)	Computation Messages	
857.00	0.0	E < Inv.El.= 861	
857.25	0.0	E < El=861.0	
857.50	0.0	E < El=861.0	
857.75	0.0	E < El=861.0	
858.00	0.0	E < El=861.0	
858.25	0.0	E < El=861.0	
858.50	0.0	E < El=861.0	
858.75	0.0	E < El=861.0	
859.00	0.0	E < El=861.0	
859.25	0.0	E < El=861.0	
859.50	0.0	E < El=861.0	
859.75	0.0	E < El=861.0	
860.00	0.0	E < El=861.0	
860.25	0.0	E < El=861.0	
860.50	0.0	E < El=861.0	
860.75	0.0	E < El=861.0	
861.00	0.0	Weir:	H =0.0
861.25	4.9	Weir:	H =.25
861.50	13.9	Weir:	H =.5
861.75	25.5	Weir:	H =.750
862.00	39.2	Weir:	H =1.0

Weir Cw = 2.8 Weir length = 14 ft
Orifice Co = .6 Orifice area = 12 sq.ft.
Q (cfs) = (Cw * L * H**1.5) or (Co * A * sqr(2*g*H))
No transition used, transition height = 0.0
Weir equation = Orifice equation @ elev.= 862.474 ft

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:38:50

```
*******************************************
*                                         *
*        OUTFLOW STRUCTURE FOR POND       *
*  catch basin with rim elevation at 861  *
*          3 - 3" dewatering holes        *
*       10 year, 24 hour storm event      *
*                                         *
*******************************************
```

Inflow Hydrograph: LLL10 .HYD
Rating Table file: LPONDDW .PND

----INITIAL CONDITIONS----
Elevation = 857.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + 0 (cfs)
857.00	0.0	0.000	0.0	0.0
857.25	0.4	0.004	0.9	1.3
857.50	0.5	0.012	3.0	3.5
857.75	0.6	0.029	6.9	7.5
858.00	0.7	0.054	13.2	13.9
858.25	0.8	0.089	21.6	22.4
858.50	0.9	0.132	32.0	32.9
858.75	0.9	0.183	44.4	45.3
859.00	1.0	0.244	59.0	60.0
859.25	1.1	0.312	75.4	76.5
859.50	1.1	0.384	92.9	94.0
859.75	1.2	0.461	111.6	112.8
860.00	1.2	0.543	131.4	132.6
860.25	1.3	0.630	152.4	153.7
860.50	1.3	0.721	174.4	175.7
860.75	1.4	0.817	197.7	199.1
861.00	1.4	0.918	222.1	223.5
861.25	6.4	1.024	247.7	254.1
861.50	15.4	1.135	274.6	290.0
861.75	27.0	1.251	302.8	329.8
862.00	40.8	1.373	332.2	373.0

Time increment (t) = 0.100 hrs.

Sheet HPs] 33

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:38:50

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL10 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH — ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	0.00	-----	0.0	0.0	0.00	857.00
11.100	0.00	0.0	0.0	0.0	0.00	857.00
11.200	0.00	0.0	0.0	0.0	0.00	857.00
11.300	0.00	0.0	0.0	0.0	0.00	857.00
11.400	0.00	0.0	0.0	0.0	0.00	857.00
11.500	0.00	0.0	0.0	0.0	0.00	857.00
11.600	1.00	1.0	0.4	1.0	0.31	857.19
11.700	2.00	3.0	2.4	3.4	0.49	857.48
11.800	3.00	5.0	6.2	7.4	0.60	857.74
11.900	11.00	14.0	18.7	20.2	0.77	858.18
12.000	21.00	32.0	48.8	50.7	0.94	858.84
12.100	27.00	48.0	94.5	96.8	1.11	859.54
12.200	26.00	53.0	145.0	147.5	1.27	860.18
12.300	19.00	45.0	187.3	190.0	1.36	860.65
12.400	12.00	31.0	215.5	218.3	1.40	860.95
12.500	9.00	21.0	229.5	236.5	3.52	861.11
12.600	6.00	15.0	234.8	244.5	4.82	861.17
12.700	3.00	9.0	234.4	243.8	4.71	861.17
12.800	3.00	6.0	232.1	240.4	4.15	861.14
12.900	3.00	6.0	230.5	238.1	3.78	861.12
13.000	3.00	6.0	229.5	236.5	3.52	861.11
13.100	3.00	6.0	228.8	235.5	3.35	861.10
13.200	2.00	5.0	227.6	233.8	3.07	861.08
13.300	2.00	4.0	226.2	231.6	2.72	861.07
13.400	2.00	4.0	225.2	230.2	2.49	861.05
13.500	2.00	4.0	224.5	229.2	2.33	861.05
13.600	2.00	4.0	224.1	228.5	2.22	861.04
13.700	1.00	3.0	223.1	227.1	1.99	861.03
13.800	0.00	1.0	221.1	224.1	1.50	861.01
13.900	0.00	0.0	218.3	221.1	1.40	860.98
14.000	0.00	0.0	215.5	218.3	1.40	860.95
14.100	0.00	0.0	212.7	215.5	1.40	860.92
14.200	0.00	0.0	209.9	212.7	1.40	860.89
14.300	0.00	0.0	207.1	209.9	1.40	860.86
14.400	0.00	0.0	204.3	207.1	1.40	860.83
14.500	0.00	0.0	201.5	204.3	1.40	860.80
14.600	0.00	0.0	198.7	201.5	1.40	860.77
14.700	0.00	0.0	195.9	198.7	1.40	860.75
14.800	0.00	0.0	193.2	195.9	1.39	860.72
14.900	0.00	0.0	190.4	193.2	1.37	860.69
15.000	0.00	0.0	187.7	190.4	1.36	860.66
15.100	0.00	0.0	185.0	187.7	1.35	860.63
15.200	0.00	0.0	182.3	185.0	1.34	860.60
15.300	0.00	0.0	179.6	182.3	1.33	860.57
15.400	0.00	0.0	177.0	179.6	1.32	860.54

EXECUTED: 08-15-2000 11:38:50

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL10 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	0.00	0.0	174.4	177.0	1.31	860.51
15.600	0.00	0.0	171.8	174.4	1.30	860.48
15.700	0.00	0.0	169.2	171.8	1.30	860.46
15.800	0.00	0.0	166.6	169.2	1.30	860.43
15.900	0.00	0.0	164.0	166.6	1.30	860.40
16.000	0.00	0.0	161.4	164.0	1.30	860.37
16.100	0.00	0.0	158.8	161.4	1.30	860.34
16.200	0.00	0.0	156.2	158.8	1.30	860.31
16.300	0.00	0.0	153.6	156.2	1.30	860.28
16.400	0.00	0.0	151.0	153.6	1.30	860.25
16.500	0.00	0.0	148.4	151.0	1.29	860.22
16.600	0.00	0.0	145.9	148.4	1.28	860.19
16.700	0.00	0.0	143.4	145.9	1.26	860.16
16.800	0.00	0.0	140.9	143.4	1.25	860.13
16.900	0.00	0.0	138.4	140.9	1.24	860.10
17.000	0.00	0.0	135.9	138.4	1.23	860.07
17.100	0.00	0.0	133.5	135.9	1.22	860.04
17.200	0.00	0.0	131.1	133.5	1.20	860.01
17.300	0.00	0.0	128.7	131.1	1.20	859.98
17.400	0.00	0.0	126.3	128.7	1.20	859.95
17.500	0.00	0.0	123.9	126.3	1.20	859.92
17.600	0.00	0.0	121.5	123.9	1.20	859.89
17.700	0.00	0.0	119.1	121.5	1.20	859.86
17.800	0.00	0.0	116.7	119.1	1.20	859.83
17.900	0.00	0.0	114.3	116.7	1.20	859.80
18.000	0.00	0.0	111.9	114.3	1.20	859.77
18.100	0.00	0.0	109.5	111.9	1.20	859.74
18.200	0.00	0.0	107.1	109.5	1.18	859.71
18.300	0.00	0.0	104.8	107.1	1.17	859.67
18.400	0.00	0.0	102.5	104.8	1.16	859.64
18.500	0.00	0.0	100.2	102.5	1.15	859.61
18.600	0.00	0.0	97.9	100.2	1.13	859.58
18.700	0.00	0.0	95.7	97.9	1.12	859.55
18.800	0.00	0.0	93.5	95.7	1.11	859.52
18.900	0.00	0.0	91.3	93.5	1.10	859.49
19.000	0.00	0.0	89.1	91.3	1.10	859.46
19.100	0.00	0.0	86.9	89.1	1.10	859.43
19.200	0.00	0.0	84.7	86.9	1.10	859.40
19.300	0.00	0.0	82.5	84.7	1.10	859.37
19.400	0.00	0.0	80.3	82.5	1.10	859.33
19.500	0.00	0.0	78.1	80.3	1.10	859.30
19.600	0.00	0.0	75.9	78.1	1.10	859.27
19.700	0.00	0.0	73.7	75.9	1.10	859.24
19.800	0.00	0.0	71.5	73.7	1.08	859.21
19.900	0.00	0.0	69.4	71.5	1.07	859.17
20.000	0.00	0.0	67.2	69.4	1.06	859.14

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:38:50

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL10 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	0.00	0.0	65.2	67.2	1.04	859.11
20.200	0.00	0.0	63.1	65.2	1.03	859.08
20.300	0.00	0.0	61.1	63.1	1.02	859.05
20.400	0.00	0.0	59.0	61.1	1.01	859.02
20.500	0.00	0.0	57.1	59.0	0.99	858.98
20.600	0.00	0.0	55.1	57.1	0.98	858.95
20.700	0.00	0.0	53.2	55.1	0.97	858.92
20.800	0.00	0.0	51.3	53.2	0.95	858.88
20.900	0.00	0.0	49.4	51.3	0.94	858.85
21.000	0.00	0.0	47.5	49.4	0.93	858.82
21.100	0.00	0.0	45.7	47.5	0.92	858.79
21.200	0.00	0.0	43.9	45.7	0.90	858.76
21.300	0.00	0.0	42.1	43.9	0.90	858.72
21.400	0.00	0.0	40.3	42.1	0.90	858.69
21.500	0.00	0.0	38.5	40.3	0.90	858.65
21.600	0.00	0.0	36.7	38.5	0.90	858.61
21.700	0.00	0.0	34.9	36.7	0.90	858.58
21.800	0.00	0.0	33.1	34.9	0.90	858.54
21.900	0.00	0.0	31.3	33.1	0.90	858.50
22.000	0.00	0.0	29.5	31.3	0.88	858.46
22.100	0.00	0.0	27.8	29.5	0.87	858.42
22.200	0.00	0.0	26.1	27.8	0.85	858.38
22.300	0.00	0.0	24.4	26.1	0.83	858.34
22.400	0.00	0.0	22.8	24.4	0.82	858.30
22.500	0.00	0.0	21.2	22.8	0.80	858.26
22.600	0.00	0.0	19.6	21.2	0.79	858.21
22.700	0.00	0.0	18.1	19.6	0.77	858.17
22.800	0.00	0.0	16.6	18.1	0.75	858.12
22.900	0.00	0.0	15.1	16.6	0.73	858.08
23.000	0.00	0.0	13.7	15.1	0.71	858.04
23.100	0.00	0.0	12.3	13.7	0.70	857.99
23.200	0.00	0.0	10.9	12.3	0.67	857.94
23.300	0.00	0.0	9.6	10.9	0.65	857.88
23.400	0.00	0.0	8.4	9.6	0.63	857.83
23.500	0.00	0.0	7.1	8.4	0.61	857.78
23.600	0.00	0.0	5.9	7.1	0.59	857.72
23.700	0.00	0.0	4.8	5.9	0.56	857.65
23.800	0.00	0.0	3.8	4.8	0.53	857.58
23.900	0.00	0.0	2.7	3.8	0.51	857.51
24.000	0.00	0.0	1.8	2.7	0.47	857.41
24.100	0.00	0.0	1.0	1.8	0.42	857.31
24.200	0.00	0.0	0.4	1.0	0.30	857.19
24.300	0.00	0.0	0.1	0.4	0.11	857.07
24.400	0.00	0.0	0.1	0.1	0.04	857.03
24.500	0.00	0.0	0.0	0.1	0.02	857.01
24.600	0.00	0.0	0.0	0.0	0.01	857.00

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:38:50

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL10 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	0.00	0.0	0.0	0.0	0.00	857.00
24.800	0.00	0.0	0.0	0.0	0.00	857.00
24.900	0.00	0.0	0.0	0.0	0.00	857.00
25.000	0.00	0.0	0.0	0.0	0.00	857.00

****************** SUMMARY OF ROUTING COMPUTATIONS ******************

```
Pond File:           LPONDDW .PND
Inflow Hydrograph:   LLL10   .HYD
Outflow Hydrograph:  OUT     .HYD

Starting Pond W.S. Elevation =   857.00 ft
```

***** Summary of Peak Outflow and Peak Elevation *****

```
Peak Inflow    =    27.00 cfs
Peak Outflow   =     4.82 cfs
Peak Elevation =   861.17 ft
```

***** Summary of Approximate Peak Storage *****

```
Initial Storage           =      0.00 ac-ft
Peak Storage From Storm   =      0.99 ac-ft
                            ---------------
Total Storage in Pond     =      0.99 ac-ft
```

Sheet 19 of 33

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL10 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 08-15-2000
11:38:50

Peak Inflow = 27.00 cfs
Peak Outflow = 4.82 cfs
Peak Elevation = 861.17 ft

```
                                                                 Flow (cfs)
      0.0   3.0   6.0   9.0  12.0  15.0  18.0  21.0  24.0  27.0  30.0  33.0
      .------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-
      |
11.3 -|x
      |x
11.4 -|x
      |x
11.5 -|x
      |x*
11.6 -| x*
      | x *
11.7 -| x  *
      | x   *
11.8 -| x    *
      | x            *
11.9 -|  x                   *
      |  x                             *
12.0 -|  x                                       *
      |  x                                             *
12.1 -|  x                                                   *
      |  x                                                  *
12.2 -|   x                                                *
      |   x                                         *
12.3 -|   x                                  *
      |   x                           *
12.4 -|   x                    *
      |     x               *
12.5 -|       x          *
      |        x      *
12.6 -|          x *
      |         *x
12.7 -|      *  x
      |      *  x
12.8 -|      * x
      |      * x
12.9 -|      * x
      |      *x
13.0 -|      *x
      |      *x
13.1 -|      *x
      |     *x
13.2 -|    * x
      |
   TIME
   (hrs)
```

* File: LLL10 .HYD Qmax = 27.0 cfs
x File: OUT .HYD Qmax = 4.8 cfs

POND-2 Version: 5.21 S/N:

EXECUTED: 08-15-2000 11:38:27

```
*******************************************
*                                         *
*        OUTFLOW STRUCTURE FOR POND       *
*  catch basin with rim elevation at 861  *
*        3 - 3" dewatering holes          *
*      25 year, 24 hour storm event       *
*                                         *
*******************************************
```

Inflow Hydrograph: LLL25 .HYD
Rating Table file: LPONDDW .PND

----INITIAL CONDITIONS----
Elevation = 857.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + 0 (cfs)
857.00	0.0	0.000	0.0	0.0
857.25	0.4	0.004	0.9	1.3
857.50	0.5	0.012	3.0	3.5
857.75	0.6	0.029	6.9	7.5
858.00	0.7	0.054	13.2	13.9
858.25	0.8	0.089	21.6	22.4
858.50	0.9	0.132	32.0	32.9
858.75	0.9	0.183	44.4	45.3
859.00	1.0	0.244	59.0	60.0
859.25	1.1	0.312	75.4	76.5
859.50	1.1	0.384	92.9	94.0
859.75	1.2	0.461	111.6	112.8
860.00	1.2	0.543	131.4	132.6
860.25	1.3	0.630	152.4	153.7
860.50	1.3	0.721	174.4	175.7
860.75	1.4	0.817	197.7	199.1
861.00	1.4	0.918	222.1	223.5
861.25	6.4	1.024	247.7	254.1
861.50	15.4	1.135	274.6	290.0
861.75	27.0	1.251	302.8	329.8
862.00	40.8	1.373	332.2	373.0

Time increment (t) = 0.100 hrs.

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:38:27

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL25 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	0.00	-----	0.0	0.0	0.00	857.00
11.100	0.00	0.0	0.0	0.0	0.00	857.00
11.200	0.00	0.0	0.0	0.0	0.00	857.00
11.300	0.00	0.0	0.0	0.0	0.00	857.00
11.400	1.00	1.0	0.4	1.0	0.31	857.19
11.500	1.00	2.0	1.5	2.4	0.45	857.37
11.600	2.00	3.0	3.4	4.5	0.52	857.56
11.700	4.00	6.0	8.2	9.4	0.63	857.83
11.800	6.00	10.0	16.7	18.2	0.75	858.13
11.900	7.00	13.0	27.9	29.7	0.87	858.42
12.000	13.00	20.0	46.1	47.9	0.92	858.80
12.100	25.00	38.0	81.9	84.1	1.10	859.36
12.200	35.00	60.0	139.4	141.9	1.24	860.11
12.300	33.00	68.0	204.6	207.4	1.40	860.84
12.400	24.00	57.0	245.1	261.6	8.27	861.30
12.500	14.00	38.0	255.8	283.1	13.65	861.45
12.600	10.00	24.0	254.1	279.8	12.82	861.43
12.700	9.00	19.0	250.8	273.1	11.16	861.38
12.800	5.00	14.0	246.7	264.8	9.07	861.32
12.900	4.00	9.0	242.1	255.7	6.78	861.26
13.000	3.00	7.0	237.9	249.1	5.58	861.21
13.100	3.00	6.0	234.5	243.9	4.73	861.17
13.200	3.00	6.0	232.1	240.5	4.17	861.14
13.300	3.00	6.0	230.6	238.1	3.79	861.12
13.400	2.00	5.0	228.8	235.6	3.37	861.10
13.500	2.00	4.0	227.0	232.8	2.92	861.08
13.600	2.00	4.0	225.7	231.0	2.62	861.06
13.700	2.00	4.0	224.9	229.7	2.42	861.05
13.800	2.00	4.0	224.4	228.9	2.28	861.04
13.900	2.00	4.0	224.0	228.4	2.19	861.04
14.000	2.00	4.0	223.7	228.0	2.13	861.04
14.100	1.00	3.0	222.9	226.7	1.92	861.03
14.200	1.00	2.0	221.6	224.9	1.62	861.01
14.300	0.00	1.0	219.8	222.6	1.40	860.99
14.400	0.00	0.0	217.0	219.8	1.40	860.96
14.500	0.00	0.0	214.2	217.0	1.40	860.93
14.600	0.00	0.0	211.4	214.2	1.40	860.90
14.700	0.00	0.0	208.6	211.4	1.40	860.88
14.800	0.00	0.0	205.8	208.6	1.40	860.85
14.900	0.00	0.0	203.0	205.8	1.40	860.82
15.000	0.00	0.0	200.2	203.0	1.40	860.79
15.100	0.00	0.0	197.4	200.2	1.40	860.76
15.200	0.00	0.0	194.6	197.4	1.39	860.73
15.300	0.00	0.0	191.9	194.6	1.38	860.70
15.400	0.00	0.0	189.1	191.9	1.37	860.67

Sheet 22 of 33

EXECUTED: 08-15-2000 11:38:27

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL25 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	0.00	0.0	186.4	189.1	1.36	860.64
15.600	0.00	0.0	183.7	186.4	1.35	860.61
15.700	0.00	0.0	181.1	183.7	1.33	860.59
15.800	0.00	0.0	178.4	181.1	1.32	860.56
15.900	0.00	0.0	175.8	178.4	1.31	860.53
16.000	0.00	0.0	173.2	175.8	1.30	860.50
16.100	0.00	0.0	170.6	173.2	1.30	860.47
16.200	0.00	0.0	168.0	170.6	1.30	860.44
16.300	0.00	0.0	165.4	168.0	1.30	860.41
16.400	0.00	0.0	162.8	165.4	1.30	860.38
16.500	0.00	0.0	160.2	162.8	1.30	860.35
16.600	0.00	0.0	157.6	160.2	1.30	860.32
16.700	0.00	0.0	155.0	157.6	1.30	860.29
16.800	0.00	0.0	152.4	155.0	1.30	860.27
16.900	0.00	0.0	149.8	152.4	1.29	860.24
17.000	0.00	0.0	147.2	149.8	1.28	860.20
17.100	0.00	0.0	144.7	147.2	1.27	860.17
17.200	0.00	0.0	142.2	144.7	1.26	860.14
17.300	0.00	0.0	139.7	142.2	1.25	860.11
17.400	0.00	0.0	137.2	139.7	1.23	860.08
17.500	0.00	0.0	134.8	137.2	1.22	860.06
17.600	0.00	0.0	132.4	134.8	1.21	860.03
17.700	0.00	0.0	130.0	132.4	1.20	860.00
17.800	0.00	0.0	127.6	130.0	1.20	859.97
17.900	0.00	0.0	125.2	127.6	1.20	859.94
18.000	0.00	0.0	122.8	125.2	1.20	859.91
18.100	0.00	0.0	120.4	122.8	1.20	859.88
18.200	0.00	0.0	118.0	120.4	1.20	859.85
18.300	0.00	0.0	115.6	118.0	1.20	859.82
18.400	0.00	0.0	113.2	115.6	1.20	859.79
18.500	0.00	0.0	110.8	113.2	1.20	859.76
18.600	0.00	0.0	108.4	110.8	1.19	859.72
18.700	0.00	0.0	106.0	108.4	1.18	859.69
18.800	0.00	0.0	103.7	106.0	1.16	859.66
18.900	0.00	0.0	101.4	103.7	1.15	859.63
19.000	0.00	0.0	99.1	101.4	1.14	859.60
19.100	0.00	0.0	96.9	99.1	1.13	859.57
19.200	0.00	0.0	94.6	96.9	1.12	859.54
19.300	0.00	0.0	92.4	94.6	1.10	859.51
19.400	0.00	0.0	90.2	92.4	1.10	859.48
19.500	0.00	0.0	88.0	90.2	1.10	859.45
19.600	0.00	0.0	85.8	88.0	1.10	859.41
19.700	0.00	0.0	83.6	85.8	1.10	859.38
19.800	0.00	0.0	81.4	83.6	1.10	859.35
19.900	0.00	0.0	79.2	81.4	1.10	859.32
20.000	0.00	0.0	77.0	79.2	1.10	859.29

Sheet 23 of 33

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:38:27

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL25 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH — ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	0.00	0.0	74.8	77.0	1.10	859.26
20.200	0.00	0.0	72.7	74.8	1.09	859.22
20.300	0.00	0.0	70.5	72.7	1.08	859.19
20.400	0.00	0.0	68.4	70.5	1.06	859.16
20.500	0.00	0.0	66.3	68.4	1.05	859.13
20.600	0.00	0.0	64.2	66.3	1.04	859.09
20.700	0.00	0.0	62.1	64.2	1.03	859.06
20.800	0.00	0.0	60.1	62.1	1.01	859.03
20.900	0.00	0.0	58.1	60.1	1.00	859.00
21.000	0.00	0.0	56.1	58.1	0.99	858.97
21.100	0.00	0.0	54.2	56.1	0.97	858.93
21.200	0.00	0.0	52.3	54.2	0.96	858.90
21.300	0.00	0.0	50.4	52.3	0.95	858.87
21.400	0.00	0.0	48.5	50.4	0.93	858.84
21.500	0.00	0.0	46.7	48.5	0.92	858.80
21.600	0.00	0.0	44.9	46.7	0.91	858.77
21.700	0.00	0.0	43.1	44.9	0.90	858.74
21.800	0.00	0.0	41.3	43.1	0.90	858.71
21.900	0.00	0.0	39.5	41.3	0.90	858.67
22.000	0.00	0.0	37.7	39.5	0.90	858.63
22.100	0.00	0.0	35.9	37.7	0.90	858.60
22.200	0.00	0.0	34.1	35.9	0.90	858.56
22.300	0.00	0.0	32.3	34.1	0.90	858.52
22.400	0.00	0.0	30.5	32.3	0.89	858.49
22.500	0.00	0.0	28.7	30.5	0.88	858.44
22.600	0.00	0.0	27.0	28.7	0.86	858.40
22.700	0.00	0.0	25.3	27.0	0.84	858.36
22.800	0.00	0.0	23.6	25.3	0.83	858.32
22.900	0.00	0.0	22.0	23.6	0.81	858.28
23.000	0.00	0.0	20.4	22.0	0.80	858.24
23.100	0.00	0.0	18.9	20.4	0.78	858.19
23.200	0.00	0.0	17.4	18.9	0.76	858.15
23.300	0.00	0.0	15.9	17.4	0.74	858.10
23.400	0.00	0.0	14.4	15.9	0.72	858.06
23.500	0.00	0.0	13.0	14.4	0.71	858.02
23.600	0.00	0.0	11.6	13.0	0.69	857.97
23.700	0.00	0.0	10.3	11.6	0.66	857.91
23.800	0.00	0.0	9.0	10.3	0.64	857.86
23.900	0.00	0.0	7.8	9.0	0.62	857.81
24.000	0.00	0.0	6.6	7.8	0.60	857.76
24.100	0.00	0.0	5.4	6.6	0.58	857.69
24.200	0.00	0.0	4.3	5.4	0.55	857.62
24.300	0.00	0.0	3.3	4.3	0.52	857.55
24.400	0.00	0.0	2.3	3.3	0.49	857.47
24.500	0.00	0.0	1.4	2.3	0.45	857.36
24.600	0.00	0.0	0.6	1.4	0.41	857.26

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:38:27

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL25 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH

ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	0.00	0.0	0.2	0.6	0.19	857.12
24.800	0.00	0.0	0.1	0.2	0.07	857.04
24.900	0.00	0.0	0.0	0.1	0.03	857.02
25.000	0.00	0.0	0.0	0.0	0.01	857.01

****************** SUMMARY OF ROUTING COMPUTATIONS ******************

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL25 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 857.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow	=	35.00 cfs
Peak Outflow	=	13.65 cfs
Peak Elevation	=	861.45 ft

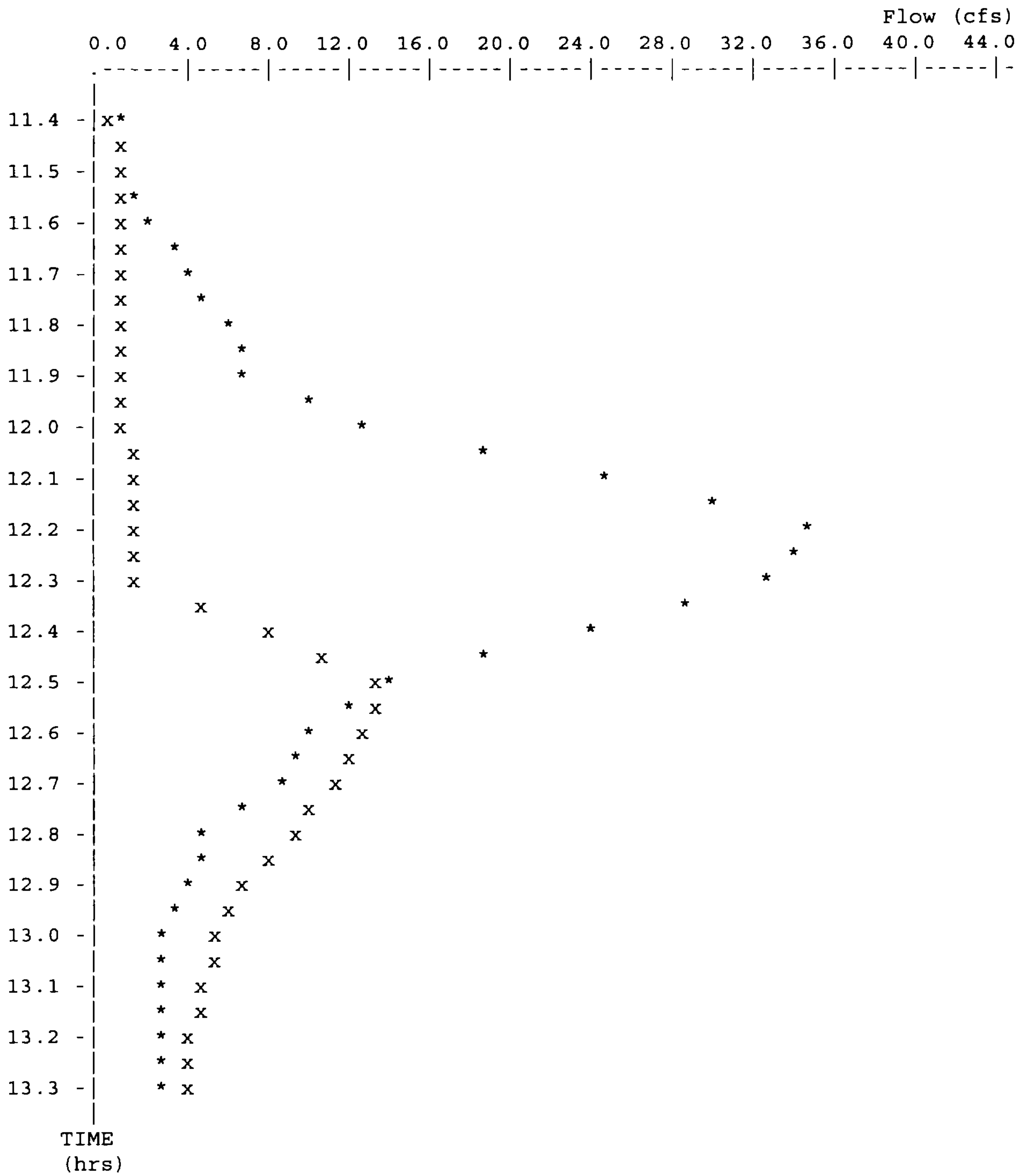
***** Summary of Approximate Peak Storage *****

Initial Storage	=	0.00 ac-ft
Peak Storage From Storm	=	1.11 ac-ft

Total Storage in Pond	=	1.11 ac-ft

Sheet 26 of 33


```
Pond File:            LPONDDW .PND
Inflow Hydrograph:    LLL25   .HYD
Outflow Hydrograph:   OUT     .HYD
                                              EXECUTED: 08-15-2000
Peak Inflow    =     35.00 cfs                          11:38:27
Peak Outflow   =     13.65 cfs
Peak Elevation =    861.45 ft
```




```
* File:  LLL25   .HYD   Qmax =    35.0 cfs
x File:  OUT     .HYD   Qmax =    13.6 cfs
```

```
*******************************************
*                                         *
*        OUTFLOW STRUCTURE FOR POND       *
*  catch basin with rim elevation at 861  *
*         3 - 3" dewatering holes         *
*       100 year, 24 hour storm event     *
*                                         *
*******************************************
```

Inflow Hydrograph: LLL100 .HYD
Rating Table file: LPONDDW .PND

----INITIAL CONDITIONS----
Elevation = 857.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + 0 (cfs)
857.00	0.0	0.000	0.0	0.0
857.25	0.4	0.004	0.9	1.3
857.50	0.5	0.012	3.0	3.5
857.75	0.6	0.029	6.9	7.5
858.00	0.7	0.054	13.2	13.9
858.25	0.8	0.089	21.6	22.4
858.50	0.9	0.132	32.0	32.9
858.75	0.9	0.183	44.4	45.3
859.00	1.0	0.244	59.0	60.0
859.25	1.1	0.312	75.4	76.5
859.50	1.1	0.384	92.9	94.0
859.75	1.2	0.461	111.6	112.8
860.00	1.2	0.543	131.4	132.6
860.25	1.3	0.630	152.4	153.7
860.50	1.3	0.721	174.4	175.7
860.75	1.4	0.817	197.7	199.1
861.00	1.4	0.918	222.1	223.5
861.25	6.4	1.024	247.7	254.1
861.50	15.4	1.135	274.6	290.0
861.75	27.0	1.251	302.8	329.8
862.00	40.8	1.373	332.2	373.0

Time increment (t) = 0.100 hrs.

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:37:56

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL100 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	0.00	-----	0.0	0.0	0.00	857.00
11.100	0.00	0.0	0.0	0.0	0.00	857.00
11.200	0.00	0.0	0.0	0.0	0.00	857.00
11.300	0.00	0.0	0.0	0.0	0.00	857.00
11.400	1.00	1.0	0.4	1.0	0.31	857.19
11.500	2.00	3.0	2.4	3.4	0.49	857.48
11.600	2.00	4.0	5.2	6.4	0.57	857.68
11.700	5.00	7.0	10.9	12.2	0.67	857.94
11.800	8.00	13.0	22.3	23.9	0.81	858.29
11.900	10.00	18.0	38.5	40.3	0.90	858.65
12.000	16.00	26.0	62.4	64.5	1.03	859.07
12.100	33.00	49.0	109.0	111.4	1.19	859.73
12.200	45.00	78.0	184.3	187.0	1.35	860.62
12.300	42.00	87.0	249.9	271.3	10.71	861.37
12.400	30.00	72.0	272.5	321.9	24.71	861.70
12.500	20.00	50.0	272.7	322.5	24.88	861.70
12.600	12.00	32.0	265.3	304.7	19.70	861.59
12.700	10.00	22.0	257.9	287.3	14.73	861.48
12.800	9.00	19.0	252.7	276.9	12.11	861.41
12.900	8.00	17.0	249.1	269.7	10.30	861.36
13.000	4.00	12.0	244.8	261.1	8.14	861.30
13.100	4.00	8.0	240.4	252.8	6.18	861.24
13.200	4.00	8.0	237.5	248.4	5.47	861.20
13.300	4.00	8.0	235.5	245.5	4.99	861.18
13.400	3.00	7.0	233.5	242.5	4.50	861.16
13.500	3.00	6.0	231.5	239.5	4.01	861.13
13.600	3.00	6.0	230.1	237.5	3.68	861.11
13.700	3.00	6.0	229.2	236.1	3.46	861.10
13.800	3.00	6.0	228.6	235.2	3.31	861.10
13.900	3.00	6.0	228.2	234.6	3.21	861.09
14.000	2.00	5.0	227.2	233.2	2.98	861.08
14.100	2.00	4.0	225.9	231.2	2.66	861.06
14.200	2.00	4.0	225.0	229.9	2.44	861.05
14.300	2.00	4.0	224.4	229.0	2.30	861.04
14.400	2.00	4.0	224.0	228.4	2.20	861.04
14.500	2.00	4.0	223.7	228.0	2.14	861.04
14.600	2.00	4.0	223.6	227.7	2.09	861.03
14.700	2.00	4.0	223.4	227.6	2.06	861.03
14.800	2.00	4.0	223.4	227.4	2.04	861.03
14.900	2.00	4.0	223.3	227.4	2.03	861.03
15.000	2.00	4.0	223.3	227.3	2.02	861.03
15.100	2.00	4.0	223.2	227.3	2.01	861.03
15.200	2.00	4.0	223.2	227.2	2.01	861.03
15.300	1.00	3.0	222.5	226.2	1.84	861.02
15.400	1.00	2.0	221.4	224.5	1.57	861.01

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:37:56

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL100 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH — ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	0.00	1.0	219.6	222.4	1.40	860.99
15.600	0.00	0.0	216.8	219.6	1.40	860.96
15.700	0.00	0.0	214.0	216.8	1.40	860.93
15.800	0.00	0.0	211.2	214.0	1.40	860.90
15.900	0.00	0.0	208.4	211.2	1.40	860.87
16.000	0.00	0.0	205.6	208.4	1.40	860.85
16.100	0.00	0.0	202.8	205.6	1.40	860.82
16.200	0.00	0.0	200.0	202.8	1.40	860.79
16.300	0.00	0.0	197.2	200.0	1.40	860.76
16.400	0.00	0.0	194.4	197.2	1.39	860.73
16.500	0.00	0.0	191.7	194.4	1.38	860.70
16.600	0.00	0.0	188.9	191.7	1.37	860.67
16.700	0.00	0.0	186.2	188.9	1.36	860.64
16.800	0.00	0.0	183.5	186.2	1.34	860.61
16.900	0.00	0.0	180.9	183.5	1.33	860.58
17.000	0.00	0.0	178.2	180.9	1.32	860.55
17.100	0.00	0.0	175.6	178.2	1.31	860.53
17.200	0.00	0.0	173.0	175.6	1.30	860.50
17.300	0.00	0.0	170.4	173.0	1.30	860.47
17.400	0.00	0.0	167.8	170.4	1.30	860.44
17.500	0.00	0.0	165.2	167.8	1.30	860.41
17.600	0.00	0.0	162.6	165.2	1.30	860.38
17.700	0.00	0.0	160.0	162.6	1.30	860.35
17.800	0.00	0.0	157.4	160.0	1.30	860.32
17.900	0.00	0.0	154.8	157.4	1.30	860.29
18.000	0.00	0.0	152.2	154.8	1.30	860.26
18.100	0.00	0.0	149.6	152.2	1.29	860.23
18.200	0.00	0.0	147.0	149.6	1.28	860.20
18.300	0.00	0.0	144.5	147.0	1.27	860.17
18.400	0.00	0.0	142.0	144.5	1.26	860.14
18.500	0.00	0.0	139.5	142.0	1.24	860.11
18.600	0.00	0.0	137.0	139.5	1.23	860.08
18.700	0.00	0.0	134.6	137.0	1.22	860.05
18.800	0.00	0.0	132.2	134.6	1.21	860.02
18.900	0.00	0.0	129.8	132.2	1.20	859.99
19.000	0.00	0.0	127.4	129.8	1.20	859.96
19.100	0.00	0.0	125.0	127.4	1.20	859.93
19.200	0.00	0.0	122.6	125.0	1.20	859.90
19.300	0.00	0.0	120.2	122.6	1.20	859.87
19.400	0.00	0.0	117.8	120.2	1.20	859.84
19.500	0.00	0.0	115.4	117.8	1.20	859.81
19.600	0.00	0.0	113.0	115.4	1.20	859.78
19.700	0.00	0.0	110.6	113.0	1.20	859.75
19.800	0.00	0.0	108.2	110.6	1.19	859.72
19.900	0.00	0.0	105.8	108.2	1.18	859.69
20.000	0.00	0.0	103.5	105.8	1.16	859.66

POND-2 Version: 5.21 S/N:
EXECUTED: 08-15-2000 11:37:56

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL100 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH — ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	0.00	0.0	101.2	103.5	1.15	859.63
20.200	0.00	0.0	98.9	101.2	1.14	859.60
20.300	0.00	0.0	96.7	98.9	1.13	859.57
20.400	0.00	0.0	94.5	96.7	1.11	859.54
20.500	0.00	0.0	92.3	94.5	1.10	859.51
20.600	0.00	0.0	90.1	92.3	1.10	859.47
20.700	0.00	0.0	87.9	90.1	1.10	859.44
20.800	0.00	0.0	85.7	87.9	1.10	859.41
20.900	0.00	0.0	83.5	85.7	1.10	859.38
21.000	0.00	0.0	81.3	83.5	1.10	859.35
21.100	0.00	0.0	79.1	81.3	1.10	859.32
21.200	0.00	0.0	76.9	79.1	1.10	859.29
21.300	0.00	0.0	74.7	76.9	1.10	859.25
21.400	0.00	0.0	72.5	74.7	1.09	859.22
21.500	0.00	0.0	70.3	72.5	1.08	859.19
21.600	0.00	0.0	68.2	70.3	1.06	859.16
21.700	0.00	0.0	66.1	68.2	1.05	859.12
21.800	0.00	0.0	64.0	66.1	1.04	859.09
21.900	0.00	0.0	62.0	64.0	1.02	859.06
22.000	0.00	0.0	60.0	62.0	1.01	859.03
22.100	0.00	0.0	58.0	60.0	1.00	859.00
22.200	0.00	0.0	56.0	58.0	0.99	858.96
22.300	0.00	0.0	54.0	56.0	0.97	858.93
22.400	0.00	0.0	52.1	54.0	0.96	858.90
22.500	0.00	0.0	50.2	52.1	0.95	858.87
22.600	0.00	0.0	48.4	50.2	0.93	858.83
22.700	0.00	0.0	46.5	48.4	0.92	858.80
22.800	0.00	0.0	44.7	46.5	0.91	858.77
22.900	0.00	0.0	42.9	44.7	0.90	858.74
23.000	0.00	0.0	41.1	42.9	0.90	858.70
23.100	0.00	0.0	39.3	41.1	0.90	858.67
23.200	0.00	0.0	37.5	39.3	0.90	858.63
23.300	0.00	0.0	35.7	37.5	0.90	858.59
23.400	0.00	0.0	33.9	35.7	0.90	858.56
23.500	0.00	0.0	32.1	33.9	0.90	858.52
23.600	0.00	0.0	30.3	32.1	0.89	858.48
23.700	0.00	0.0	28.6	30.3	0.88	858.44
23.800	0.00	0.0	26.9	28.6	0.86	858.40
23.900	0.00	0.0	25.2	26.9	0.84	858.36
24.000	0.00	0.0	23.5	25.2	0.83	858.32
24.100	0.00	0.0	21.9	23.5	0.81	858.28
24.200	0.00	0.0	20.3	21.9	0.79	858.23
24.300	0.00	0.0	18.8	20.3	0.78	858.19
24.400	0.00	0.0	17.2	18.8	0.76	858.14
24.500	0.00	0.0	15.8	17.2	0.74	858.10
24.600	0.00	0.0	14.3	15.8	0.72	858.06

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL100 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	0.00	0.0	12.9	14.3	0.71	858.01
24.800	0.00	0.0	11.5	12.9	0.68	857.96
24.900	0.00	0.0	10.2	11.5	0.66	857.91
25.000	0.00	0.0	8.9	10.2	0.64	857.86

****************** SUMMARY OF ROUTING COMPUTATIONS ******************

Pond File: LPONDDW .PND
Inflow Hydrograph: LLL100 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 857.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow	=	45.00 cfs
Peak Outflow	=	24.88 cfs
Peak Elevation	=	861.70 ft

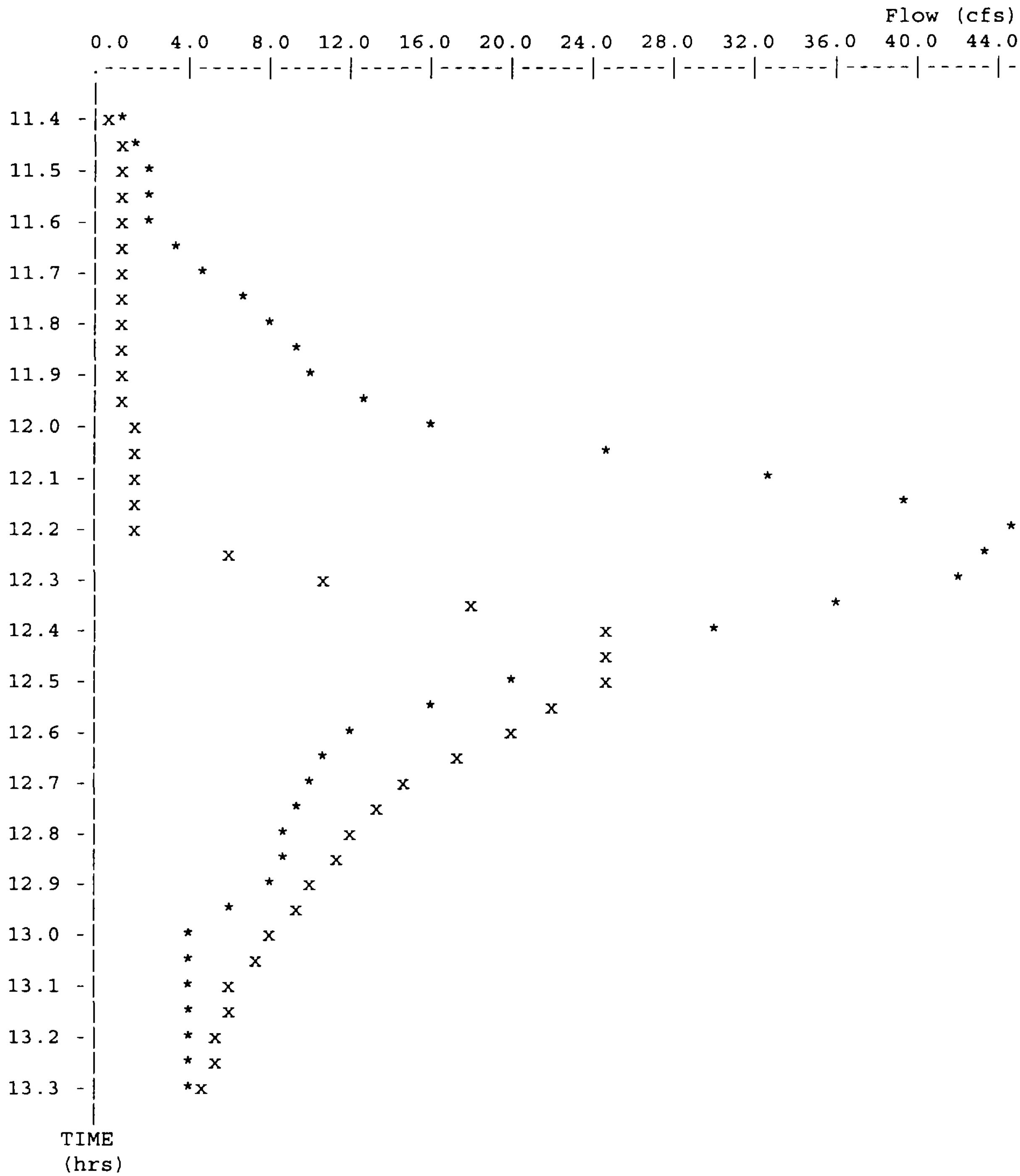
***** Summary of Approximate Peak Storage *****

Initial Storage	=	0.00 ac-ft
Peak Storage From Storm	=	1.23 ac-ft

Total Storage in Pond	=	1.23 ac-ft

Sheet 33 of 55


```
Pond File:            LPONDDW  .PND
Inflow Hydrograph:    LLL100   .HYD
Outflow Hydrograph:   OUT      .HYD
                                              EXECUTED: 08-15-2000
Peak Inflow     =     45.00 cfs                          11:37:56
Peak Outflow    =     24.88 cfs
Peak Elevation  =    861.70 ft
```




```
* File:  LLL100   .HYD   Qmax =    45.0 cfs
x File:  OUT      .HYD   Qmax =    24.9 cfs
```

APPENDIX A7
BASIN CULVERT DESIGN

GOLDER ASSOCIATES	Subject: DESIGN FOR BASIN CULVERT		
	Job No: 993-6573	Made by: BRB	Date: 6/05/00
	Ref: Lemon Lane	Check by: UCJ	Sheet: 1 of 2
		Review by: ΔJ	

OBJECTIVE: To select the pipe diameter (D) for a concrete culvert from the detention basin, in the southwest corner of the site, to Sargent's Pond. The maximum discharge is 25.0 cfs for the 100 year, 24 hour storm event, with a headwater depth (HW) of less than 5.0 ft for the Lemon Lane Landfill.

METHOD:

1) Using the nomograph (Figure 33, Reference 1), determine the required HW by aligning a straight edge through alternate pipe diameters and calculated flow rate (from Reference 2) to intersect scale 1, (HW/D for square edge). Since we will use a flared end section (comparable to a groove end with headwall), use scale 2. To find HW/D value for the design condition, draw a horizontal line to scale 2, from the point on scale 1. This will provide the required HW/D. To obtain the HW, multiply the value determined from scale 2 by the diameter. The diameters we are considering are 18 and 24 inches. Since 5.0 ft is the maximum HW, any value greater than 5 is too much and therefore the pipe is too small. The ideal HW is approximately 4.5 ft, to provide 0.5 ft of freeboard on the upgradient end of the culvert.

REFERENCES:

1) American Concrete Pipe Association, "Concrete Pipe Design Manual," dated 1985.

2) Golder Associates Inc., Calculations entitled "Basin Design," dated 6/05/00.

CALCULATION: As stated in the objective, the pipe discharge is a maximum of 25.0 cfs.

The attached sheet 2 of 3 (Reference 1), provide the nomograph with the calculated discharges for each pipe, for the two evaluated diameter pipes. From the nomograph the HW/D is obtained, then HW is calculated, as described in Method 1.

Headwater Depths (ft)		
Discharge value (cfs)	Pipe Diameter (in)	HW
25.0	18	6.90
25.0	24	3.26

RESULTS: The results for the discharge in the basin culvert, show that the 18 inch diameter pipe is inadequate for the maximum discharge. Wherein, the 24 inch diameter pipe satisfies the HW requirement, ideally.

CONCLUSION: The 24 inch diameter pipe is the best choice for the culvert design for the basin. For the basin culvert, a 24 inch diameter will obtain a headwater depth of less than 4.5 feet for the maximum discharge value, which is ideal.

SHEET 2 OF 2

18" DIA PIPE

— Q_{max} = 25 cfs

HW/D = 4.60 HW = 6.90

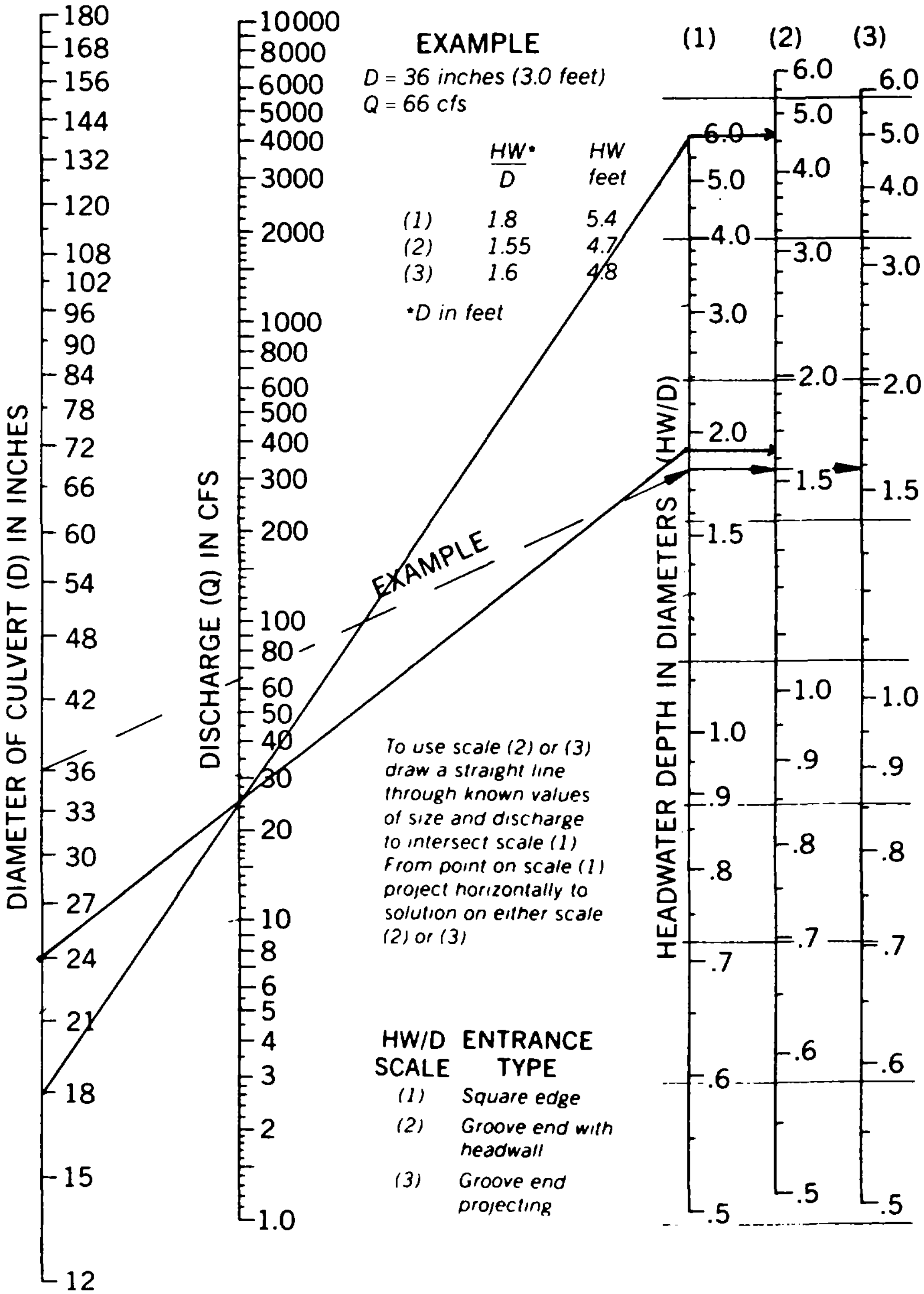
24" DIA PIPE

— Q_{max} = 25 cfs

HW/D = 1.63 HW = 3.26

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3 REVISED MAY 1964

APPENDIX A8
VERIFY CAPACITY OF EXISTING 24" C.M.P.

OBJECTIVE: To verify the existing pipe diameter (D) for peak flow rates, for the 25 year design storm, with a headwater depth (HW) of less than 11 ft for the Lemon Lane Landfill. The elevation between the invert of the pipe and the road it traverses is 11 feet. If this 11 feet is exceeded, the road will be overtopped.

METHOD:

1) Use the attached maps (Reference 2) of the site to determine the portion of the delineated watershed discharging to the existing 24" diameter CMP culvert.

2) Based upon the peak runoff values from the hydrographs for the 25 year design storm, determine the peak flow using the equation found from Method 1. The 100 year design storm was checked for overtopping of access road under more critical events.

3) Using the nomograph (Chart 2, Reference 1), determine the required HW by aligning a straight edge through existing pipe diameter and calculated flow rate (from Method 2) to intersect scale 1, (HW/D for square edge). For conservatism assume that the section (comparable to a groove end with headwall), use scale 3. To find HW/D value for the design condition, draw a horizontal line to scale 3, from the point on scale 1. This will provide the required HW/D. To obtain the HW, multiply the value determined from scale 2 by the diameter.

REFERENCES:

1) US Army Corps of Engineers, "HEC-2 – Water Surface Profiles: User's Manual," September 1990.

2) Golder Associates Inc., Calculations entitled "Runoff Rates - Proposed," dated 5/23/00.

CALCULATION: As stated in Method 1, the pipe discharge is determined first. From map estimation, the discharge in existing culvert is the flow of watersheds 2A and 2Bb. The equation for discharge in existing culvert is,

$$Q_{EX} = 2A + 2Bb$$

The values of each watershed vary per design storm event, the table below gives peak values of runoff rates (in cfs) for each watershed for the 25 and 100 year design storms from the tabular hydrographs.

Peak Runoff Rates (cfs) (from Reference 2, see copy attached sheets 4-7 of 9)		
Watershed	25 year	100 year
2A	28	37
2Bb	5	7

From the discharge equation and peak runoff rate, the discharge for the existing culvert can be calculated for each storm event. The equations are displayed above. The table below summarizes the discharge (Q).

Culvert Design Q (cfs)		
Culvert	25 year	100 year
Q_{EX}	33	44

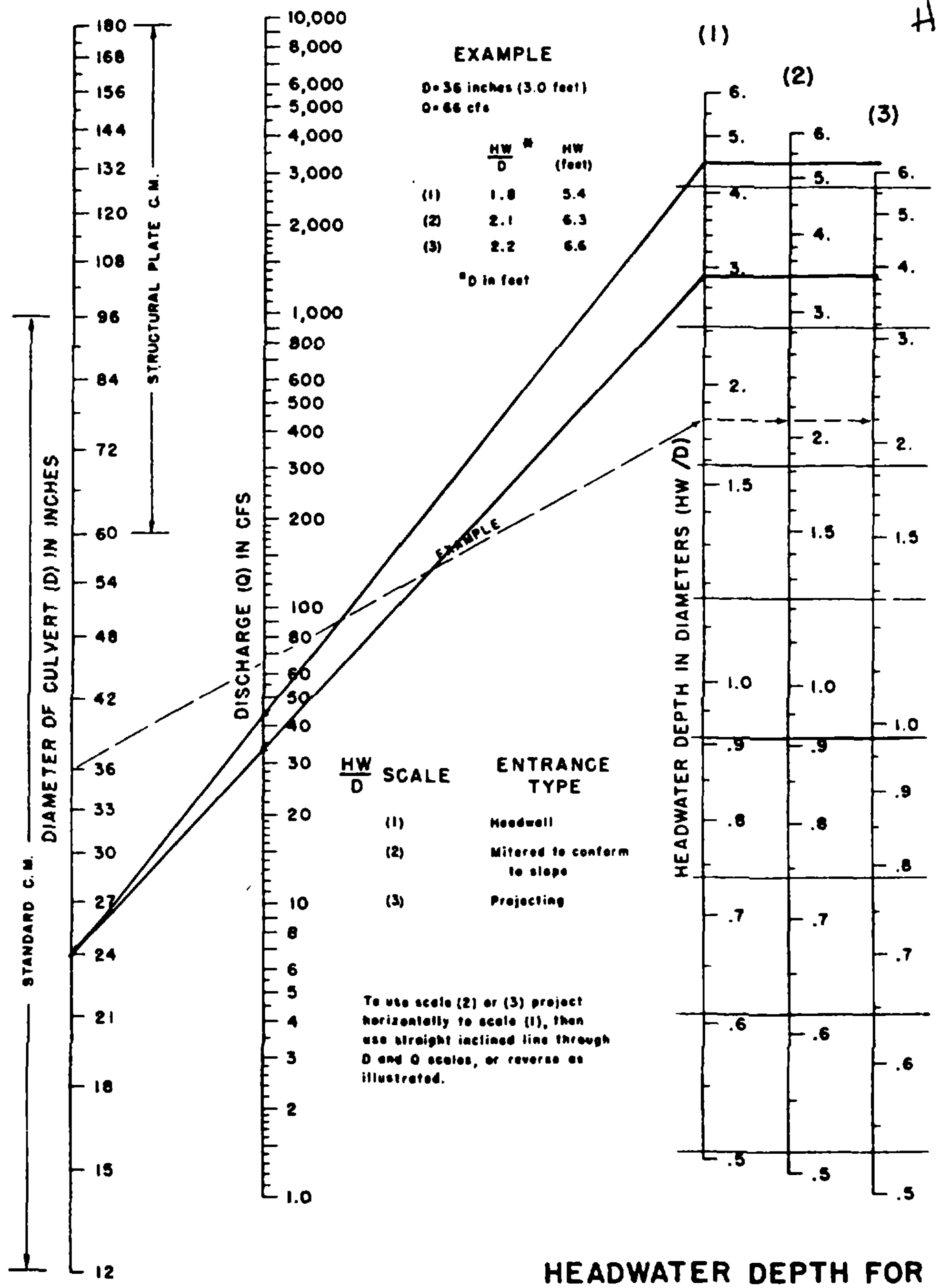
The attached sheet 3 of 9 (Reference 1), provide the nomographs with the calculated discharge for the pipe for each design storm. From the nomographs the HW/D is obtained, then HW is calculated, as described in Method 3.

Headwater Depths (ft)			
Culvert	Pipe Diameter (in)	25 year	100 year
D	24	7.70	12.40

RESULTS: The results for the discharge in existing culvert, show that each pipe diameter satisfies the HW limitations for the 25 year storm design, but is overtopped for the 100 year storm event as evidenced by the fact that the head required to pass the peak design flow rate is more than 11 feet stated in the objective.

Sheet 3 of 9
D=24" CMP
Q_{25} = 33cfs
Q_{100} = 44cfs
HW_{25} = 2x3.85 = 7.70
HW_{100} =6.2x2= 12.40

CHART 2



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Sheet 4 of 9

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: [illegible] Date: 6/1/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 25 years

---------- Subareas ----------	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	5.0	5.0
Curve number	70	79
Runoff(in)	2.04	2.80
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.17	0.11
(Used)	0.10	0.10

Time Total ------------- Subarea Contribution to Total Flow (cfs) ------------

Time (hr)	Total Flow	1	2A
11.0	2	1	1
11.3	3	2	1
11.6	4	2	2
11.9	9	5	4
12.0	16	9	7
12.1	30	17	13
12.2	52	30	22
12.3	66P	38P	28P
12.4	64	37	27
12.5	48	28	20
12.6	33	19	14
12.7	24	14	10
12.8	18	10	8
13.0	12	7	5
13.2	9	5	4
13.4	7	4	3
13.6	7	4	3
13.8	5	3	2
14.0	5	3	2
14.3	4	2	2
14.6	4	2	2
15.0	3	2	1
15.5	3	2	1
16.0	3	2	1
16.5	2	1	1
17.0	2	1	1
17.5	2	1	1
18.0	2	1	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: BCB Date: 6/1/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 25 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	2.80	2.04	2.04	2.04	2.80	2.80	2.80
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.11	0.17	0.17	0.17	0.11	0.11	0.11
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Time	Total	Subarea Contribution to Total Flow (cfs)						
(hr)	Flow	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	7	1	1	1	1	2	0	1
12.0	13	3	3	1	1	3	1	1
12.1	25	6	5P	2P	2	6	2	2
12.2	35P	9P	5	2	3P	9P	3P	4
12.3	33	9	3	1	3	9	3	5P
12.4	24	6	2	1	2	6	2	5
12.5	14	4	1	0	1	4	1	3
12.6	10	2	1	0	1	3	1	2
12.7	9	2	1	0	1	2	1	2
12.8	5	1	1	0	0	2	0	1
13.0	3	1	0	0	0	1	0	1
13.2	3	1	0	0	0	1	0	1
13.4	2	1	0	0	0	1	0	0
13.6	2	1	0	0	0	1	0	0
13.8	2	1	0	0	0	1	0	0
14.0	2	1	0	0	0	1	0	0
14.3	0	0	0	0	0	0	0	0
14.6	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

Sheet 6 of 9

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: BCG Date: 6/1/00

Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.048 sq mi Rainfall type: II Frequency: 100 years

Subareas	1	2A
Area(sq mi)	0.03	0.02
Rainfall(in)	6.0	6.0
Curve number	70	79
Runoff(in)	2.81	3.68
Tc (hrs)	0.42	0.43
(Used)	0.40	0.40
TimeToOutlet	0.00	0.00
Ia/P	0.14	0.09
(Used)	0.10	0.10

Time Total ------------- Subarea Contribution to Total Flow (cfs) ------------

Time (hr)	Total Flow	1	2A
11.0	3	2	1
11.3	4	2	2
11.6	5	3	2
11.9	12	7	5
12.0	21	12	9
12.1	41	24	17
12.2	70	41	29
12.3	89P	52P	37P
12.4	87	51	36
12.5	65	38	27
12.6	45	26	19
12.7	32	19	13
12.8	24	14	10
13.0	15	9	6
13.2	12	7	5
13.4	10	6	4
13.6	8	5	3
13.8	7	4	3
14.0	7	4	3
14.3	5	3	2
14.6	5	3	2
15.0	5	3	2
15.5	4	2	2
16.0	4	2	2
16.5	3	2	1
17.0	3	2	1
17.5	3	2	1
18.0	3	2	1
19.0	2	1	1
20.0	2	1	1
22.0	2	1	1
26.0	0	0	0

P - Peak Flow

TABULAR HYDROGRAPH METHOD Version 2.10

Project : LEMON LANE User: VEF Date: 02-25-2000

County : BLOOMINGTON State: IN Checked: BC Date: 6/1/00

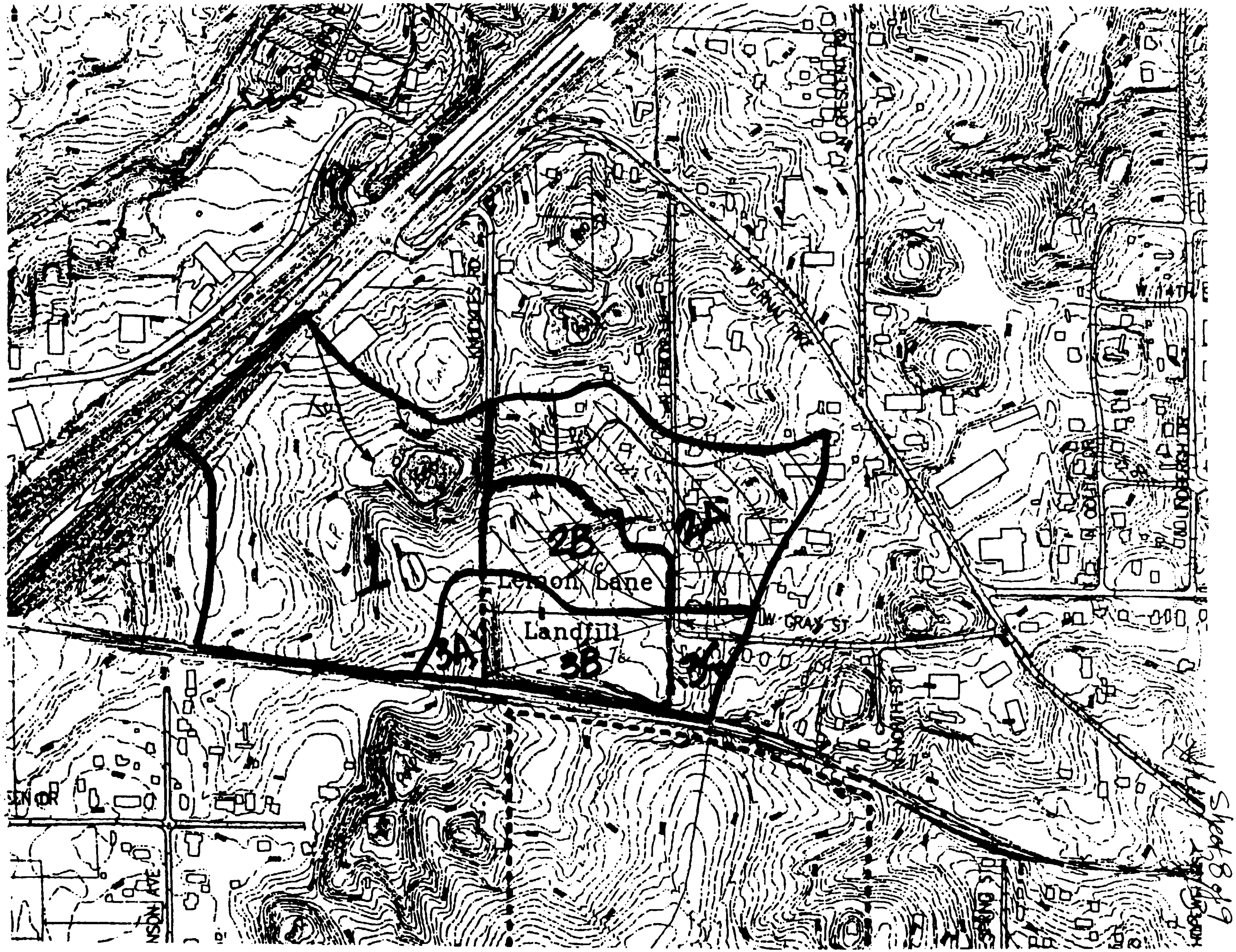
Subtitle: PROPOSED CONDITIONS

Total watershed area: 0.020 sq mi Rainfall type: II Frequency: 100 years

	Subareas						
	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
Area(sq mi)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall(in)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Curve number	79	70	70	70	79	79	79
Runoff(in)	3.68	2.81	2.81	2.81	3.68	3.68	3.68
Tc (hrs)	0.30	0.21	0.23	0.31	0.30	0.27	0.44
(Used)	0.30	0.20	0.20	0.30	0.30	0.30	0.40
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.09	0.14	0.14	0.14	0.09	0.09	0.09
(Used)	0.10	0.10	0.10	0.10	0.10	0.10	0.10

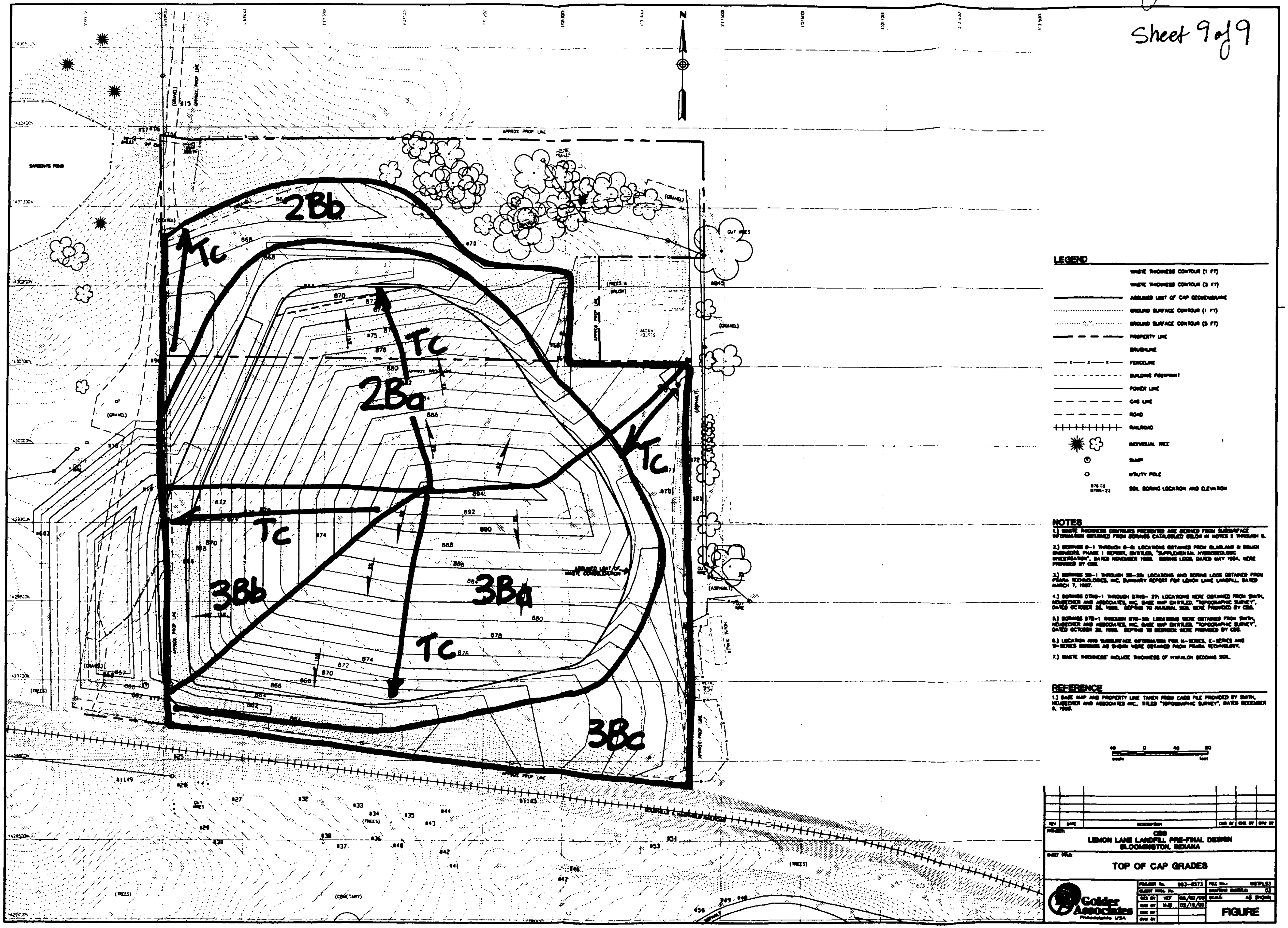
Time	Total	Subarea Contribution to Total Flow (cfs)						
(hr)	Flow	2Ba	2Bb	3Bc	3A	3Ba	3Bb	3C
11.0	0	0	0	0	0	0	0	0
11.3	0	0	0	0	0	0	0	0
11.6	2	1	0	0	0	1	0	0
11.9	10	2	2	1	1	2	1	1
12.0	16	4	4	1	1	4	1	1
12.1	33	7	7P	3P	3	8	2	3
12.2	45P	11P	7	3	4P	12P	3P	5
12.3	42	11	4	2	4	12	3	6P
12.4	30	8	2	1	3	8	2	6
12.5	20	5	2	1	2	5	1	4
12.6	12	3	1	0	1	3	1	3
12.7	10	2	1	0	1	3	1	2
12.8	9	2	1	0	1	2	1	2
13.0	4	1	1	0	0	1	0	1
13.2	4	1	1	0	0	1	0	1
13.4	3	1	0	0	0	1	0	1
13.6	3	1	0	0	0	1	0	1
13.8	3	1	0	0	0	1	0	1
14.0	2	1	0	0	0	1	0	0
14.3	2	1	0	0	0	1	0	0
14.6	2	1	0	0	0	1	0	0
15.0	2	1	0	0	0	1	0	0
15.5	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0

P - Peak Flow

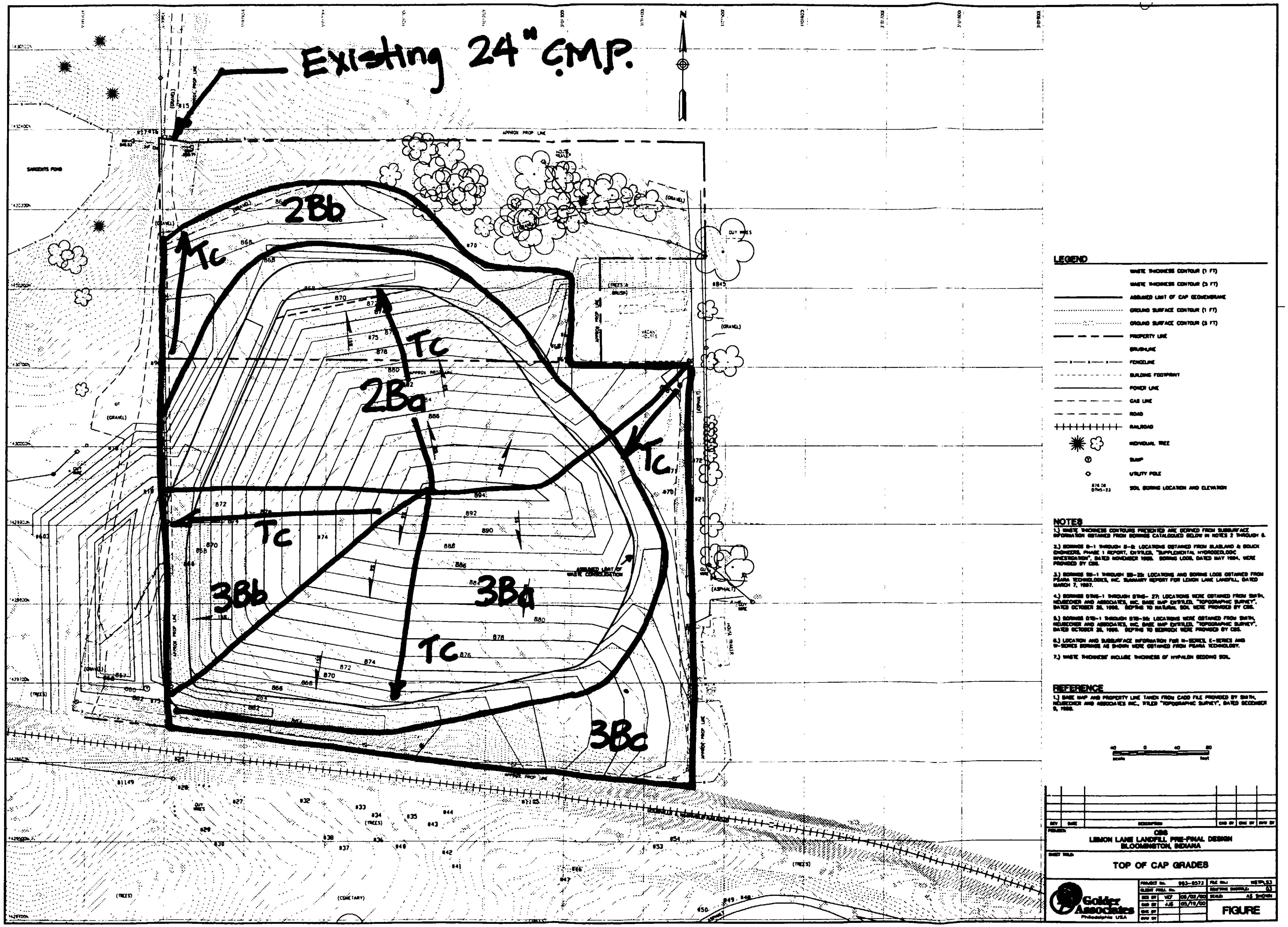


Lemon Lane
Landfill
1
2B
3A
3B
W GRAY ST
Sheet 8 of 9

Sheet 9 of 9


2Bb
Tc
2Ba
Tc
Tc
Tc
3Bb
3Ba
Tc
3Bc
N
SARGENTS POND
(GRAVEL)
(TREES)
(CEMETARY)
LEGEND
WASTE THICKNESS CONTOUR (1 FT)
WASTE THICKNESS CONTOUR (5 FT)
ASSUMED LIMIT OF CAP GEOMEMBRANE
GROUND SURFACE CONTOUR (1 FT)
GROUND SURFACE CONTOUR (5 FT)
PROPERTY LINE
BRUSHLINE
FENCELINE
BUILDING FOOTPRINT
POWER LINE
GAS LINE
ROAD
RAILROAD
INDIVIDUAL TREE
SUMP
UTILITY POLE
SOIL BORING LOCATION AND ELEVATION
NOTES
REFERENCE
scale
feet
CBS
LEMON LANE LANDFILL PRE-FINAL DESIGN
BLOOMINGTON, INDIANA
TOP OF CAP GRADES
Golder Associates
Philadelphia USA
993-6373
AS SHOWN
05/02/00
05/10/00
FIGURE

Sheet 9A of 9



Existing 24" C.M.P.
2Bb
Tc
2Ba
Tc
Tc
Tc
3Bb
3Ba
Tc
3Bc
LEGEND
UTILITY POLE
SOIL BORING LOCATION AND ELEVATION
NOTES
REFERENCE
CBS
LEMON LANE LANDFILL PRE-FINAL DESIGN
BLOOMINGTON, INDIANA
TOP OF CAP GRADES
Golder Associates
Philadelphia USA
AS SHOWN
FIGURE

APPENDIX A9
SOIL LOSS ANALYSIS

Golder Associates	SUBJECT Soil Loss Analysis.		
	Job No. 993-6573 Ref. Lemon Lane	Made by SRB Checked VGT Reviewed DW	Date 5/12/00 Sheet 1 of 9

OBJECTIVE: TO DETERMINE THE SOIL LOSS ASSOCIATED WITH THE PROPOSED CAP GRADING PLAN FOR LEMON LANE LANDFILL.

METHOD: PER REFERENCE 1,

$$A = RKLSCP$$

WHERE
A = AVERAGE ANNUAL SOIL LOSS, TONS/ACRE
R = RAINFALL AND RUNOFF EROSIVITY INDEX
K = SOIL ERODIBILITY FACTOR, TONS/ACRE
L = SLOPE-LENGTH FACTOR
S = SLOPE-STEEPNESS FACTOR
C = COVER-MANAGEMENT FACTOR
P = PRACTICE FACTOR

REFERENCES:
1) USEPA, "EVALUATING COVER SYSTEMS FOR SOLID AND HAZARDOUS WASTE," SEPTEMBER 1982.
2) GOLDER ASSOCIATES, DRAWING "ANTICIPATED TOP OF COVER GRADING PLAN," DATED 2/24/00.

ASSUMPTIONS: 1) COVER SOIL ORGANIC CONTENT IS 2%.

CASES EVALUATED: Due to the potential varying volume of waste to be consolidated under the cap, the grading of the cap may change to accommodate this volume. Based upon slope stability considerations and material limitations, the minimum and maximum slope inclinations were evaluated: 200 ft at 5% and 100 ft at 25%, respectively. Finally, the critical slope matching the currently proposed grading configuration was also evaluated: 90 ft @ 15% plus 180 ft @ 9%. However, due to the limitations of the soil loss equation, this slope was divided in 3-equal slope lengths: 90 ft at 15% plus 90 ft @ 9% plus 90 ft @ 9%.

Golder Associates	SUBJECT Soil Loss Analysis		
	Job No. 993-6573 Ref. Lemon Lane	Made by BCB Checked [illegible] Reviewed [illegible]	Date 5/12/00 Sheet 2 of 9

CALCULATION: 1) LEMON LANE LANDFILL IS IN BLOOMINGTON, IN

$R = 200$ (FIGURE 20, REF. 1, SEE ATTACHED SHEET 4 OF 9) ✓

2) PROPOSED COVER SOIL IS LOAM.

$K = 0.34$ (TABLE 5, REF 1, SEE ATTACHED SHEET 5 OF 9) ✓

3) THE SITE SLOPES ARE (REF. 2, SEE ATTACHED SHEET 6 OF 9)

A) 100 ft @ 25% ✓
(WORST CASE SCENARIO - UPPER)

B) 330 ft @ 5% ✓
(WORST CASE SCENARIO - LOWER)

C) 90 @ 9%, 90 @ 9%, 90 @ 15%
(ACTUAL CONDITION PROPOSED)

DETERMINE LS FOR EACH SLOPE (TABLE 6, REF 1, SEE ATTACHED SHEETS 6&7 OF 9)

A) $LS_A = 5.9$ ✓

B) $LS_B = 0.76$ ✓

C) $LS_C = \dfrac{0.58(LS_{9\%}) + 1.06(LS_{9\%}) + 1.37(LS_{15\%})}{3}$

$LS_C = 1.73$ ✓

$LS = 0.58(LS_A) + 1.06(LS_B) + 1.37(LS_C)$
This equation is based upon having 3 equal length segments with the same or differing inclination.

INTERPOLATION: $\dfrac{x_1 - x_3}{y_1 - y_3} = \dfrac{x_1 - x_2}{y_1 - y_2}$

WHERE y_2 IS UNKNOWN

$LS_{100@9} = \dfrac{10-8}{1.4-0.99} = \dfrac{10-9}{1.4-y_2}$ $\quad y_2 = 1.20$ ✓

$LS_{75@9} = \dfrac{10-8}{1.2-0.86} = \dfrac{10-9}{1.2-y_2}$ $\quad y_2 = 1.03$ ✓

$LS_{90@9} = \dfrac{100-75}{1.20-1.03} = \dfrac{100-90}{1.20-y_2}$ $\quad y_2 = 1.13$ ✓

FOLLOWING THE SAME METHOD FIND THE $LS_{90@15}$.

$LS_{90@15} = 2.43$ ✓

Golder Associates	SUBJECT Soil Loss Analysis		
	Job No. 993-6573 Ref. Lemon Lane	Made by BEB Checked VEY Reviewed DW	Date 5/12/00 Sheet 3 of 9

4) COVER-MANAGEMENT FACTOR IS GRASS AND MEADOW

$C = 0.004$ (TABLE 7, REF 1, SEE ATTACHED SHEET 8 OF 9) ✓

5) PRACTICE FACTOR IS NONE

$P = 1.0$ (TABLE 8, REF 1, SEE ATTACHED SHEET 9 OF 9) ✓

6) SOIL LOSS

$A_A = (200)(0.34)(5.9)(0.004)(1.0)$
$A_A = 1.60$ TONS/ACRE/YEAR ✓

$A_B = (200)(0.34)(0.76)(0.004)(1.0)$
$A_B = 0.21$ TONS/ACRE/YEAR ✓

$A_C = (200)(0.34)(1.73)(0.004)(1.0)$
$A_C = 0.47$ TONS/ACRE/YEAR

FOR ALL SLOPES, THE AVERAGE ANNUAL EROSION POTENTIAL IS LESS THAN 2 TONS/ACRE/YR RECOMMENDED BY EPA.

Not only is erosion objectionable in itself but erosion can degrade the cover and seriously reduce its effectiveness.

Evaluate Erosion Potential — Step 19

The USDA universal soil loss equation (USLE) is a convenient tool for use in evaluating erosion potential. The USLE predicts average annual soil loss as the product of six quantifiable factors. The equation is:

$$A = R\ K\ L\ S\ C\ P$$

where A = average annual soil loss, in tons/acre
- R = rainfall and runoff erosivity index
- K = soil erodibility factor, tons/acre
- L = slope-length factor
- S = slope-steepness factor
- C = cover-management factor
- P = practice factor

The data necessary as input to this equation are available to the evaluator in a figure and tables included below. Note that the evaluations in Step 8 on soil composition and Steps 25-32 on vegetation all impact on the evaluation of erosion also.

Factor R in the USLE can be calculated empirically from climatological data. For average annual soil loss determinations, however, R can be obtained directly from Figure 20. Factor K, the average soil loss for a given

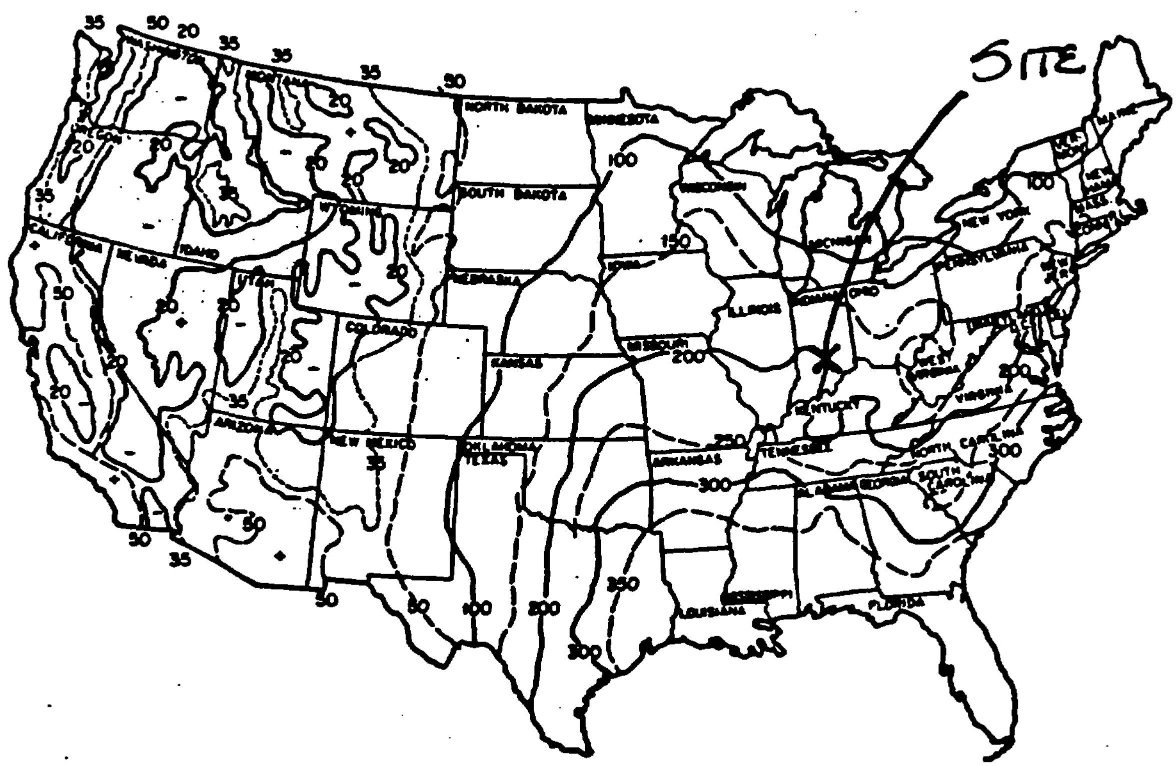


Figure 20. Average annual values of rainfall-erosivity factor R.[11]

soil in a unit plot, pinpoints differences in erosion according to differences in soil type. Long-term plot studies under natural rainfall have produced K values generalized in Table 5 for the USDA soil types.

TABLE 5. APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES[11]

Texture class	Organic matter content <0.5% K	2% K	4% K
Sand	0.05	0.03	0.02
Fine sand	.16	.14	.10
Very fine sand	.42	.36	.28
Loamy sand	.12	.10	.08
Loamy fine sand	.24	.20	.16
Loamy very fine sand	.44	.38	.30
Sandy loam	.27	.24	.19
Fine sandy loam	.35	.30	.24
Very fine sandy loam	.47	.41	.33
Loam	.38	.34	.29
Silt loam	.48	.42	.33
Silt	.60	.52	.42
Sandy clay loam	.27	.25	.21
Clay loam	.28	.25	.21
Silty clay loam	.37	.32	.26
Sandy clay	.14	.13	.12
Silty clay	.25	.23	.19
Clay		0.13–0.29	

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

The evaluator must next consider the shape of the slope in terms of length and inclination. The appropriate LS factor is obtained from Table 6. A nonlinear slope may have to be evaluated as a series of segments, each with uniform gradient. Two or three segments should be sufficient for most engineered landfills, provided the segments are selected so that they are also of equal length (Table 6 can be used, with certain adjustments). Enter Table 6 with the total slope length and read LS values corresponding to the percent slope of each segment. For three segments, multiply the chart LS values for the upper, middle, and lower segments by 0.58, 1.06, and 1.37, respectively. The average of the three products is a good estimate of the

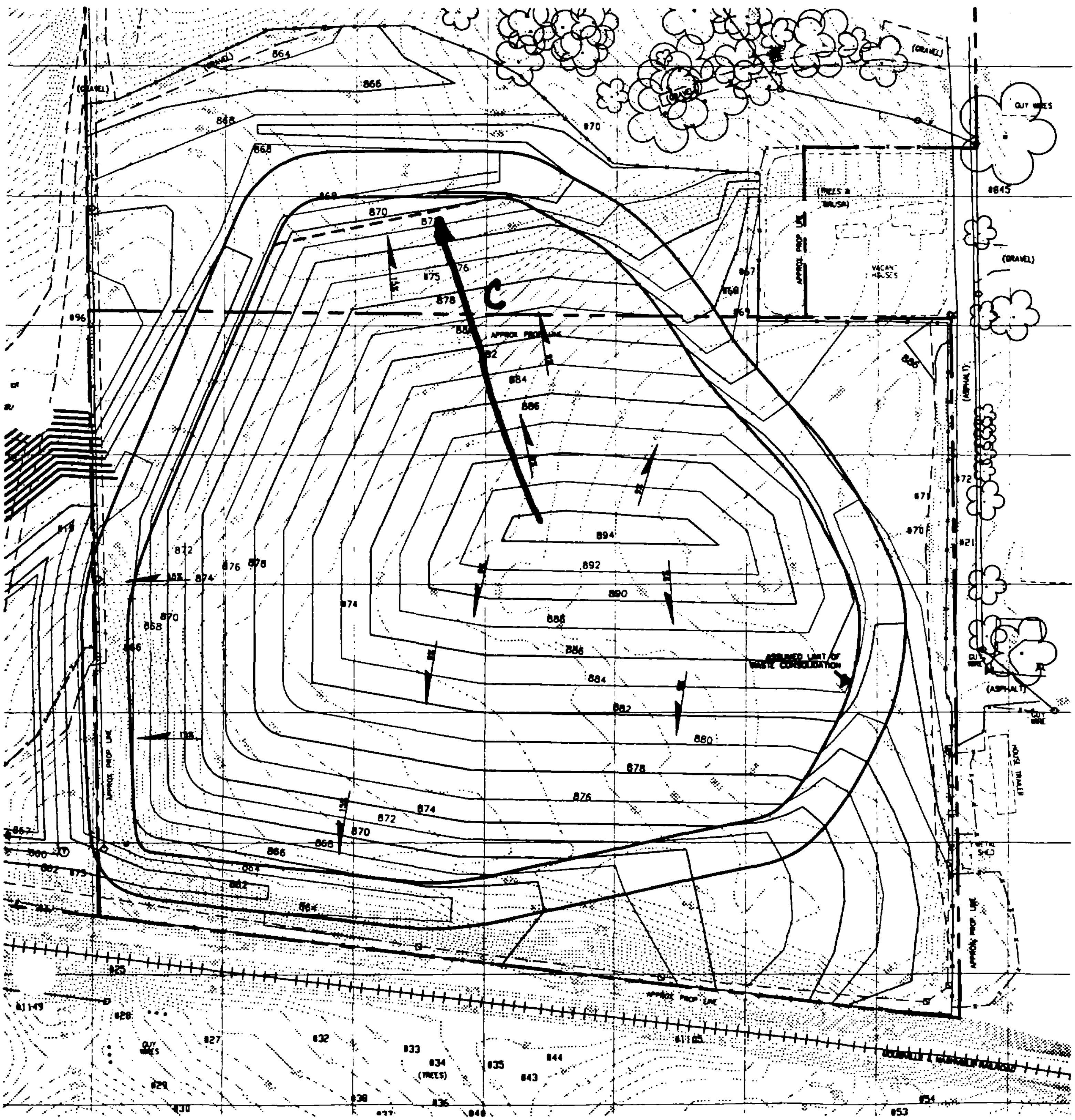

C
APPROX PROP LINE
VACANT HOUSES
GUY WIRES
(GRAVEL)
(ASPHALT)
ASSUMED LIMIT OF WASTE CONSOLIDATION
HOUSE TRAILER
(TREES)
894
892
890
888
886
884
882
880
878
876
874
872
870
868
866
864

TABLE 6. VALUES OF THE FACTOR LS FOR SPECIFIC COMBINATIONS OF SLOPE LENGTH AND STEEPNESS[11]

% Slope	Slope length (feet)											
	25	50	75	100	150	200	300	400	500	600	800	1000
0.5	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.19	0.20
1	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.21	0.22	0.24	0.26
2	0.13	0.16	0.19	0.20	0.23	0.25	0.28	0.31	0.33	0.34	0.38	0.40
3	0.19	0.23	0.26	0.29	0.33	0.35	0.40	0.44	0.47	0.49	0.54	0.57
4	0.23	0.30	0.36	0.40	0.47	0.53	0.62	0.70	0.76	0.82	0.92	1.0
5	0.27	0.38	0.46	0.54	0.66	0.76	0.93	1.1	1.2	1.3	1.5	1.7
6	0.34	0.48	0.58	0.67	0.82	0.95	1.2	1.4	1.5	1.7	1.9	2.1
8	0.50	0.70	0.86	0.99	1.2	1.4	1.7	2.0	2.2	2.4	2.8	3.1
10	0.69	0.97	1.2	1.4	1.7	1.9	2.4	2.7	3.1	3.4	3.9	4.3
12	0.90	1.3	1.6	1.8	2.2	2.6	3.1	3.6	4.0	4.4	5.1	5.7
14	1.2	1.6	2.0	2.3	2.8	3.3	4.0	4.6	5.1	5.6	6.5	7.3
16	1.4	2.0	2.5	2.8	3.5	4.0	4.9	5.7	6.4	7.0	8.0	9.0
18	1.7	2.4	3.0	3.4	4.2	4.9	6.0	6.9	7.7	8.4	9.7	11.0
20	2.0	2.9	3.5	4.1	5.0	5.8	7.1	8.2	9.1	10.0	12.0	13.0
25	3.0	4.2	5.1	5.9	7.2	8.3	10.0	12.0	13.0	14.0	17.0	19.0
30	4.0	5.6	6.9	8.0	9.7	11.0	14.0	16.0	18.0	20.0	23.0	25.0
40	6.3	9.0	11.0	13.0	16.0	18.0	22.0	25.0	28.0	31.0	--	--
50	8.9	13.0	15.0	18.0	22.0	25.0	31.0	--	--	--	--	--
60	12.0	16.0	20.0	23.0	28.0	--	--	--	--	--	--	--

Values given for slopes longer than 300 feet or steeper than 18% are extrapolations beyond the range of the research data and, therefore, less certain than the others.

overall effective LS value. If two segments are sufficient, multiply by 0.71 and 1.29.

Factor C in the USLE is the ratio of soil loss from land cropped under specified conditions to that from clean-tilled, continuous fallow. Therefore, C combines effects of vegetation, crop sequence, management, and agricultural (as opposed to engineering) erosion-control practices. On landfills, freshly covered and without vegetation or special erosion-reducing procedures of cover placement, C will usually be about unity. Where there is vegetative cover or significant amounts of gravel, roots, or plant residues or where cultural practices increase infiltration and reduce runoff velocity, C is much less than unity. Estimate C by reference to Table 7 for anticipated cover management, but also consider changes that may take place in time. Meadow values are usually most appropriate. See Reference 1 for additional guidance.

Factor P in the USLE is similar to C except that it accounts for additional erosion-reducing effects of land management practices that are superimposed on the cultural practices, e.g., contouring, terracing, and contour strip-cropping. Approximate values of P, related only to slope steepness,

TABLE 7. GENERALIZED VALUES OF FACTOR C FOR STATES EAST OF THE ROCKY MOUNTAINS[11]

Crop, rotation, and management	Productivity level	
	High	Mod.
	C value	
Base value: continuous fallow, tilled up and down slope	1.00	1.00
CORN		
C, RdR, fall TP, conv	0.54	0.62
C, RdR, spring TP, conv	.50	.59
C, RdL, fall TP, conv	.42	.52
C, RdR, wc seeding, spring TP, conv	.40	.49
C, RdL, standing, spring TP, conv	.38	.48
C-W-M-M, RdL, TP for C, disk for W	.039	.074
C-W-M-M-M, RdL, TP for C, disk for W	.032	.061
C, no-till pl in c-k sod, 95-80% rc	.017	.053
COTTON		
Cot, conv (Western Plains)	0.42	0.49
Cot, conv (South)	.34	.40
MEADOW		
Grass & Legume mix	0.004	0.01
Alfalfa, lespedeza or Sericia	.020	
Sweet clover	.025	
SORGHUM, GRAIN (Western Plains)		
RdL, spring TP, conv	0.43	0.53
No-till pl in shredded 70-50% rc	.11	.18
SOYBEANS		
B, RdL, spring TP, conv	0.48	0.54
C-B, TP annually, conv	.43	.51
B, no-till pl	.22	.28
C-B, no-till pl, fall shred C stalks	.18	.22
WHEAT		
W-F, fall TP after W	0.38	
W-F, stubble mulch, 500 lbs rc	.32	
W-F, stubble mulch, 1000 lbs rc	.21	

Abbreviations defined:

B - soybeans
C - corn
c-k - chemically killed
conv - conventional
cot - cotton
F - fallow
M - grass & legume hay
pl - plant
W - wheat
wc - winter cover

lbs rc - pounds of crop residue per acre remaining on surface after new crop seeding
% rc - percentage of soil surface covered by residue mulch after new crop seeding
70-50% rc - 70% cover for C values in first column; 50% for second column
RdR - residues (corn stover, straw, etc.) removed or burned
RdL - all residues left on field (on surface or incorporated)
TP - turn plowed (upper 5 or more inches of soil inverted, covering residues)

are listed in Table 8. These values are based on rather limited field data, but P has a narrower range of possible values than the other five factors.

TABLE 8. VALUES OF FACTOR P[11]

Practice	Land slope (percent)				
	1.1-2	2.1-7	7.1-12	12.1-18	18.1-24
	(Factor P)				
Contouring (P_c)	0.60	0.50	0.60	0.80	0.90
Contour strip cropping (P_{sc})					
R-R-M-M[1]	0.30	0.25	0.30	0.40	0.45
R-W-M-M	0.30	0.25	0.30	0.40	0.45
R-R-W-M	0.45	0.38	0.45	0.60	0.68
R-W	0.52	0.44	0.52	0.70	0.90
R-O	0.60	0.50	0.60	0.80	0.90
Contour listing or ridge planting (P_{cl})	0.30	0.25	0.30	0.40	0.45
Contour terracing (P_t)[2]	[3] $0.6/\sqrt{n}$	$0.5/\sqrt{n}$	$0.6/\sqrt{n}$	$0.8/\sqrt{n}$	$0.9/\sqrt{n}$
No support practice	1.0	1.0	1.0	1.0	1.0

[1] R = rowcrop, W = fall-seeded grain, O = spring-seeded grain, M = meadow. The crops are grown in rotation and so arranged on the field that rowcrop strips are always separated by a meadow or winter-grain strip.

[2] These P_t values estimate the amount of soil eroded to the terrace channels and are used for conservation planning. For prediction of off-field sediment, the P_t values are multiplied by 0.2.

[3] n = number of approximately equal-length intervals into which the field slope is divided by the terraces. Tillage operations must be parallel to the terraces.

Example: An owner/operator proposes to close one section of his small landfill with a sandy clay subsoil cover having the surface configuration shown in Figure 21. The factor R has been established as 200 for this locality. The evaluator questions anticipated erosion along the steep side and assigns the following values to the other factors in the USLE after inspecting Tables 5 through 8:

$$K = 0.14 \quad LS = 8.3 \quad C = 1.00 \quad P = 0.90$$

The rate of erosion for the steep slope of the landfill is calculated as follows:

$$A = 200\ (0.14\ \text{tons/acre})\ (8.3)\ (1.00)\ (0.90) = 209\ \text{tons/acre}$$

This erosion not only exceeds a limit recommended by the permitting authority but also indicates a potential

APPENDIX B

DRAINAGE CALCULATIONS

<table>
<tr><td rowspan="4">Golder Associates</td><td colspan="3">SUBJECT: Lemon Lane Landfill – Geocomposite Design</td></tr>
<tr><td>Job No.: 993-6573</td><td>Made by: RSV</td><td>Date: 5/22/2000</td></tr>
<tr><td rowspan="2">Ref.: Pre-Final Design Report</td><td>Checked: MFH</td><td>Sheet 1 of 29</td></tr>
<tr><td>Reviewed: BJ</td><td></td></tr>
</table>

OBJECTIVE: To evaluate the required minimum transmissivity of the geocomposite drainage layer to adequately drain surface water infiltration.

METHOD: Methodology based on References 1 through 6 to evaluate the required minimum transmissivity of the geocomposite drainage layer. Adequate drainage of surface water infiltration is necessary to promote veneer cap stability and limit the head build up on top of the barrier layer. The analysis considered two cases, which assess the anticipated grading as depicted on Reference 7, assessed by water balance methods, and a third case using HELP Model analysis of the governing case, determined from the water balance analyses, for comparison. The cases are summarized as follows:

Case 1: Minimum 9% Slopes: Considers required transmissivity based on limiting hydraulic head build-up on top of the barrier layer to a conservative, 'no head' condition (i.e., flow is restricted to within the geocomposite cross section). Limiting the hydraulic head is the driving design parameter for relatively flat slopes where stability is not a major concern. Excessive hydraulic head build-up could induce infiltration of surface water through the barrier layer, which is contradictory to the intent of the geosynthetic cap. This case is assessed using water balance techniques under simplified unit gradient analysis (References 1 and 4) to determine the required ultimate transmissivity of the geocomposite drainage layer within the flatter slope.

Case 2: Maximum 15% Slopes: Considers required transmissivity based on promoting veneer cap stability through reduction of pore water pressure build-up which would otherwise ultimately induce excess seepage forces that negatively impact stability. Stability is the driving design parameter for relatively steep slopes. This case is assessed using water balance techniques under simplified unit gradient analysis (References 1 and 4) to determine the required ultimate transmissivity of the geocomposite drainage layer to maintain flow within the geocomposite to prevent the generation of seepage induced forces, due to hydraulic head build-up, within steeper slopes.

Case 3: HELP Analysis: Considers the proposed cap configuration based on the governing case from the water balance analyses, which was determined to be Case 1. Assessed using HELP Model analysis (Reference 5) and parameters consistent with those used in the water balance analysis to determine the maximum hydraulic head build-up upon the barrier layer.

To complete the design requirements for the geocomposite drainage layer, a calculation, based on the methods presented in Reference 3, was performed to determine the appropriate Apparent Opening Size of the nonwoven geotextile components to prevent soil clogging of the geocomposite.

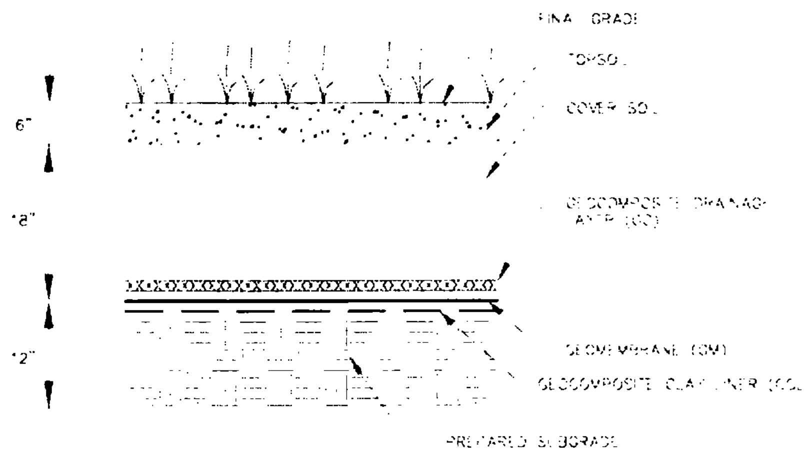
REFERENCES:

1. "The Design of Drainage Systems Over Geosynthetically Lined Slopes," GRI Report #19, R. Koerner and T.Y. Soong, 1997.
2. "Final Covers for Solid Waste Landfills and Abandoned Dumps," R. Koerner and D. Daniel, 1997.
3. "Designing with Geosynthetics," 4th edition, R. Koerner, 1998.
4. "Design Manual of Lateral Drainage Systems for Landfills," G.N. Richardson and A. Zhao, 1999.
5. "The Hydrologic Evaluation of Landfill Performance (HELP) Model," version 3.07, USEPA, 1997.
6. "The Hydrologic Evaluation of Landfill Performance (HELP) Model – Users Guide for Version 3," USEPA, 1997.
7. "Drawing 3 - Subgrade Grading Plan" Pre-Final Design Report, Golder Associates, May 2000.
8. Laboratory Testing of Anticipated Cover Soil Material, Golder Associates, April-May 1999.
9. "Tendrain 70-2," Tenax Corporation, 1999.
10. "TEX-NET Ultra TN5002/1625," Fluid Systems Inc., 2000.

ASSUMPTIONS:

1. Proposed geosynthetic cap configuration is as follows:

Golder Associates	SUBJECT: Lemon Lane Landfill – Geocomposite Design		
	Job No.: 993-6573	Made by: RSV	Date: 5/22/2000
	Ref.: Pre-Final Design Report	Checked: MFW	Sheet 3 of 29
		Reviewed: BJ	



PROPOSED CAP CONFIGURATION

NOT TO SCALE

2. Maximum proposed cap slopes will not exceed 15% with corresponding slope lengths not to exceed 100 feet.
3. Minimum proposed cap slopes will not be less than 9% with corresponding slope lengths not to exceed 200 feet.
4. During the lifetime of the cap, the cover soil could potentially saturate under severe or multiple precipitation events. Therefore, the methods of water balance analysis conservatively assume the hydraulic gradient is equal to one (unit gradient) which results in the rate of infiltration being equal to the cover soil hydraulic conductivity.
5. Assume 18 inches of cover soil with Unified Classification System soil classification of SC and having a hydraulic conductivity of 5.2×10^{-4} cm/sec (Reference 8).
6. Assume 6 inches of topsoil with USDA textural classification of loam, moderately compacted, and having a saturated hydraulic conductivity of 1.9×10^{-5} cm/sec (Reference 6). Since the topsoil hydraulic conductivity is lower than the cover soil, the infiltration (impingment) rate for the water balance analyses, and the runoff curve number for the HELP Model analysis, shall be based upon the topsoil properties.
7. For the HELP Model analysis, the following was assumed:
   a. Evapotranspiration, precipitation, temperature, and solar radiation were simulated by the model for the closest nearby city of Indianapolis, IN for a 20 year history
   b. The soil and geosynthetic layers comprising the proposed cap configuration were modeled as follows:

Layer No.	Material	HELP Classification*	Description
1	Topsoil	22	Default moderately compacted loam.
2	Cover Soil	7	Default HELP Classification chosen for hydraulic conductivity that matched laboratory testing on the anticipated Cover Soil material.
3	GC	0	Modified HELP Classification No. 20with a hydraulic conductivity of 2.67cm/sec based on the governing ultimate transmissivity from Case 1 reduced by $\Pi RF = 6$.
4	GM	36	Default 40 mil low-density polyethylene GM.
5	GCL	0	Modified HELP Classification No. 17 with hydraulic conductivity and thickness of readily available GCLs.
6	Subgrade	7	Default fine silty loam.

* - Refer to Reference 6 for a description of the classifications.

8. As otherwise stated in the calculations.

CALCULATIONS: Attached.

DEFINITIONS:

Q_{in} = rate of surface water infiltration
Q_{out} = flow capacity of the geocomposite
k_{TS} = hydraulic conductivity of the cover soil
k_{GC} = hydraulic conductivity of the geocomposite
L = maximum drainage length
A = unit cross-sectional area
i_N = hydraulic gradient for flow normal to slope = 1 (unit gradient)
i_S = hydraulic gradient for flow parallel to slope = $\sin\beta$
r = impingment rate = k_{TS}
β = slope angle
S = slope (in units of length/length)
t_{GC} = thickness of the geocomposite
Ψ_{req} = required geocomposite transmissivity = $(k_{GC})(t_{GC})$
Ψ_{ult} = ultimate geocomposite transmissivity
FS_{global} = overall factor-of-safety for the design
RF_{in} = reduction factor for geotextile intrusion
RF_{cr} = reduction factor for creep
RF_{cc} = reduction factor for chemical clogging
RF_{bc} = reduction factor for biological clogging
ΠRF = $FS_{global} \times RF_{in} \times RF_{cr} \times RF_{cc} \times RF_{bc}$

CONCLUSIONS: Based on the methodology and assumptions stated herein, an ultimate transmissivity of the geocomposite drainage layer of 8.2×10^{-4} m^2/sec is required. The required ultimate transmissivity is governed by the analysis for Case 1 where the slopes are at 9% and limited to a length of 200 feet. If during construction slopes are proposed to be constructed at less than 9% or at lengths in excess of 200 feet, than this analysis would need to be revised by the Engineer prior to construction.

HELP Model analysis using the prescribed soil and geosynthetic layers defined herein with a geocomposite hydraulic conductivity of 2.67 cm/sec, based on an allowable transmissivity of 1.36×10^{-4} m^2/sec, produced a maximum head build up on top of the barrier layer of 2.3 inches. This is considered to be acceptable and a conservative estimate of the head generation when considering conservative assumption of the analysis, recall ΠRF = 6 was used to calculate the allowable hydraulic conductivity.

In addition to an ultimate transmissivity of the geocomposite of 8.2×10^{-4} m^2/sec, the required Apparent Opening Size (AOS) for the geotextiles bonded to either side of the geonet core to form the composite was assessed and determined to be a minimum of 70.

Based on available manufacture's product data sheets, a geocomposite drainage layer material with ultimate transmissivity of 8.2×10^{-4} cm/sec and an AOS of at least 70 is readily available.

WATER BALANCE ANALYES – CASES 1 & 2

* WATER BALANCE - CONSIDERS CONSERVATIVELY NO HEAD BUILD-UP ON THE BARRIER LAYER

- USING WATER BALANCE METHODOLOGY:

$$Q_{IN} = Q_{OUT}$$

- INFILTRATING SURFACE WATER INTO A UNIT WIDTH OF GEOCOMPOSITE IS GIVEN BY

$$Q_{IN} = k_{TS} \, L \, i_{N}$$

BUT $i_N = 1$ → UNIT GRADIENT WHEN THE SOIL IS SATURATED

- FLOW CAPACITY OF THE GEOCOMPOSITE IS FOUND USING DARCY'S LAW:

$$\begin{aligned} Q_{OUT} &= k_{GC} \, i_S \, A \\ &= k_{GC} \, i_S \left[(t_{GC})(1') \right] \\ &= (k_{GC} \, t_{GC}) \, i_S \\ &= \psi_{REQ} \sin\beta \end{aligned}$$

WHERE $i_S = \sin\beta$
$\psi_{REQ} = k_{GC} \, t_{GC}$

- FOR DESIGN A SAFETY FACTOR MUST BE INCORPORATED:

$$\Pi RF \, Q_{IN} = Q_{OUT}$$

$$\Pi RF \left[k_{TS} \, L \, i_N \right] = \psi_{REQ} \sin\beta \qquad \text{BUT } i_N = 1$$

$$(\psi_{REQ})_{ULT.} = \frac{\Pi RF \left[k_{TS} \, L \right]}{\sin\beta}$$

* THE ADDITION OF A SAFETY FACTOR INCREASES THE MIN. REQUIRED TRANSMISSIVITY, ψ_{REQ}, TO SATISFY THE DESIGN, I.E., $Q_{IN} = Q_{OUT}$, TO THE ULTIMATE REQUIRED TRANSMISSIVITY, $(\psi_{REQ})_{ULT}$ OR SIMPLY ψ_{ULT}.

- DETERMINE ΠRF (REFERENCES 1 AND 3)

$$\Pi RF = FS_{GLOBAL} \times RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC}$$

FROM REFERENCE 3, TABLE 4.2, PAGE 403:

REDUCTION FACTOR	RANGE	USE
RF_{IN}	1.3-1.5	1.5
RF_{CR}	1.1-1.4	1.25
RF_{CC}	1.0-1.2	1.1
RF_{BC}	1.2-1.5	1.35

FOR FS_{GLOBAL}, 2 IS A COMMON VALUE

$$\therefore \Pi RF = 2 \times 1.5 \times 1.25 \times 1.1 \times 1.35$$

$$= 5.57$$

SAY $\underline{\Pi RF = 6}$

- ASSESS DESIGN SLOPES:

• CASE 1 — 9% AND 200' LENGTHS

$$\psi_{ULT} = \frac{6\left[(2\times10^{-7}\,M/s)(200')(0.3048\,M/ft)\right]}{\sin 5.14^\circ}$$

WHERE: $k_{TS} = 1.9\times10^{-5}$ cm/sec
$\therefore$ SAY $= 2\times10^{-7}$ M/sec
$\beta = \tan^{-1}\frac{100(0.09)}{100} = 5.14^\circ$

GOVERNS → $\underline{\psi_{ULT} = 8.16\times10^{-4}\ m^2/sec}$

• CASE 2 — 15% AND 100' LENGTHS

$$\psi_{ULT} = \frac{6\left[(2\times10^{-7}\,M/s)(100')(0.3048\,M/ft)\right]}{\sin 8.53^\circ}$$

WHERE $\beta = \tan^{-1}\frac{100(0.15)}{100}$
$= 8.53^\circ$

$\underline{\psi_{ULT} = 2.47\times10^{-4}\ m^2/sec}$

HELP MODEL ANALYSIS – CASE 3

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


PRECIPITATION DATA FILE:      D:\LLL\CASE1\DATA4.D4
TEMPERATURE DATA FILE:        D:\LLL\CASE1\DATA7.D7
SOLAR RADIATION DATA FILE:    D:\LLL\CASE1\DATA13.D13
EVAPOTRANSPIRATION DATA:      D:\LLL\CASE1\DATA11.D11
SOIL AND DESIGN DATA FILE:    D:\LLL\CASE1\DATA10.D10
OUTPUT DATA FILE:             D:\LLL\CASE1\LLLCASE1.OUT


TIME:  12:09     DATE:   5/23/2000


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

     TITLE:  LEMON LANE LANDFILL - 9% SLOPES AT 200 FT. LENGTH

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


     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  22
          THICKNESS                   =       6.00   INCHES
          POROSITY                    =       0.4190 VOL/VOL
          FIELD CAPACITY              =       0.3070 VOL/VOL
          WILTING POINT               =       0.1800 VOL/VOL
          INITIAL SOIL WATER CONTENT  =       0.4057 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =   0.189999992000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2831	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0136	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	2.67000008000	CM/SEC ← SEE Pg. 18
SLOPE	=	9.00	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 4

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	=	5.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	5.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.25	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.	=	0.999999994000E-08	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1961	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #22 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 9.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	90.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	6.000	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.628	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.136	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.536	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	10.073	INCHES
TOTAL INITIAL WATER	=	10.073	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM INDIANAPOLIS INDIANA

STATION LATITUDE	=	39.73	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	107	
END OF GROWING SEASON (JULIAN DATE)	=	293	
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	75.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR INDIANAPOLIS INDIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.65	2.46	3.61	3.68	3.66	3.99
4.32	3.46	2.74	2.51	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR INDIANAPOLIS INDIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
26.00	29.90	40.00	52.40	62.50	71.60
75.10	73.20	66.60	54.80	41.80	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR INDIANAPOLIS INDIANA
AND STATION LATITUDE = 39.73 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.47	2.79	3.82	3.21	4.10	3.91
	4.28	3.19	2.81	1.95	2.81	2.88
STD. DEVIATIONS	1.28	1.23	1.87	1.72	2.27	2.15
	1.87	1.89	1.33	1.28	1.34	1.04
RUNOFF						
TOTALS	1.097	1.727	2.260	0.202	0.346	0.452
	0.447	0.343	0.362	0.127	0.273	0.617
STD. DEVIATIONS	1.146	0.810	2.188	0.261	0.536	0.617
	0.534	0.532	0.389	0.196	0.455	0.672
EVAPOTRANSPIRATION						
TOTALS	0.450	0.474	1.576	3.278	3.641	4.608
	3.465	3.055	2.006	1.211	0.935	0.575
STD. DEVIATIONS	0.188	0.212	0.490	0.687	1.346	1.328
	1.163	1.347	0.721	0.460	0.229	0.135

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.1875	0.1161	1.8347	0.9149	0.2391	0.1687
	0.0023	0.0007	0.0244	0.1064	0.3895	0.7237
STD. DEVIATIONS	0.3258	0.3710	0.7105	0.6832	0.3337	0.2831
	0.0088	0.0012	0.0938	0.2619	0.6828	0.7808

PERCOLATION/LEAKAGE THROUGH LAYER 5

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

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0012	0.0015	0.0037	0.0045	0.0026	0.0021
	0.0010	0.0007	0.0007	0.0011	0.0016	0.0026
STD. DEVIATIONS	0.0016	0.0056	0.0053	0.0038	0.0031	0.0026
	0.0015	0.0009	0.0005	0.0026	0.0018	0.0038

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0009	0.0006	0.0232	0.0045	0.0011	0.0008
	0.0000	0.0000	0.0001	0.0005	0.0019	0.0035
STD. DEVIATIONS	0.0016	0.0020	0.0227	0.0034	0.0016	0.0014
	0.0000	0.0000	0.0005	0.0013	0.0034	0.0037

****

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.23	(6.116)	832649.5	100.00
RUNOFF	8.251	(2.8837)	179704.72	21.582
EVAPOTRANSPIRATION	25.272	(3.5144)	550432.94	66.106
LATERAL DRAINAGE COLLECTED FROM LAYER 3	4.70784	(1.43979)	102536.766	12.31452
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.073	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.003	(0.002)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.02338	(0.02549)	509.165	0.06115
CHANGE IN WATER STORAGE	-0.025	(0.9434)	-534.26	-0.064

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	4.55	99099.008
RUNOFF	2.583	56256.7305
DRAINAGE COLLECTED FROM LAYER 3	0.81384	17725.47270
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000004	0.08533
AVERAGE HEAD ON TOP OF LAYER 4	1.992	
MAXIMUM HEAD ON TOP OF LAYER 4	2.302	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	6.3 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000986	21.47913
SNOW WATER	4.56	99285.8516

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3801
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1268

*** 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	1.9311	0.3219
2	5.5738	0.3097
3	0.0045	0.0226
4	0.0000	0.0000
5	0.1875	0.7500
6	1.8854	0.1571
SNOW WATER	0.000	

****
****

DETERMINE k_{GC} FOR MODELING LAYER 3:

GOVERNING $(\psi_{GC})_{ULT} = 8.16 \times 10^{-4}\ m^2/s$ CASE 1

$$(\psi_{GC})_{ALLOW} = (\psi_{GC})_{ULT} / \Pi RF$$

$$(\psi_{GC})_{ALLOW} = \frac{8.16 \times 10^{-4}\ m^2/s}{6} = 1.36 \times 10^{-4}\ m^2/s$$

BUT, $\psi_{GC} = k_{GC}\, t_{GC}$

SO, $k_{GC} = \psi_{GC} / t_{GC}$

$$\therefore \quad k_{GC} = \frac{(1.36 \times 10^{-4}\ m^2/s)(10{,}000\ cm^2/m^2)}{0.2\ in\ (2.54\ cm/in)}$$

$$k_{GC} = 2.67\ cm/sec$$

APPARENT OPENING SIZE

CHECK SOIL RETENTION:

- LOWER GEOTEXTILE IN CONTACT WITH GEOMEMBRANE AND THEREFORE NOT APPLICABLE TO CHECK
- UPPER GEOTEXTILE MUST RETAIN COVER SOIL. THEREFORE CHECK.

FROM REFERENCE #3 PG 86

$$O_{95} < (2 \text{ or } 3)\, d_{85} \quad \text{CARROLL EQUATION}$$

WHERE O_{95} = 95% OPENING SIZE OF GEOTEXTILE

d_{85} = SOIL PARTICLE SIZE (mm) FOR WHICH 85% IS FINER

THE GRADATION OF THE ANTICIPATED COVER SOIL MATERIAL IS AS ATTACHED (REFERENCE #8) WITH d_{85} = 8.0 mm

$$\therefore \quad O_{95} < 2(8.0\text{mm})$$

$$O_{95} < 16.0 \text{ mm}$$

$\therefore$ APPARENT OPENING SIZE (AOS) ≥ 3/4" US STD. SIEVE (19.0 mm)

TYPICAL GEOTEXTILES HAVE AOS OF #70 OR #80 US STD. SIEVES. (REFERENCE #9 & 10)

$\therefore$ AOS = #70 = 0.21 mm = O_{95}
AOS = #80 = 0.18 mm = O_{95}

AND O_{95} = 0.21 mm < 16.0 mm

$\therefore$ A GEOCOMPOSITE WITH AN UPPER GEOTEXTILE WITH AOS = #70 IS ACCEPTABLE PROVIDED THE ANTICIPATED COVER SOIL IS USED.

REFERENCES

REFERENCE #6

TABLE 4. DEFAULT SOIL, WASTE, AND GEOSYNTHETIC CHARACTERISTICS

Classification			Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP	USDA	USCS	vol/vol	vol/vol	vol/vol	cm/sec
1	CoS	SP	0.417	0.045	0.018	1.0×10^{-2}
2	S	SW	0.437	0.062	0.024	5.8×10^{-3}
3	FS	SW	0.457	0.083	0.033	3.1×10^{-3}
4	LS	SM	0.437	0.105	0.047	1.7×10^{-3}
5	LFS	SM	0.457	0.131	0.058	1.0×10^{-3}
6	SL	SM	0.453	0.190	0.085	7.2×10^{-4}
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-4}
8	L	ML	0.463	0.232	0.116	3.7×10^{-4}
9	SiL	ML	0.501	0.284	0.135	1.9×10^{-4}
10	SCL	SC	0.398	0.244	0.136	1.2×10^{-4}
11	CL	CL	0.464	0.310	0.187	6.4×10^{-5}
12	SiCL	CL	0.471	0.342	0.210	4.2×10^{-5}
13	SC	SC	0.430	0.321	0.221	3.3×10^{-5}
14	SiC	CH	0.479	0.371	0.251	2.5×10^{-5}
15	C	CH	0.475	0.378	0.265	1.7×10^{-5}
16	Barrier Soil		0.427	0.418	0.367	1.0×10^{-7}
17	Bentonite Mat (0.6 cm)		0.750	0.747	0.400	3.0×10^{-9}
18	Municipal Waste (900 lb/yd^3 or 312 kg/m^3)		0.671	0.292	0.077	1.0×10^{-3}
19	Municipal Waste (channeling and dead zones)		0.168	0.073	0.019	1.0×10^{-3}
20	Drainage Net (0.5 cm)		0.850	0.010	0.005	$1.0\times10^{+1}$
21	Gravel		0.397	0.032	0.013	3.0×10^{-1}
22	L*	ML	0.419	0.307	0.180	1.9×10^{-5}
23	SiL*	ML	0.461	0.360	0.203	9.0×10^{-6}
24	SCL*	SC	0.365	0.305	0.202	2.7×10^{-6}
25	CL*	CL	0.437	0.373	0.266	3.6×10^{-6}
26	SiCL*	CL	0.445	0.393	0.277	1.9×10^{-6}
27	SC*	SC	0.400	0.366	0.288	7.8×10^{-7}
28	SiC*	CH	0.452	0.411	0.311	1.2×10^{-6}
29	C*	CH	0.451	0.419	0.332	6.8×10^{-7}
30	Coal-Burning Electric Plant Fly Ash*		0.541	0.187	0.047	5.0×10^{-5}
31	Coal-Burning Electric Plant Bottom Ash*		0.578	0.076	0.025	4.1×10^{-3}
32	Municipal Incinerator Fly Ash*		0.450	0.116	0.049	1.0×10^{-2}
33	Fine Copper Slag*		0.375	0.055	0.020	4.1×10^{-2}
34	Drainage Net (0.6 cm)		0.850	0.010	0.005	$3.3\times10^{+1}$

* Moderately Compacted

(Continued)

Reference #6 23 of 29

TABLE 4 (continued). DEFAULT SOIL, WASTE, AND GEOSYNTHETIC CHARACTERISTICS

Classification		Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP	Geomembrane Material	vol/vol	vol/vol	vol/vol	cm/sec
35	High Density Polyethylene (HDPE)				$2.0x10^{-13}$
36	Low Density Polyethylene (LDPE)				$4.0x10^{-13}$
37	Polyvinyl Chloride (PVC)				$2.0x10^{-11}$
38	Butyl Rubber				$1.0x10^{-12}$
39	Chlorinated Polyethylene (CPE)				$4.0x10^{-12}$
40	Hypalon or Chlorosulfonated Polyethylene (CSPE)				$3.0x10^{-12}$
41	Ethylene-Propylene Diene Monomer (EPDM)				$2.0x10^{-12}$
42	Neoprene				$3.0x10^{-12}$

(concluded)

user-defined soil option accepts non-default soil characteristics for layers assigned soil type numbers greater than 42. This is especially convenient for specifying characteristics of waste layers. User-specified soil characteristics can be assigned any soil type number greater than 42.

When a default soil type is used to describe the top soil layer, the program adjusts the saturated hydraulic conductivities of the soils in the top half of the evaporative zone for the effects of root channels. The saturated hydraulic conductivity value is multiplied by an empirical factor that is computed as a function of the user-specified maximum leaf area index. Example values of this factor are 1.0 for a maximum LAI of 0 (bare ground), 1.8 for a maximum LAI of 1 (poor stand of grass), 3.0 for a maximum LAI of 2 (fair stand of grass), 4.2 for a maximum LAI of 3.3 (good stand of grass) and 5.0 for a maximum LAI of 5 (excellent stand of grass).

The manual option requires values for porosity, field capacity, wilting point, and saturated hydraulic conductivity. These and related soil properties are defined below.

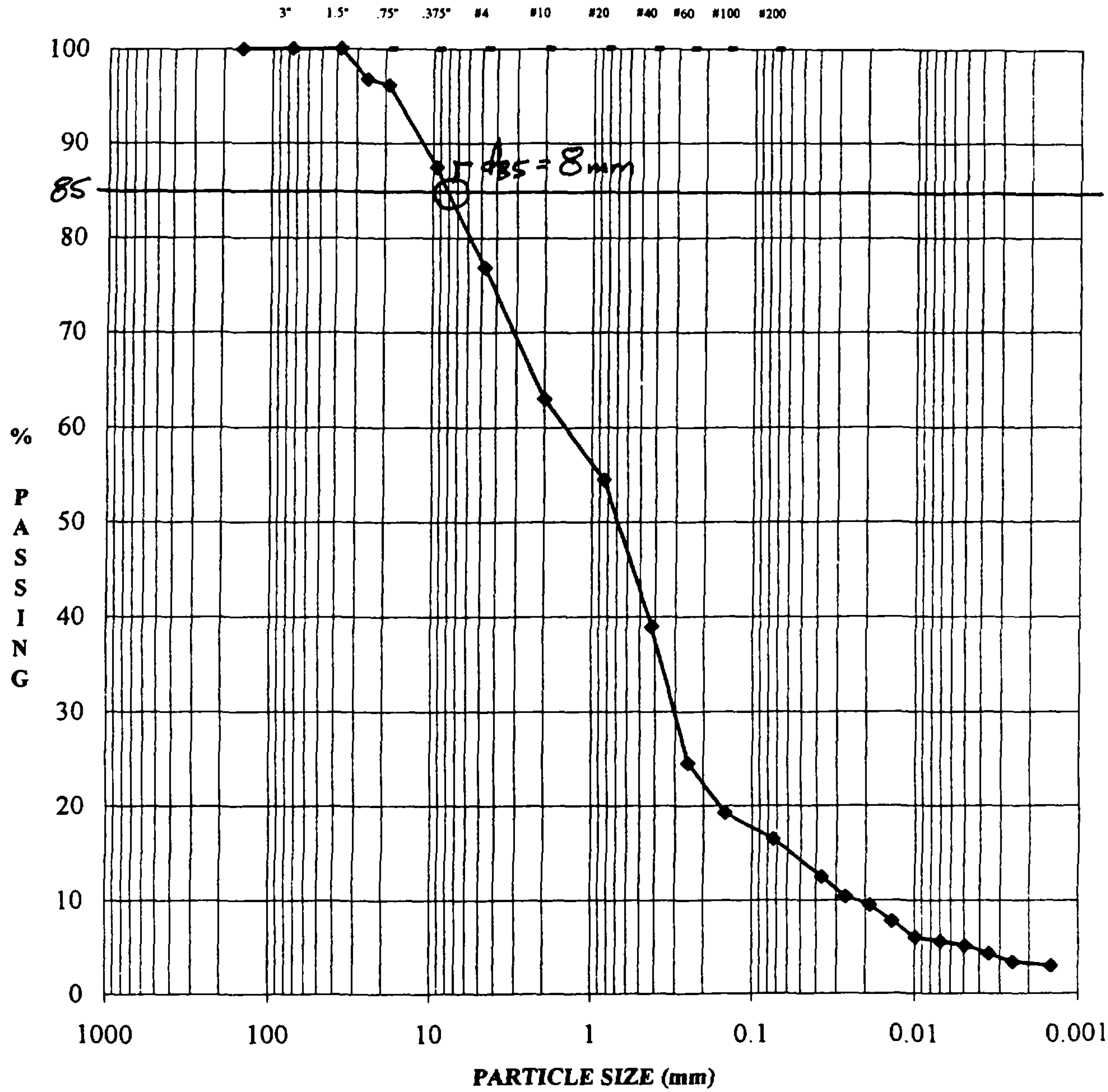
Soil Water Storage (Volumetric Content): the ratio of the volume of water in a soil to the total volume occupied by the soil, water and voids.

Total Porosity: the soil water storage/volumetric content at saturation (fraction of total volume).

REFERENCE #8

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422

US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLE	GRAVEL		SAND			FINES

SAMPLE #:	BS-1	Mc:	6.03%		DATE:	2/4/00
		Gs:	2.65	(ASSUMED)	TECH:	RDD
		Atterberg Limits			REVIEW:	RMW
WET COLOR:	Strong brown	LL:	27			
DESCRIPTION:	Clayey sand with gravel (SC)	PL:	18			
		PI :	9			

CBS/LEMON LANE LANDFILL/IN
993-6573.0210

GOLDER ASSOCIATES INC.
CHERRY HILL, NEW JERSEY

MEASUREMENT OF HYDRAULIC CONDUCT. .TY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER (ASTM D 5084)
METHOD C, FALLING HEAD WITH INCREASING TAILWATER LEVEL

Reference #8

CBS/LEMON LANE LF/IN	**SAMPLE #:** BS-1 #1	**TYPE:** REMOLD	**TECH** JMP
993-6573	@ 5 psi		**REVIEW** RMW

SAMPLE DATA, INITIAL / **SAMPLE DATA, FINAL**

height, cm	10.080	B-value	0.95	height, cm	10.504
diameter, cm	10.193	cell pressure, psi	95.00	diameter, cm	10.030
area, cm^2	81.60	bottom pressure, psi	90.00	area, cm^2	79.01
volume, cm^3	822.54	top pressure, psi	90.00	volume, cm^3	829.94
weight, g	1609.78	head, cm	0	weight, g	1693.17
% moisture	10.38	maximum gradient	1.19	% moisture	15.16
dry density, pcf	110.63	minimum gradient	0.38	dry density, pcf	110.55
volume solids, cm^3	542.13	total back pressure, psi	90.00	volume solids, cm^3	546.59
volume voids, cm^3	280.40	maximum effective stress	5.0	volume voids, cm^3	283.35
void ratio	0.52	minimum effective stress	5.0	void ratio	0.52
% saturation	54.01	specific gravity	2.69	% saturation	78.65

$$k = \frac{a\ L_f}{2\ A\ t} \ln(h_1/h_2)$$

a =	0.94	cm^2	
L_f =	10.50	cm	
A_f =	79.01	cm^2	
t =	15	sec	** Reading #4
h_1/h_2 =	1.34	cm	** Reading #4
k =	1.2E-03	cm/sec	** Reading #4

TIME FUNCTION						READINGS						
Date	Hour	Minute	dt,elapsed (min)	dt,elapsed (sec)	dt,reading (sec)	Inflow (cm^3)	Outflow (cm^3)	Head (cm)	(h_1/h_2) (inc.)	Gradient	Permeability (cm/sec)	Reading
4/28/00	20	24	0	0	0	14.0	26.0	12.51		1.19		
4/28/00	20	24	0.25	15	15	15.3	24.6	9.61	1.30	0.92	1.1E-03	#1
4/28/00	20	24	0.5	30	15	16.4	23.5	7.29	1.32	0.69	1.2E-03	#2
4/28/00	20	24	0.75	45	15	17.3	22.6	5.39	1.35	0.51	1.3E-03	#3
4/28/00	20	25	1	60	15	18.0	22.0	4.02	1.34	0.38	1.2E-03	** #4

INFLOW RATE, cm^3/sec	6.75E-02	**PERMEABILITY REPORTED AS**	**1.2E-03**	**AVG**
OUTFLOW RATE, cm^3/sec	6.67E-02			
INFLOW / OUTFLOW RATIO	1.01			

GOLDER ASSOCIATES INC.
CHERRY HILL, NEW JERSEY

COMMENTS:

25 of 29

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER (ASTM D 5084)
METHOD C, FALLING HEAD WITH INCREASING TAILWATER LEVEL

REFERENCE #8

CBS/LEMON LANE LF/IN	SAMPLE #:	BS-1 #2	TYPE: REMOLD	TECH	JMP
993-6573		@ 5 psi		REVIEW	RMW

SAMPLE DATA, INITIAL / **SAMPLE DATA, FINAL**

height, cm	9.991	B-value	0.93	height, cm	10.02
diameter, cm	10.217	cell pressure, psi	95.00	diameter, cm	10.190
area, cm^2	81.99	bottom pressure, psi	90.00	area, cm^2	81.55
volume, cm^3	819.12	top pressure, psi	90.00	volume, cm^3	817.16
weight, g	1741.04	head, cm	0	weight, g	1795.31
% moisture	10.38	maximum gradient	2.60	% moisture	13.06
dry density, pcf	120.15	minimum gradient	1.67	dry density, pcf	121.25
volume solids, cm^3	586.34	total back pressure, psi	90.00	volume solids, cm^3	590.29
volume voids, cm^3	232.78	maximum effective stress	5.0	volume voids, cm^3	226.87
void ratio	0.40	minimum effective stress	5.0	void ratio	0.38
% saturation	70.36	specific gravity	2.69	% saturation	91.43

$$k = \frac{a\,L_f}{2\,A\,t}\ln(h_1/h_2)$$

a =	0.94	cm^2	
L_f =	10.02	cm	
A_f =	81.55	cm^2	
t =	60	sec	** Reading #4
h_1/h_2 =	1.28	cm	** Reading #4
k =	2.4E-04	cm/sec	** Reading #4

TIME FUNCTION						READINGS						
Date	Hour	Minute	dt,elapsed (min)	dt,elapsed (sec)	dt,reading (sec)	Inflow (cm^3)	Outflow (cm^3)	Head (cm)	(h_1/h_2) (inc.)	Gradient	Permeability (cm/sec)	Reading
5/2/00	17	1	0	0	0	11.8	36.7	26.03		2.60		
5/2/00	17	1	0.25	15	15	12.6	36.0	24.44	1.06	2.44	2.4E-04	#1
5/2/00	17	1	0.5	30	15	13.4	35.3	22.86	1.07	2.28	2.6E-04	#2
5/2/00	17	1	0.75	45	15	14.1	34.6	21.38	1.07	2.13	2.6E-04	#3
5/2/00	17	2	1.75	105	60	16.6	32.7	16.74	1.28	1.67	2.4E-04	** #4

INFLOW RATE, cm^3/sec	4.57E-02
OUTFLOW RATE, cm^3/sec	3.81E-02
INFLOW / OUTFLOW RATIO	1.20

PERMEABILITY REPORTED AS **2.5E-04** AVG

GOLDER ASSOCIATES INC.
CHERRY HILL, NEW JERSEY

COMMENTS:

26 OF 29

REFERENCE #8

FROM LABORATORY FLEXIBLE WALL PERMEAMETER TESTING:

COVER SOIL @ 85% STD. PROCTOR:

$$k = 1.2 \times 10^{-3} \text{ cm/sec}$$

COVER SOIL @ 92% STD. PROCTOR:

$$k = 2.5 \times 10^{-4} \text{ cm/sec}$$

ANTICIPATED CAP COMPACTION DURING CONSTRUCTION IS 90% STD. PROCTOR.

$\therefore$ ASSUME LINEAR INTERPOLATION VALID

$$\frac{2.5 \times 10^{-4} \text{ cm/sec} - 1.2 \times 10^{-3} \text{ cm/sec}}{92\% - 85\%} = -1.36 \times 10^{-4} \frac{\text{cm/sec}}{\%}$$

$$k_{90} = 1.2 \times 10^{-3} \text{ cm/sec} + 5\%\left(-1.36 \times 10^{-4} \frac{\text{cm/sec}}{\%}\right)$$

$$\underline{\underline{k_{90} = 5.2 \times 10^{-4} \text{ cm/sec}}}$$

TENDRAIN 70-2

DOUBLE-SIDED GEOCOMPOSITE (GEOTEXTILE - TRI-PLANAR GEONET -GEOTEXTILE)

The drainage geocomposite is comprised of a tri-planar geonet structure consisting of thick supporting ribs with diagonally placed top and bottom ribs and with a thermally bonded, non-woven geotextile on both sides. The product is capable of providing high flow rates in a soil environment under high normal loads and will have properties conforming with the values and test methods listed below:

PROPERTIES	TEST METHOD	UNIT	VALUE	QUALIFIER
GEONET CORE				
Tensile Strength - MD	ASTM D4595	lb/ft (kN/m)	1000 (14.6)	c, Note 1
Compressive Behavior (% Retained thickness)				
@50,000 psf (short term)	ASTM D1621	%	50	a, Note 2
@25,000 psf (5,000 hours)		%	50	a
Resin Density	ASTM D1505	g/cm^3	0.94	c
Resin Melt Index	ASTM D1238	g/10 min.	1.0	d
Carbon Black Content	ASTM D4218	%	2.0	c
Thickness	ASTM D5199	mils (mm)	300 (7.6)	c, Note 3
GEOTEXTILE				
Apparent Opening Size (AOS)	ASTM D4751	US Sieve (mm)	70 (0.21)	b, Note 4
Weight	ASTM D3776	oz/yd^2 (g/m^2)	6 (203)	b, Note 4
Thickness	ASTM D5199	mils (mm)	55 (1.4)	b, Note 4
Water Flow Rate	ASTM D4491	$gal/min/ft^2$ (lpm/m^2)	90 (3668)	b, Note 4
Permeability	ASTM D4491	cm/sec	0.24	b, Note 4
Permittivity	ASTM D4491	sec^{-1}	1.3	b, Note 4
Puncture Strength	ASTM D4833	lbs (N)	90 (400)	b, Note 4
Trapezoid Tear	ASTM D4533	lbs (N)	65 (290)	b, Note 4
Grab Tensile Strength	ASTM D4632	lbs (N)	160 (712)	b, Note 4
Grab Elongation	ASTM D4632	%	50	b, Note 4
Mullen Burst	ASTM D3786	psi (kPa)	325 (2241)	b, Note 4
UV Resistance @500 Hours	ASTM D4355	%	70	b, Note 4
GEOCOMPOSITE				
Roll Width		ft (m)	6.7 (2.0)	a, Note 5
Roll Length		ft (m)	200 (61)	a, Note 5
Ply Adhesion	ASTM D413	lb/in (N/m)	1.0 (175)	c, Note 6

HYDRAULIC BEHAVIOR OF GEOCOMPOSITE IN SOIL

Transmissivity - MD (X 10^{-4} ~~m^2/sec) ASTM D 4716-95~~ — c, Notes 7 8

Gradient/Load:	15,000 psf (720 kPa)	25,000 psf (900 kPa)
0.1	22.5	10.0
0.5	12.0	5.0
1	8.0	4.0

Flow Rate Per Unit Width - MD gpm/ft (lpm/m) ASTM D 4716-95 — c, Notes 7 8

Gradient/Load:	15,000 psf (720 kPa)		25,000 psf (900 kPa)	
0.1	1.1	(13.65)	0.5	(6.20)
0.5	2.9	(36.00)	1.2	(14.90)
1	3.9	(48.40)	1.9	(23.60)

Qualifiers: a = Typical Value b = Minimum Average Roll Value (MARV)
c = Minimum Value d = Maximum Value

NOTES:

1. Tensile properties tested by manufaaturer every 40,000 square feet of product per ASTM D4595 with a specimen width of 8.0 in. and cross-head speed of 0.04 in/min
2. Compression behavior tested by manufacturer every 40,000 square feet of product per ASTM D1621 with a 2 in. x 2 in. specimen and a constant rate of strain of 0.04 in./min.
3. Thickness measured by manufacturer every 40,000 square feet of product per ASTM D5199 with a 2.22 in. diameter presser foot and 2.9 psi pressure.
4. Geotextile properties listed are prior to lamination.
5. Roll dimensions are measured at the time of manufacture.
6. Ply adhesion tested by manufacturer every 40,000 square feet of product per ASTM D413 with a 2 in. wide strip where the geotextile bonded to either side of the geonet is pulled apart at a speed of 2.0 in/min. The value reported for each laminated side is the average of the peak values from 5 specimens. Both the top and bottom geotextile interfaces are evaluated.
7. Geocomposite transmissivity measured by manufacturer every 100,000 square feet of product as per ASTM D4716-95 with testing boundary conditions as follows: steel plate / uniform sand / geocomposite / 60 mil HDPE geomembrane / steel plate
8. 4831 gpm/ft = 1 m^2/sec

REFERENCE #10

29 OF 29

FLUID SYSTEMS

Check out our TEX-NET Ultra Specification Sheets!

TEX-NET® ULTRA

TEX-NET® ULTRA TN5002/1625 SPECIFICATIONS

TEX-NET Ultra TN5002/1625 is a high flow geocomposite manufactured by heat bonding Trevira® needlepunched polyester geotextiles to two sides of a POLY-NET PN5000 HDPE geonet core. TEX-NET Ultra TN5002/1625 conforms to the property values listed in the following tables.

GEOCOMPOSITE PROPERTIES			
PROPERTY	**TEST**	**UNITS**	**MINIMUM[2]**
			TN5002/1625
Transmissivity[1]	ASTM D 4716	m^2/sec	1,000 psf - 2 x 10^{-3} 10,000 psf - 1 x 10^{-3}
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0
Tensile Strength (MD)	ASTM D 4632	lbs	500
COMPONENT PROPERTIES[3]			
GEONET	**TEST**	**UNITS**	**MINIMUM[2] PN 5000**
Polymer Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.250
Mass Per Unit Area	ASTM D 5261	lbs/ft^2	0.20
Tensile Strength	ASTM D 5035	lbs/in	50
GEOTEXTILE	**TEST**	**UNITS**	**MINIMUM[2] 1625**
Fabric Weight	ASTM D 5261	oz/yd^2	7.1
Grab Strength	ASTM D 4632	lbs	205
Puncture Resistance	ASTM D 4833	lbs	95
Water Flow Rate	ASTM D 4491	gpm/ft^2	95
AOS	ASTM D 4751	Sieve Size	100 > 70 OK

1. Measured using water @ 20° C (68°F) with a gradient of 0.1, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific Laboratory.
2. These values represent minimum acceptable test values for a roll as tested according to FSI's Manufacturing Quality Control Manual. Individual test specimen values are not addressed in this specification.
3. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

APPENDIX C

GEOSYNTHETIC TEST RESULTS AND CALCULATIONS

APPENDIX C1
CAP GEOSYNTHETIC TEST RESULTS

July 2000

SUMMARY OF DIRECT SHEAR TEST RESULTS

CBS

LEMON LANE LF

INDIANA

993-6573

SAMPLE DESIGNATION	Reference Value	GC VS SAND (LL BEDDING	GCL VS CLAY (LL-WEST)	GCL VS SOIL (IMPORTED)	GC vs GM vs GCL	-	-	-	-	-
DIRECT SHEAR										
Friction Angle (°)										
Peak	-	38.4	28.6	34.7	35.4	-	-	-	-	-
Residual @ 3 in	-	36.7	27.2	36.8	23.3	-	-	-	-	-
Adhesion (psf)										
Peak	-	0.0	71.9	13.7	0.0	-	-	-	-	-
Residual @ 3 in	-	0.0	139.4	8.1	40.0	-	-	-	-	-
ASTM D5321										

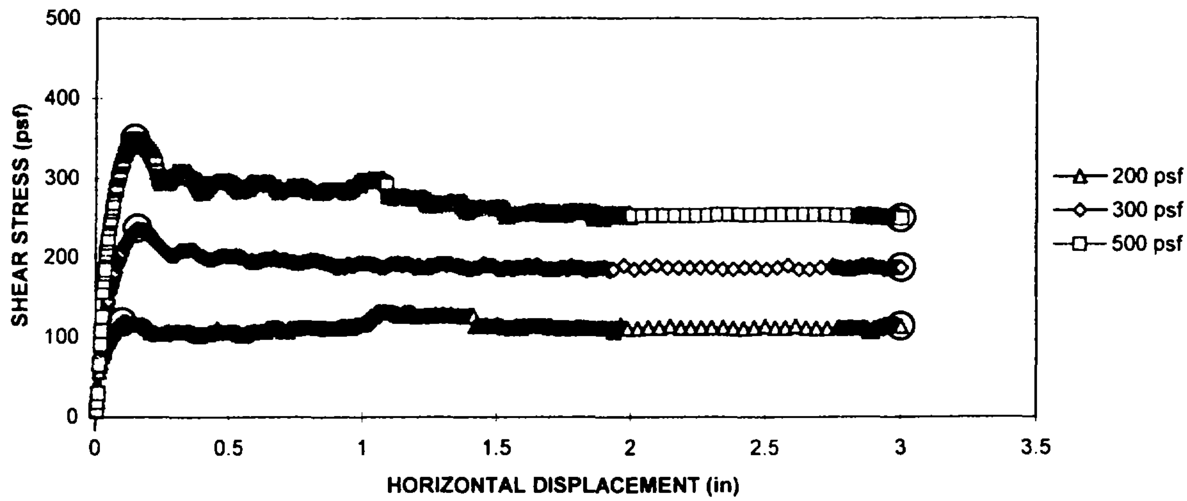
NOTE: The test results relate only to the samples and laboratory conditions tested. GAI neither accepts responsibility for nor makes claim as to the final use and purpose of the material.

JULY 2000 | 993-6573

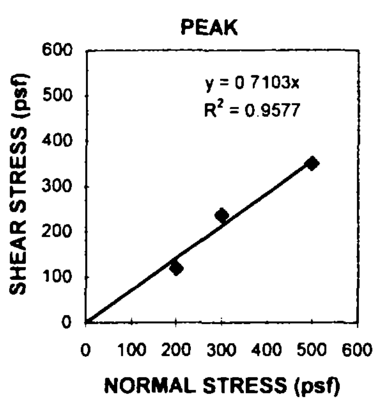
DIRECT SHEAR TEST RESULTS

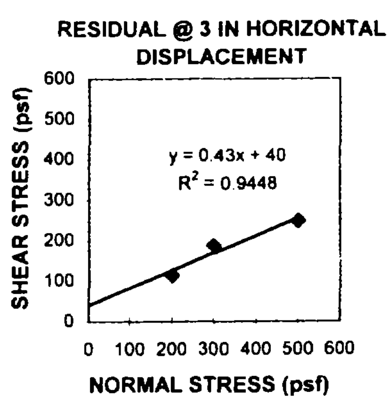
PROJECT NAME: CBS / LEMON LANE LF / IN
SAMPLE NUMBER: GEOCOMPOSITE VS GEOMEMBRANE VS GCL

INTERFACE TESTED: GEOCOMPOSITE VS GEOMEMBRANE VS GCL (FLOATING SYSTEM)
SOIL CONDITIONS: NO SOIL
TEST CONDITIONS: SATURATED AND CONSOLIDATED 15 MINUTES PRIOR TO SHEAR
SHEAR RATE: 0.04 IN/MIN
SUBSTRATE: POROUS PVC PLATES



Normal Stress psf	Shear Stress Peak[1] psf	Shear Stress Residual psf	Peak Friction Angle	Peak Adhesion[2] psf	Residual Friction Angle	Residual Adhesion[2] psf	GCL Final Moisture %
200	119	114					109.0
300	237	187	35.4	0.0	23.3	40.0	106.1
500	350	249					90.1





Observations After Test

200 psf: Shearing occurred between the Geocomposite and the Geomembrane.
300 psf: Shearing occurred between the Geomembrane and the GCL.
500 psf: Shearing occurred between the Geocomposite and the Geomembrane.

Material	Roll No.
Geocomposite	38380
Geomembrane	123763-00
GCL	2900

(1) The peak shear stresses for 200, 300, and 500 psf normal stresses were chosen at 0.103, 0.158, and 0.148 in horizontal displacements, respective which may not show the maximum shear stress.
(2) The adhesion (or cohesion) value is based on the "best-fit" line which may not show true adhesion.

Golder Associates Inc.

APPENDIX C2
GEOSYNTHETIC DESIGN CALCULATIONS FOR LINED BASIN

Golder Associates	SUBJECT: Lemon Lane Landfill – Pond Liner		
	Job No.: 993-6573	Made by: RSV	Date: 5/23/2000
	Ref.: Pre-Final Design Report	Checked: MFH	Sheet 1 of 12
		Reviewed: BJ	

OBJECTIVE: Considering the proposed pond liner configuration and maximum design slope of 5H:1V (11.3°), evaluate the required minimum interface friction angle to provide an acceptable factor-of-safety against veneer instability using infinite slope analysis. Geosynthetic runout/anchorage requirements will also be determined.

METHOD: Methodology based on References Nos. 1, 2, and 3 to evaluate proposed pond liner stability on maximum 5H:1V slopes. The veneer stability analysis considered three typically encountered cases as follows:

Case 1: Drained Cover Soil: Considers veneer stability of the proposed geosynthetic cap configuration without additional induced seepage forces resulting from a hydraulic head build-up upon the barrier layer.

Case 2: Partially Saturated Cover Soil with Construction Loading: Considers veneer stability of the proposed geosynthetic cap configuration with additional induced seepage forces resulting from a partial hydraulic head build-up upon the barrier layer and additional static load exerted by typical low ground pressure construction equipment.

Case 3: Partially Saturated Cover Soil: Considers veneer stability of the proposed geosynthetic cap configuration with additional induced seepage forces resulting from a partial hydraulic head build-up upon the barrier layer.

The methodology of Reference 3 was used to evaluate the required runout/anchorage length of the geosynthetic components of the liner system.

REFERENCES:

1. "Stability of Lined Slopes at Landfills and Surface Impoundments," D. H. Mitchell, M. A. McLean and T. E. Gates, EPA 600/2-89/057.
2. "Final Covers for Solid Waste Landfills and Abandoned Dumps," R. Koerner and D. Daniel, 1997.
3. "Designing with Geosynthetics," 4th edition, R. Koerner, 1998.
4. "Soil-Mechanics in Engineering Practice," 2nd edition, K. Terzaghi and R.B. Peck, 1967.
5. "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments," R. Koerner and G. N. Richardson, 1987.
6. "Interfacial Friction Study of Cap and Liner Components for Landfill Design," M. M. Koutsourais, C. J. Sprague and R. C. Pucetas, Proceedings of the 4th GRI Seminar (December 1990).

7. "Caterpillar Performance Handbook" 28th edition, Caterpillar Inc., 1997.

ASSUMPTIONS:

1. Maximum pond slopes to be constructed will not exceed 5H:1V.
2. Proposed geosynthetic cap configuration is as shown on page 9 herein.
3. Cover soil will be a predominately granular, free-draining material with a total unit weight of 115 pcf and saturated unit weight of 135 pcf. Conservatively assume that the 6-inch topsoil layer will have similar unit weights to the cover soil material.
4. Soil material placement will be with low ground pressure equipment weighing 20 tons or less.
5. No distribution of equipment loading over depth (i.e., load spreading) will be made for conservatism.
6. Infinite slope analysis is appropriate based on its conservatism (i.e., neglects additional passive toe resistance).
7. Geomembrane shall be a 40 mil textured (both sides), very flexible/linear low-density polyethylene geomembrane.
8. Adhesion (c_a) is neglected for conservatism.
9. As otherwise stated in the calculations.

CALCULATIONS: Attached.

DEFINITIONS: As defined in the calculations.

CONCLUSIONS: Based on the methodology and assumptions stated above, a minimum residual interface friction angle of 19.1° is required to satisfy a minimum factory-of-safety of 1.3 for Case 3, which is considered critical. The associated interface friction angles for each case using typically accepted factors-of-safety are presented in the following table.

Case	***Condition***	***Factor of Safety***	***Interface Friction Angle***
1	Drained	1.5	16.7°
2	Partially Saturated & Construction Load	1.3	15.4°
3	Partially Saturated	1.3	19.1°

Case 3 is considered to be the governing case due to the seepage induced forces within the partially saturated slope that reduce the stability (as compared to Cases 1 and 2). It is envisioned that the pond side slopes could become partially saturated during storm events that promote surface water collection within the pond. A factor-of-safety of 1.3 is considered appropriate for such a short-term event. That is, the slope will eventually return to drained conditions (Case 1) as evapotranspiration causes the ponded water to disperse.

The analysis of the pond conservatively assumes that the pond will not always contain ponded water, and thus, neglects any hydrostatic resistance offered by ponded water. As such, the analysis models the pond slopes as conventional side slopes via infinite slope analysis. Infinite slope analysis is a conservative approach to modeling slopes because the analysis neglects passive resisting forces generated by the slope's toe, which increases the factor of safety against instability.

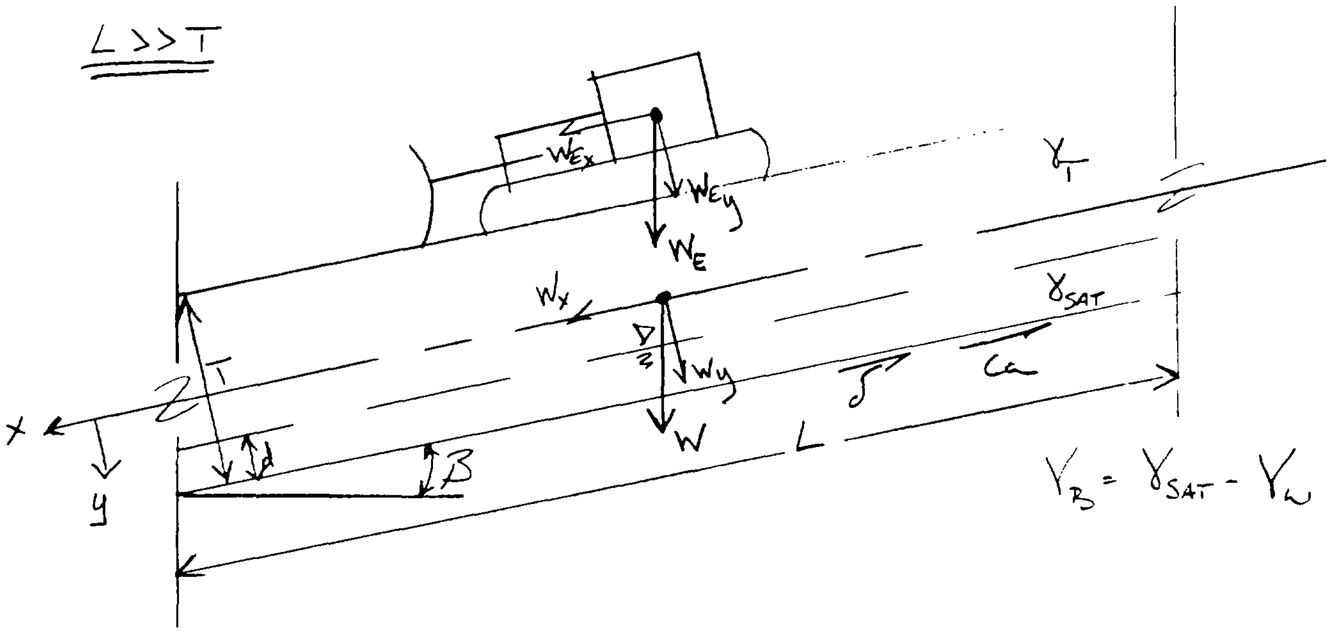
The geosynthetic components of the pond lining should also resist forces generated by a cover soil slide. To do this, the geosynthetics must have adequate runout/anchorage at their edges to hold the geosynthetics in place. At the same time, it is desirable to prevent the geosynthetics from experiencing material failure as a result of instability. Simply, it is more desirable for the synthetic to pull-out of its runout/anchorage than to experience a break. As a result of the analysis, it was found that a runout length less than 3.5 feet would allow pull-out of the geosynthetics without tensile material failure under the assumed conditions and properties. Since the slopes were designed to resist instability by frictional forces alone, no tensile reinforcement from the geosynthetics is required. Therefore, the runout/anchorage length is based on a more conservative approach of reduced geomembrane strength.

Based on the analysis presented herein, a minimum residual interface friction angle of 19.1° is required. Site specific testing should be performed prior to construction to confirm that the materials of construction can achieve the required residual interface friction, in accordance with ASTM D5321, with actual geosynthetics, soil materials, and conditions for construction of the pond liner.

Golder Associates	SUBJECT LEMON LANE LANDFILL - POND LINER		
	Job No. 993-6573 Ref. PRE-FINAL DESIGN	Made by [illegible] Checked MPH Reviewed GW	Date 5/23/2000 Sheet 4 of 12

* GENERAL METHOD OF INFINITE SLOPE ANALYSIS:

L >> T



$$W = \gamma_T(T-d) + \gamma_B(d)$$

$$W_x = W \sin\beta$$

$$W_y = W \cos\beta$$

W_E = EQUIPMENT LOAD IN PSF

$$W_{Ex} = W_E \sin\beta$$

$$W_{EY} = W_E \cos\beta$$

- RESISTING FORCES (F_R):

$$F_R = W_y \tan\delta + W_{EY} \tan\delta + c_a$$

- DRIVING FORCES (F_D):

$$F_D = W_x + W_{Ex} + F_S$$

- SEEPAGE FORCE (FS):

$$F_S = i\,\gamma_w d = \gamma_w d \sin\beta$$

WHERE:

γ_T = TOTAL SOIL UNIT WEIGHT
γ_B = BUOYANT SOIL UNIT WEIGHT
= $\gamma_{SAT} - \gamma_w$
γ_{SAT} = SATURATED SOIL UNIT WEIGHT
γ_w = UNIT WEIGHT OF WATER
T = THICKNESS OF COVER SOIL
d = height OF WATER
W = WEIGHT OF SOIL MASS
W_E = EQUIPMENT WEIGHT
β = SLOPE ANGLE
δ = CRITICAL INTERFACE FRICTION ANGLE
i = HYDRAULIC GRADIENT
= $\sin\beta$
c_a = SOIL ADHESION

Golder Associates

SUBJECT LEMON LANE LANDFILL – POND LINER		
Job No. 993-6578 Ref. PRE-FINAL DESIGN	Made by EJ Checked MFW Reviewed BJ	Date 5/23/2000 Sheet 5 of 12

$$\therefore \quad FS = \frac{F_R}{F_D} = \frac{W_y \tan\delta + W_{E_y} \tan\delta + C_a}{W_x + W_{E_x} + \gamma_W d \sin\beta}$$

$$FS = \frac{[\gamma_T (T-d) + \gamma_B (d) + W_E] \cos\beta \tan\delta + C_a}{[\gamma_T (T-d) + \gamma_B (d) + W_E + \gamma_W (d)] \sin\beta}$$

$$FS = \frac{[\gamma_T (T-d) + \gamma_B (d) + W_E] \cos\beta \tan\delta + C_a}{[\gamma_T (T-d) + \gamma_{SAT} (d) + W_E] \sin\beta}$$

$$FS = \frac{[\gamma_T (T-d) + (\gamma_{SAT} - \gamma_W) d + W_E] \cos\beta \tan\delta + C_a}{[\gamma_T (T-d) + \gamma_{SAT} (d) + W_E] \sin\beta}$$

THE ATTACHED SPREADSHEET ANALYSIS UTILIZES THIS DERIVED EQUATION ALONG WITH THE APPROPRIATE ASSUMPTIONS FOR THE EQUATION PARAMETERS.

Infinite Slope Stability Analysis
Lemon Lane Landfill

Case 1: Drained Cover Soil - Infinite Slope Analysis

Unit Weight of Soil (γ_t):	115 pcf
Saturated Unit Weight of Soil (γ_{sat}):	135 pcf
Thickness of Soil (T):	1.5 feet
Slope Angle (β):	11.3 degrees
Unit Weight of Water (γ_w):	62.4 pcf
Depth of Water (d):	0 feet
Critical Friction Angle (δ):	16.7 degrees
Adhesion (c_a):	0 pcf
Weight of the Equipment:	0 lb
Contact Area:	0 sf
Weight per Unit Area (We):	0 psf
Description of Equipment:	

$$FS = \frac{[\gamma_t(T\text{-}d) + (\gamma_{sat}\text{-}\gamma_w)d + W_e]\cos\beta\tan\delta + c_a}{[\gamma_t(T\text{-}d) + (\gamma_{sat})d + W_e]\sin\beta}$$

FS = ***1.50***

Assumptions:

1. The critical interface occurs between the geotextile cushion and the subgrade soil.
2. Analysis per EPA's 600/2-89/057, *Stability of Lined Slopes at Landfills and Surface Impoundments*, applies.
3. The unit weight of the cover soil is based on the given borrow materials.
4. The adhesion effects of the materials along the critical interface are negligible.
5. Infinite slope analysis is appropriate based on its conservatism (i.e., neglects passive toe resistance).

6012

Infinite Slope Stability Analysis
Lemon Lane Landfill

Case 2: Partially Saturated Cover Soil with Construction Loading - Infinite Slope Analysis

Unit Weight of Soil (γ_t):	115 pcf
Saturated Unit Weight of Soil (γ_{sat}):	135 pcf
Thickness of Soil (T):	1.5 feet
Slope Angle (β):	11.3 degrees
Unit Weight of Water (γ_w):	62.4 pcf
Depth of Water (d):	0.75 feet
Critical Friction Angle (δ):	15.4 degrees
Adhesion (c_a):	0 pcf
Weight of the Equipment:	36400 lb
Contact Area:	57 sf
Weight per Unit Area (We):	638 psf
Description of Equipment:	CAT D6M LGP

$$FS = \frac{[\gamma_t(T-d) + (\gamma_{sat}-\gamma_w)d + W_e]\cos\beta\tan\delta + c_a}{[\gamma_t(T-d) + (\gamma_{sat})d + W_e]\sin\beta}$$

FS = *1.30*

Assumptions:

1. The critical interface occurs between the geotextile cushion and the subgrade soil.
2. Analysis per EPA's 600/2-89/057, *Stability of Lined Slopes at Landfills and Surface Impoundments*, applies.
3. The unit weight of the cover soil is based on the given borrow materials.
4. The adhesion effects of the materials along the critical interface are negligible.
5. Infinite slope analysis is appropriate based on its conservatism (i.e., neglects passive toe resistance).

Infinite Slope Stability Analysis
Lemon Lane Landfill

Case 3: Partially Saturated Cover Soil - Infinite Slope Analysis

Unit Weight of Soil (γ_t):	115 pcf
Saturated Unit Weight of Soil (γ_{sat}):	135 pcf
Thickness of Soil (T):	1.5 feet
Slope Angle (β):	11.3 degrees
Unit Weight of Water (γ_w):	62.4 pcf
Depth of Water (d):	0.75 feet
Critical Friction Angle (δ):	19.1 degrees
Adhesion (c_a):	0 pcf
Weight of the Equipment:	0 lb
Contact Area:	0 sf
Weight per Unit Area (We):	0 psf
Description of Equipment:	CAT D6M LGP

$$FS = \frac{[\gamma_t(T-d) + (\gamma_{sat}-\gamma_w)d + W_e]\cos\beta\tan\delta + c_a}{[\gamma_t(T-d) + (\gamma_{sat})d + W_e]\sin\beta}$$

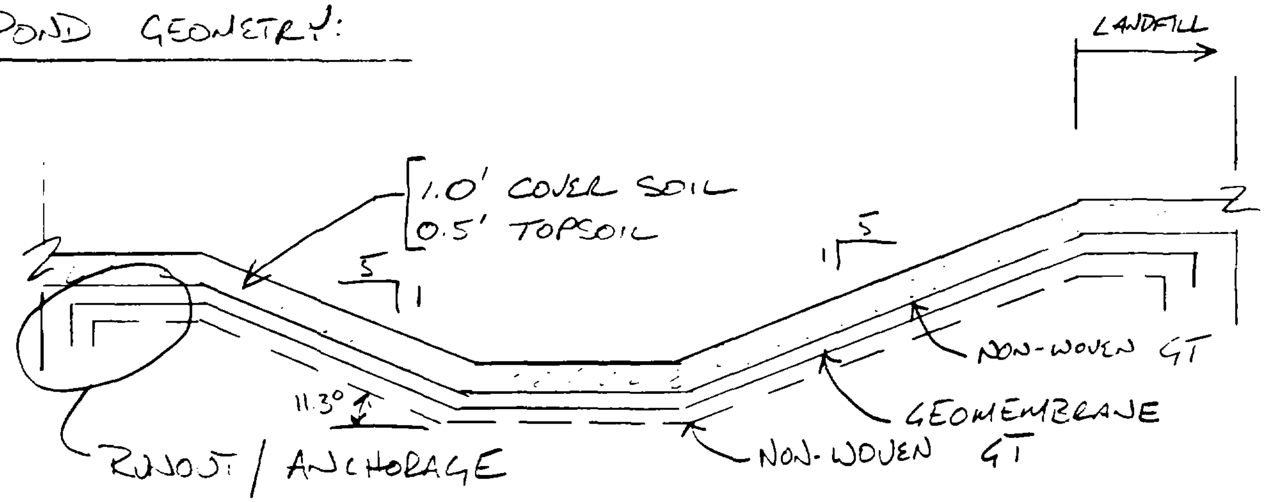
FS = ***1.30***

Assumptions:

1. The critical interface occurs between the geotextile cushion and the subgrade soil.
2. Analysis per EPA's 600/2-89/057, *Stability of Lined Slopes at Landfills and Surface Impoundments*, applies.
3. The unit weight of the cover soil is based on the given borrow materials.
4. The adhesion effects of the materials along the critical interface are negligible.
5. Infinite slope analysis is appropriate based on its conservatism (i.e., neglects passive toe resistance).

Golder Associates	SUBJECT LEMON LANE LANDFILL – POND LINER		
	Job No. 993-6573 Ref. PRE-FINAL DESIGN	Made by BSV Checked MFH Reviewed DJ	Date 5/23/2000 Sheet 9 of 12

*** POND GEOMETRY:**



*** DETERMINE REQUIRED RUNOUT / ANCHORAGE:**

FROM REFERENCE (SEE ATTACHED)

$$L_{RO} = \frac{T_{allow}(\cos\beta - \sin\beta \tan\delta_L)}{\sigma_n(\tan\delta_U + \tan\delta_L)}$$

WHERE: L_{RO} = RUNOUT LENGTH
T_{ALLOW} = ALLOWABLE TENSILE STRENGTH OF GEOSYNTHETIC
β = SLOPE ANGLE
δ_L = FRICTION ANGLE OF LOWER INTERFACE
δ_U = FRICTION ANGLE OF UPPER INTERFACE
σ_n = APPLIED NORMAL STRESS

BUT $T_{allow} = T_{ULT}/FS$
$\beta = 11.3°$
$\delta_L = 19.1°$ – REQUIRED BY STABILITY ANALYSIS (ATTACHED)
$\delta_U = 0°$ – CONSERVATIVE AS COVER SOIL WOULD LIKELY CRACK AND SLIDE ON THE GEOSYNTHETICS
σ_n = ? – BASED ON CONSERVATIVE ANALYSIS OF AN EMPTY POND
$= (115\,pcf)(1.5\,ft)$
$= 172.5\,psf$

Golder Associates	SUBJECT LEMON LANE LANDFILL - POND LINER		
	Job No. 993-6573 Ref. PRE-FINAL DESIGN	Made by Checked MFW Reviewed	Date 5/23/2000 Sheet 10 of 12

$$\therefore FS(L_{RO}) = \frac{T_{ULT}\left[\cos 11.3^\circ - (\sin 11.3^\circ)(\tan 19.1^\circ)\right]}{172.5\,psf\,(\tan 0^\circ + \tan 19.1^\circ)}$$

THE LINER CROSS-SECTION UTILIZES A 10oz/sy NON-WOVEN GEOTEXTILE CUSHION BETWEEN THE PREPARED SUBGRADE AND OVERLYING TEXTURED VFPE GEOMEMBRANE. AS SUCH THE CRITICAL INTERFACE FOR INSTABILITY HAS BEEN ASSUMED TO BE THE NON-WOVEN GEOTEXTILE TO SUBGRADE FOR THE POND LINER DESIGN. INFINITE SLOPE STABILITY ANALYSIS SHOWED THE AN INTERFACE FRICTION ANGLE OF 19.1° IS REQUIRED FOR STABILITY CONDITIONAL APPROPRIATE FACTORS OF SAFETY. HENCE, RUNOUT/ANCHORAGE WILL BE BASED ON THE GEOTEXTILE STRENGTH FOR THIS REASON AND THAT THE GEOTEXTILE STRENGTH IS LESS THAN THE SPECIFIED GEOMEMBRANE PROPERTIES (THIS WILL BE CHECKED).

FROM THE TECHNICAL SPECIFICATIONS:

SECTION 02590 "VFPE GEOMEMBRANE"

- TENSILE STRENGTH AT BREAK = 110 ppi

SECTION 02595 "GEOTEXTILE"

- GRAB TENSILE STRENGTH AT BREAK FOR 10oz/sy NON-WOVEN = 230 lbs

SO.

VFPE = 110 ppi = 1320 lb/ft

NWGT = 230 lb = 230 lbs/ft

Golder Associates	SUBJECT: LEMON LANE LANDFILL - POND DESIGN		
	Job No. 993-6573 Ref. PRE-FINAL DESIGN	Made by [illegible] Checked MFH Reviewed DJ	Date [illegible] Sheet 11 of 12

∴ COMPUTE THE RUNOUT LENGTH FOR THE NON-WOVEN GEOTEXTILE:

$$FS(L_{RO}) = \frac{230\ \text{lb/ft}\left[\cos 11.3^\circ - (\sin 11.3^\circ)(\tan 19.1^\circ)\right]}{172.5\ \text{psf}\ (\tan 0^\circ + \tan 19.1^\circ)}$$

$$FS(L_{RO}) = 3.5\ \text{FEET}$$

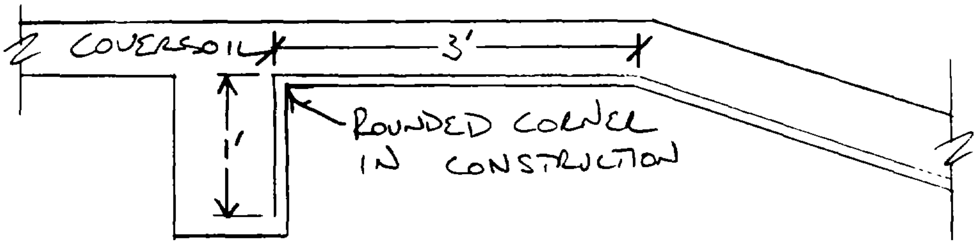
$$L_{RO} = \frac{3.5\ \text{FEET}}{FS}$$ ∴ $L_{RO} < 3.5$ FEET TO ENSURE PULLOUT INSTEAD OF TENSILE FAILURE

CHECK GEOMEMBRANE:

$$FS(L_{RO}) = \frac{1320\ \text{lb/ft}\left[\cos 11.3^\circ - (\sin 11.3^\circ)(\tan [illegible])\right]}{172.5\ \text{psf}\ (\tan 0^\circ + \tan [illegible])}$$

$$\underline{\underline{FS(L_{RO}) = 20.7\ \text{FEET}}}$$ ∴ $L_{RO} < 3.5$ FEET ENSURES MEMBRANE WILL NOT FAIL IN TENSION (BREAK)

NOTE, TYPICAL DESIGN DETAILS USE A 3 FOOT RUNOUT TERMINATING IN A 1 FOOT ANCHOR TRENCH:



THIS IS ACCEPTABLE AS LONG AS THE TEXTILE IS NOT TUCKED INTO THE TRENCH AND HAS A RUNOUT ONLY, AS SUCH THE ANCHORAGE OF BOTH MATERIAL WILL PROVIDE FOR PULLOUT WITHOUT MATERIAL FAILURE.

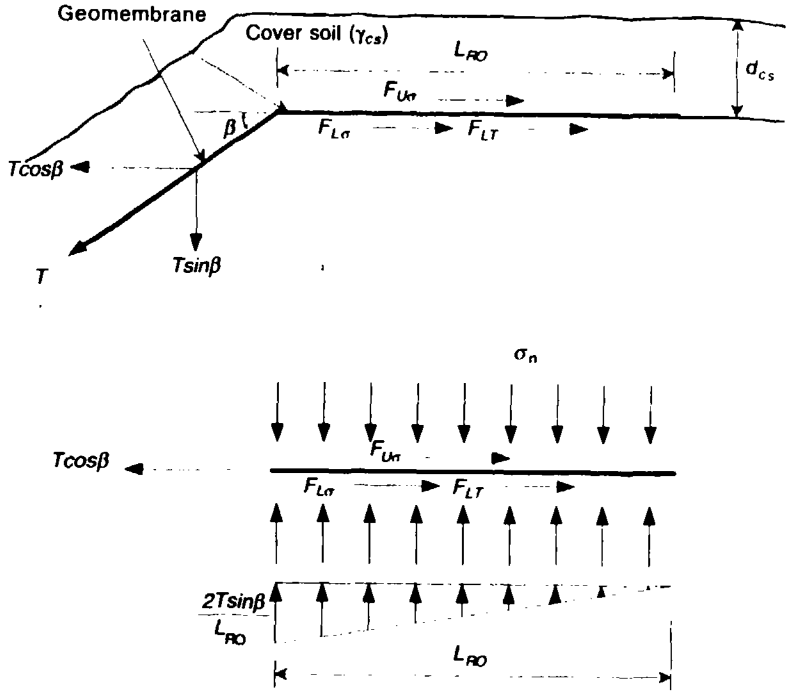


Figure 5.30 Cross section of geomembrane runout section and related stresses and forces involved.

$$= \sigma_n \tan \delta_U(L_{RO}) + \sigma_n \tan \delta_L(L_{RO}) + 0.5\left(\frac{2T_{allow} \sin \beta}{L_{RO}}\right)(L_{RO}) \tan \delta_L$$

$$L_{RO} = \frac{T_{allow}(\cos \beta - \sin \beta \tan \delta_L)}{\sigma_n(\tan \delta_U + \tan \delta_L)} \quad (5.25)$$

where

T_{allow} = allowable force in geomembrane stress = $\sigma_{allow} t$, where
σ_{allow} = allowable stress in geomembrane, and
t = thickness of geomembrane;
β = side slope angle;
$F_{U\sigma}$ = shear force above geomembrane due to cover soil (note that for thin cover soils tensile cracking will occur and this value will be negligible);
$F_{L\sigma}$ = shear force below geomembrane due to cover soil;
F_{LT} = shear force below geomembrane due to vertical component of T_{allow};
σ_n = applied normal stress from cover soil;
δ = angle of shearing resistance between geomembrane and adjacent material (i.e., soil or geotextile); and
L_{RO} = length of geomembrane runout.

Example 5.13 illustrates the use of the concept and the equations just developed.

Example 5.13

Consider a 1.0 mm thick VLDPE geomembrane with a mobilized allowable stress of 7000 kPa, which is on a 3(H) to 1(V) side slope. Determine the required runout length to resist this stress without use of a vertical anchor trench. In this analysis use 300 mm of cover soil weighing 16.5 kN/m³ and a friction angle of 30° with the geomembrane.

Solution: From the design equations just presented,

$$T_{allow} = \sigma_{allow} t$$
$$= (7000)(0.001)$$
$$T_{allow} = 7.0 \text{ kN/m}$$

and

$$L_{RO} = \frac{T_{allow}(\cos \beta - \sin \beta \tan \delta_L)}{\sigma_n(\tan \delta_U + \tan \delta_L)}$$
$$= \frac{(7.0)[\cos 18.4 - (\sin 18.4)(\tan 30)]}{(16.5)(0.30)[\tan 0 + \tan 30]}$$
$$= \frac{5.37}{2.86}$$
$$L_{RO} = 1.9 \text{ m}$$

Note that this value is strongly dependent on the value of mobilized allowable stress used in the analysis. To mobilize the failure strength of the geomembrane would require a longer runout length or embedment in an anchor trench. This, however, might not be desirable. Pullout without geomembrane failure might be a preferable phenomenon. It is a site-specific situation.

The situation with an anchor trench at the end of the runout section is illustrated in Figure 5.31. The configuration requires some important assumptions regarding the state of stress within the anchor trench and its resistance mechanism. In order to provide lateral resistance, the vertical distance within the anchor trench has lateral forces acting upon it. More specifically, an active earth pressure (P_A) is tending to destabilize the situation, whereas a passive earth pressure (P_P) is tending to resist pullout. As will

REFERENCE #3

12 of 1

APPENDIX D

GLOBAL SLOPE STABILITY CALCULATIONS

Golder Associates	SUBJECT: Lemon Lane Landfill – Global Slope Stability Analysis		
	Job No.: 993-6573	Made by: RSV	Date: 5/23/2000
	Ref.: Pre-Final Design Report	Checked:	Sheet 1 of 26
		Reviewed:	

OBJECTIVE: To evaluate the global slope stability of the landfill mass considering the anticipated 'worst-case' slope geometry (i.e., maximum 4H:1V side slopes with 100 foot lengths and 5% crown slopes) under static and pseudo-static seismic loading conditions.

METHOD: Methodology based on the use of typical slope stability theories and methods presented in common geotechnical texts and coded into the SLOPE/W slope stability analysis software package (Reference 1). In particular, the Janbu method of analysis was selected for its conservatism to evaluate the critical slope configuration, determined by examination of References 8 and 9, using interpreted subsurface conditions and the assumed geosynthetic cap design with the corresponding properties as presented herein. The analysis considered four cases assessed by SLOPE/W using Janbu analysis to determine the relative factors-of-safety as follows. The cases were then subdivided into two subparts in which the unit weight of the waste material, the most variable parameter, was varied at anticipated maximum and minimum values based on Reference 7.

Case 1: Static Load Analysis: Considers the critical slope configuration in an at rest condition.

- a: Maximum unit weight of weight assessed.
- b: Minimum unit weight of weight assessed.

Case 2: Pseudo-Static Seismic Analysis: Considers the critical slope configuration with pseudo-static seismic forces generated through the use of a coefficient of horizontal ground acceleration.

- a: Maximum unit weight of weight assessed.
- b: Minimum unit weight of weight assessed.

REFERENCES:

1. "SLOPE/W," Version 4.23, GEO-SLOPE International Ltd., 1999.
2. "Final Covers for Solid Waste Landfills and Abandoned Dumps," R. Koerner and D. Daniel, 1997.
3. "Stability Analysis of Earth Slopes," Y. Huang, 1983.
4. "Foundations & Earth Structures," NAVFAC Design Manual 7.02, 1986.
5. "Geotechnical Properties of Municipal Solid Wastes and their Use in Landfill Design," J. Fassett et al., 1994.
6. Laboratory Testing, Golder Associates, April-May 1999.
7. "National Seismic Hazard Mapping Project," Probabilistic Ground Motion Values for Bloomington, IN, USGS, via the Internet, 2000.
8. "Drawing 4 – Final Cap Grading Plan" Pre-Final Design Report, Golder Associates, May 2000.
9. "Drawing 5 – Cap Cross Sections" Pre-Final Design Report, Golder Associates, May 2000.
10. Review and Correlation of Site-specific N-Values for the Native Soil at Lemon Lane Landfill, Golder Associates, May 2000 (Attached).

11. "Stability of Lined Slopes at Landfills and Surface Impoundments," D. H. Mitchell, M. A. McLean and T. E. Gates, EPA 600/2-89/057.

ASSUMPTIONS:

1. The critical slope configuration is as presented on the attached figure and cross-sections as developed from interpretation of References 8 and 9. The critical slope considers a worst-case scenario through the pond located at the southwest corner of the site with an upslope geometry consisting of the maximum allowable landfill design slope of 4H:1V over a 100 foot slope length tapering into a crown with the minimum allowable 5% slope. Although this geometry does not reflect the grading depicted on the design drawings, it is considered to be the most critical and conditions encountered during construction could alter the design slopes to this worst-case geometry. This geometry is considered to be worst-case due to the location of the pond in proximity to the toe of slope (i.e., loss of passive resistance due to the pond excavation at the toe). Further, a 4H:1V slope over a 100 foot length will generate a larger driving force because of the additional volume, and therefore mass, a 4H:1V slope provides as compared to a slope of lesser inclination.
2. The bedrock and native soil layers are as depicted on the attached figures and are based upon data from site borehole investigations.
3. Strength parameters of the soil layers were assigned as follows:

Soil Type	Total Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)	Reference No.
Cover	115	30	0	4
Waste (min.)	60	23	200	5
Waste (max.)	85	23	200	5
Native Soil	98	0	750	4,6,10

4. Groundwater is located within the bedrock.
5. The coefficient of horizontal ground acceleration, a_g, is 0.1g based on data from Reference 7.
6. As otherwise stated in the calculations.

CALCULATIONS: Attached.

CONCLUSIONS: Based on the methodology and assumptions stated herein, a factory-of-safety against global instability was calculated for each of the cases specified with the results summarized in the following table.

Case	FS	File Name
1a	2.0	GS1A.slp
1b	2.8	GS1B.slp
2a	1.3	GS1A-S.slp
2b	1.6	GS1B-S.slp

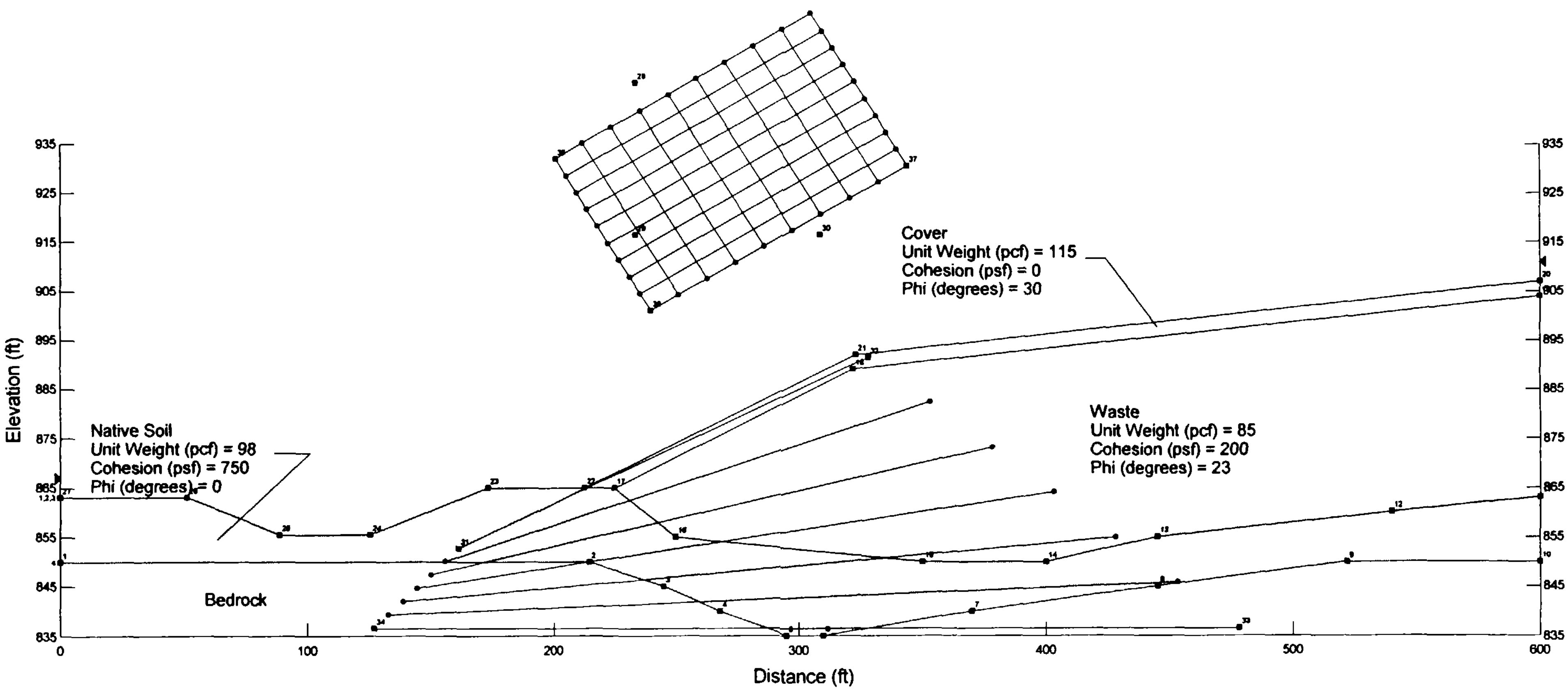
The calculated factors-of-safety for the assumed worst-case site conditions are in excess of the typically acceptable factors-of-safety of 1.5 for static slope stability and 1.1 for seismic slope stability (Reference 11). The analysis further suggests that the factor-of-safety increases with decreasing unit weight of the waste material, which is typically a very non-homogenous material with highly variable properties.

As a result, the calculated factors-of-safety against global instability are considered conservative and acceptable under the assumed worst-case slope configuration. This analysis is further considered conservative due to the fact that the case analyzed has steeper slopes than the proposed design grades presented on Reference 8 in which the side slopes are at a maximum of 15% with crown slopes at 9%. This is considerably different than the worst-case analysis, and as such, the design slopes will have a greater factor-of-safety against instability than the worst-case slopes. This is clearly seen in the approximate 10 foot difference in crest elevation between the analyzed worst-case and proposed design grades.

In addition, the soil properties, unit weight and cohesion, assigned to the native soil material are considered conservative based on the evaluation of site-specific data (Reference 10). The global stability analysis utilized a unit weight for the native soil based on remolded lab samples, which generally underestimate true in-situ conditions, especially when compared to N-value correlations. Typically remolded lab samples yield values less than N-value correlated in-situ strengths for cohesive materials. The site-specific evaluation and correlation of N-values suggests that the unit weight could be 20-30% higher than the lab data. Similarly, a conservative value of 750 psf for cohesion was used for the analysis, whereas the site-specific evaluation suggested that the native soil cohesion could be on the order of 2000 psf. An increase in either the unit weight or cohesion of the native soil would yield a higher factor-of-safety against instability.

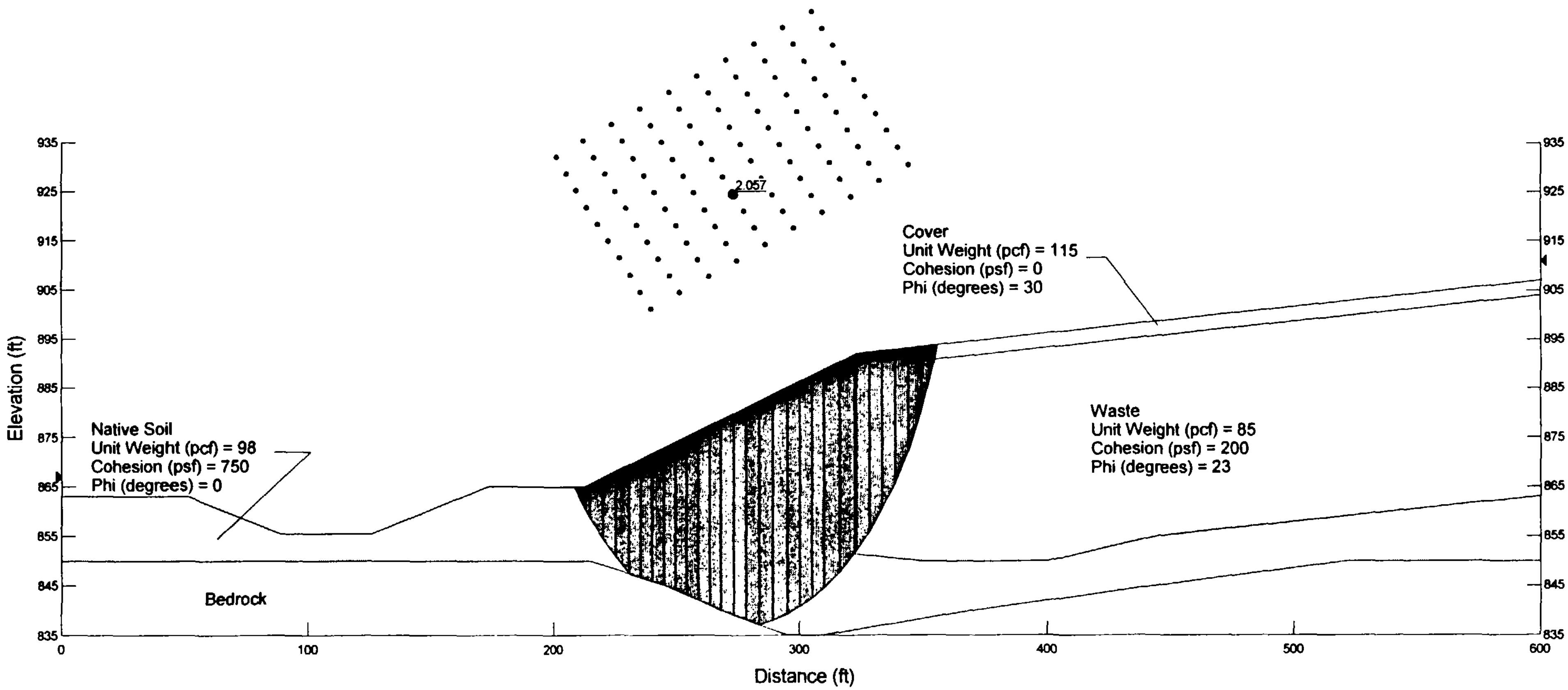
If during construction slopes are proposed to be constructed other than those presented in the Design Report, then this analysis may not need to be revised by the Engineer prior to construction as long as the proposed slopes do not exceed the worst-case scenario presented here.

Lemon Lane Landfill - Global Slope Stability Analysis
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1A.slp
Date: 5/23/00



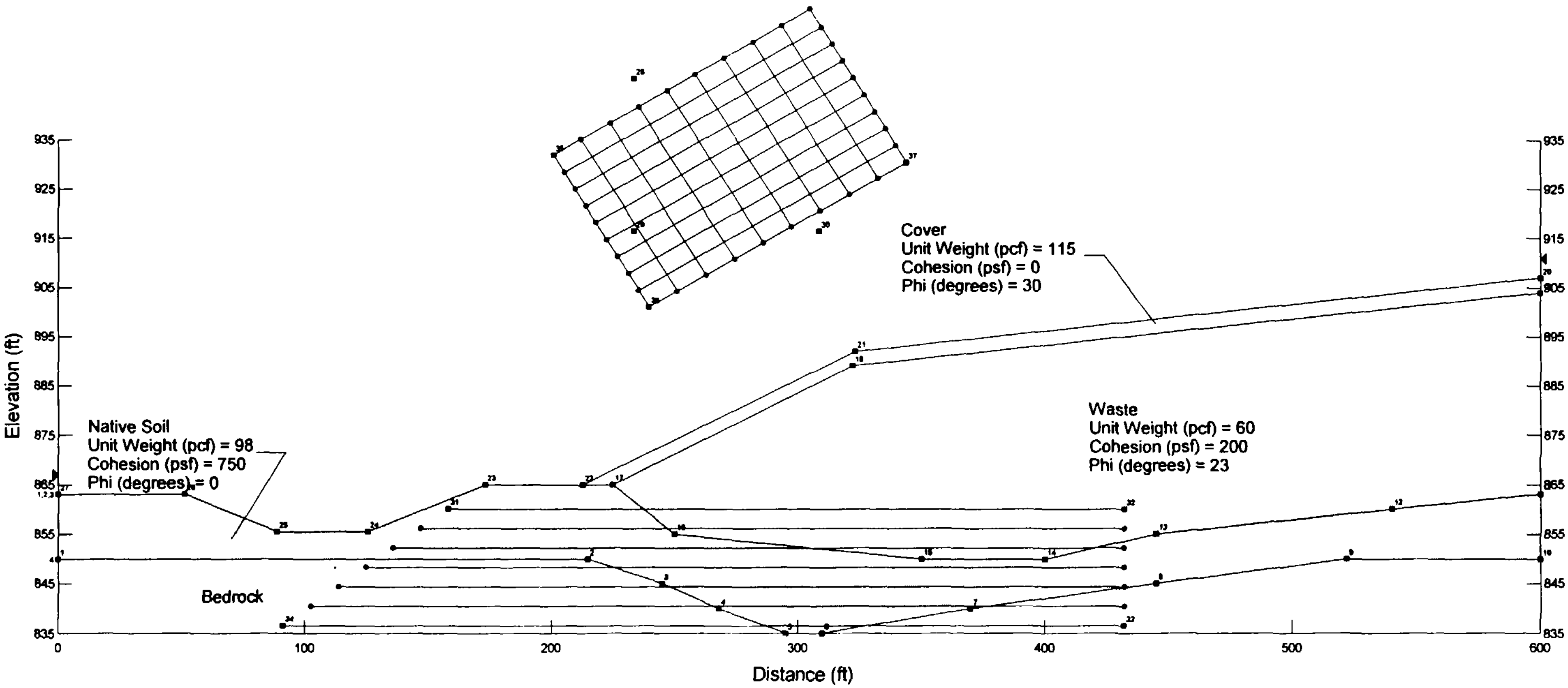
5 of 26

Lemon Lane Landfill - Global Slope Stability Analysis
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1A.slp
Date: 5/23/00
Analysis Method: Janbu



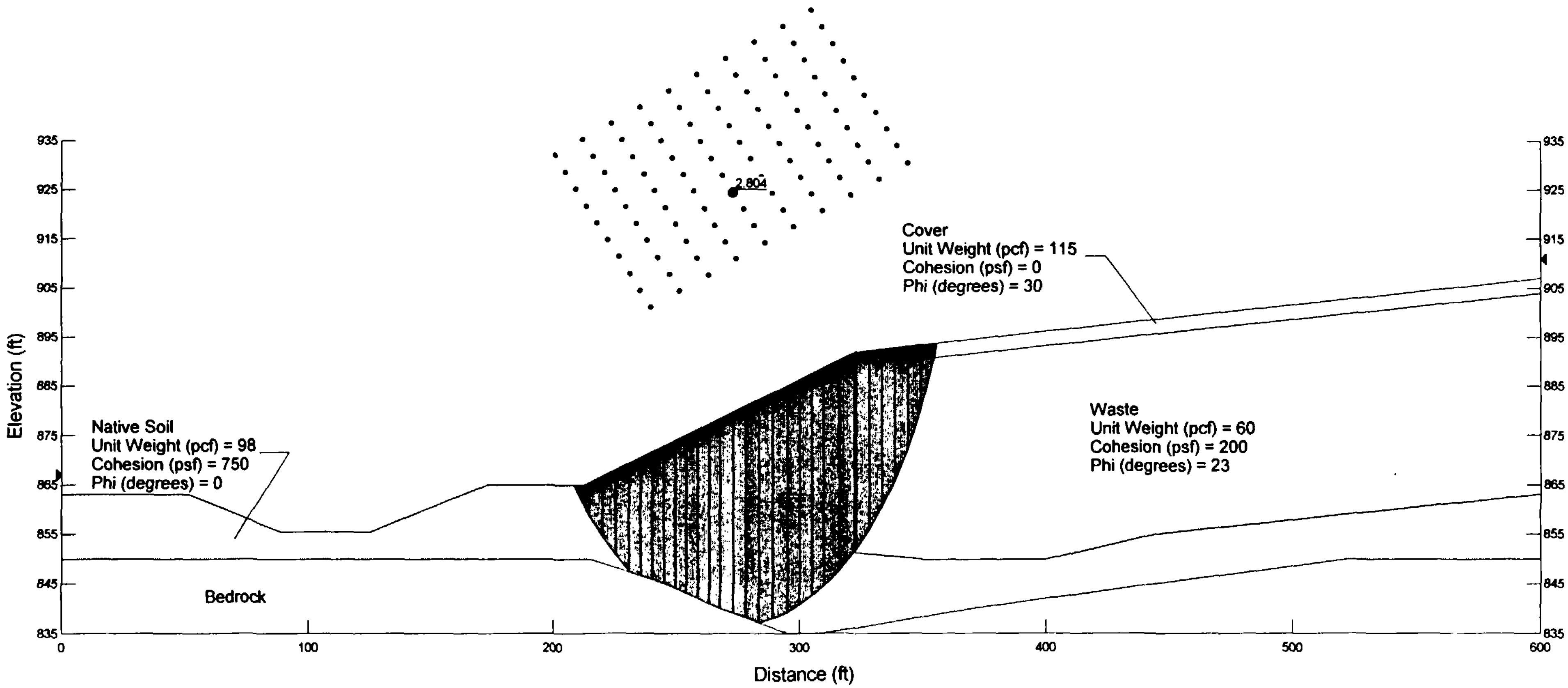
CASE 1B

Lemon Lane Landfill - *Global Slope Stability Analysis*
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1B.slp
Date: 5/23/00



8 of 26

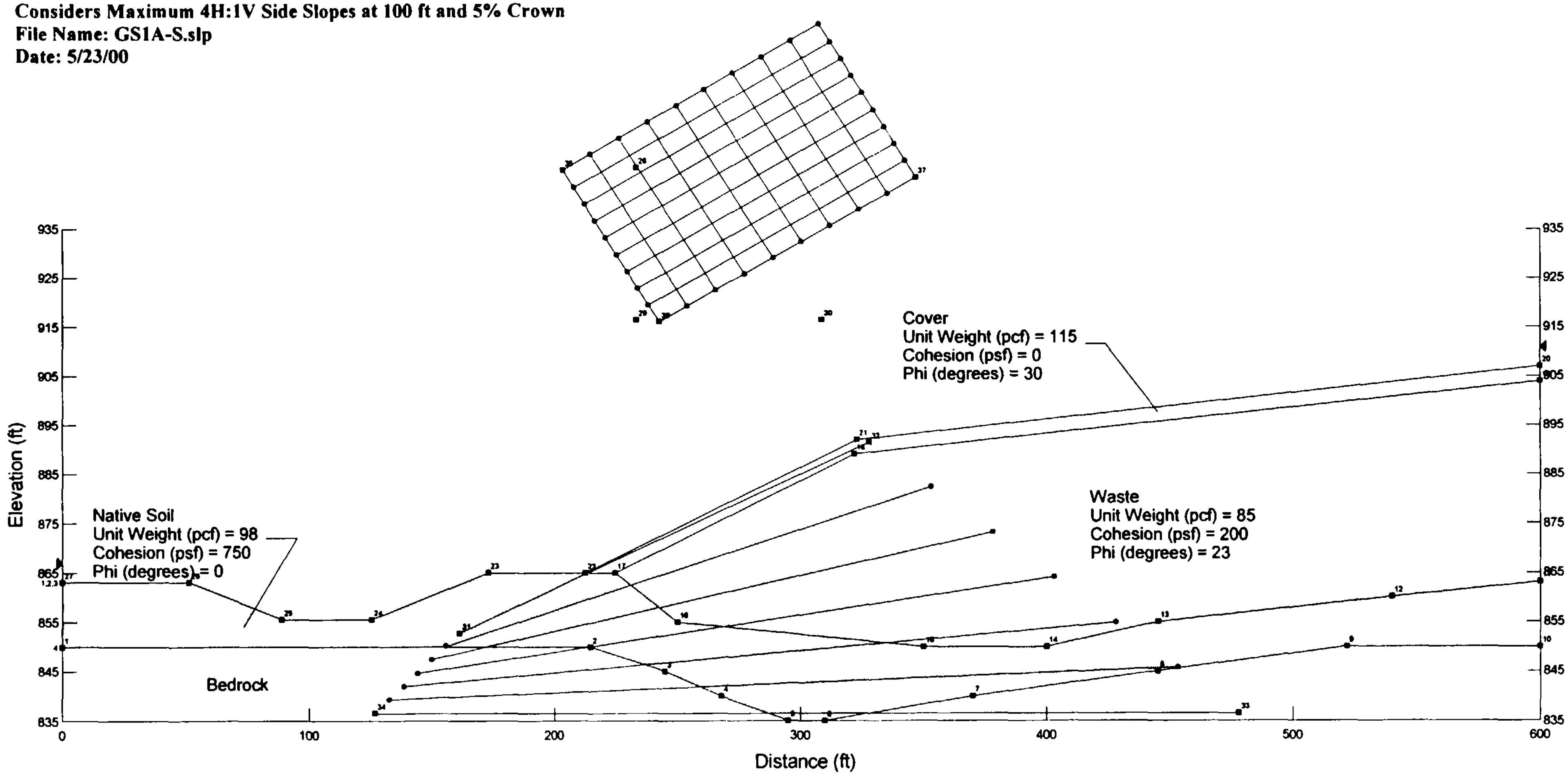
Lemon Lane Landfill - Global Slope Stability Analysis
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1B.slp
Date: 5/23/00
Analysis Method: Janbu



9 of 26

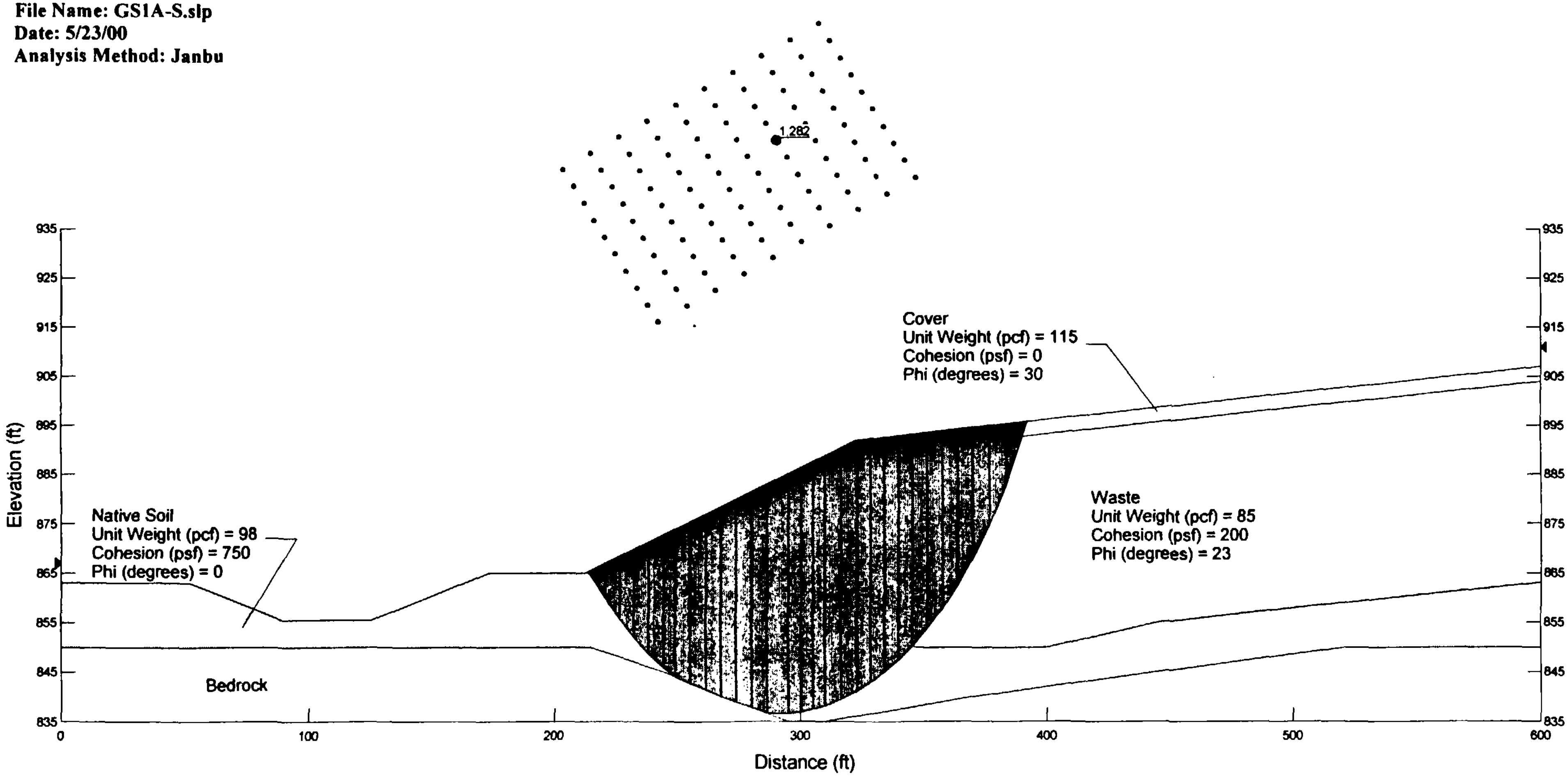
CASE 2A

Lemon Lane Landfill - Global Slope Stability Analysis
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1A-S.slp
Date: 5/23/00



11 of 26

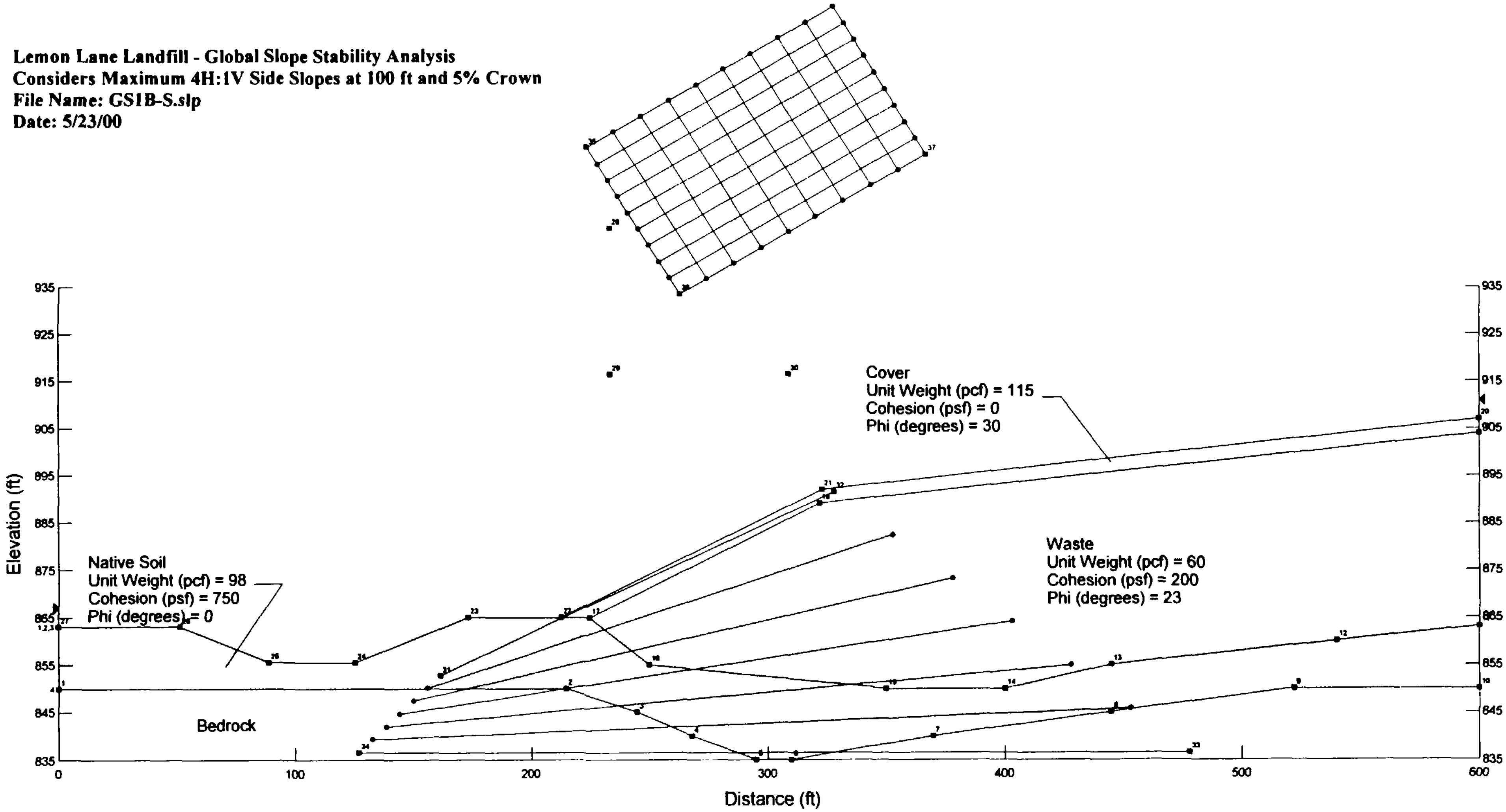
Lemon Lane Landfill - Global Slope Stability Analysis
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1A-S.slp
Date: 5/23/00
Analysis Method: Janbu



12 of 26

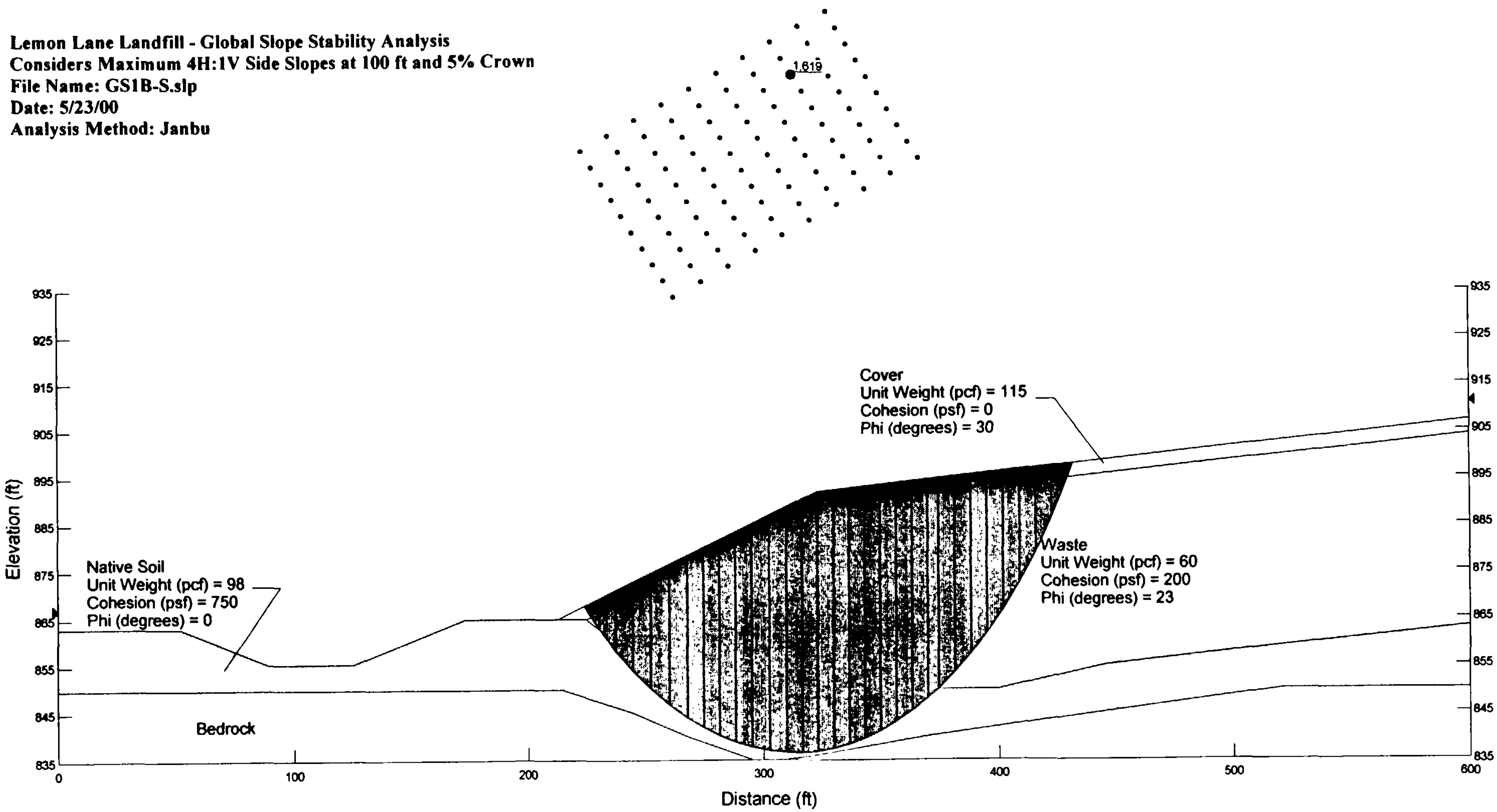
CASE 2B

Lemon Lane Landfill - Global Slope Stability Analysis
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1B-S.slp
Date: 5/23/00



14 of 26

Lemon Lane Landfill - Global Slope Stability Analysis
Considers Maximum 4H:1V Side Slopes at 100 ft and 5% Crown
File Name: GS1B-S.slp
Date: 5/23/00
Analysis Method: Janbu



15 of 26

REFERENCES

REFERENCE #4

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi) — Percent of Original Height	Typical Value of Compression: At 3.6 tsf (50 psi) — Percent of Original Height	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: ϕ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan ϕ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown. (..) indicates insufficient data available for an estimate.

CONSERVATIVELY, USE:
$\gamma = 115pcf$
$\phi = 30°$
$c = 0psf$

CONSERVATIVELY, USE
$\phi = 0°$
$c = 750psf$

1 OF 2

Reference #5

TABLE II - UNIT WEIGHT DATA

REFERENCE	LOCATION	WASTE TYPE	WASTE AGE	PLACEMENT METHOD	MOISTURE CONTENT (%)	UNIT WEIGHT TOTAL (pcf)	UNIT WEIGHT DRY (pcf)	TEST METHOD	RELIABILITY	COMMENTS
Cambell, 1982	London	MSW		Thin layers; Cat 816		63		Full-Scale Field Test	Fair	Do not have details on measurement technique.
	•	MSW		5 ft lifts Cat 816		41		"	•	
	Northhampton	MSW		6.5 ft lifts L61D Loader		41		"	•	
	•	MSW		'Minimal'		29		"	•	
	Sussex	MSW		Pulverised 'Minimal'		43		"	•	
	Northhampton	MSW		5 ft lifts Cat 816		49		"	•	
	•	MSW		•		49		"	•	
	•	MSW		Thin layers; Cat 816		59		"	•	
	•	MSW		5 ft lifts Cat 955 Dozer		42		"	•	
Earth Technolgy, 1988	Los Angeles, CA	MSW			30.8 55.3	80.8 82.8	61.8 53.3	Plastic Tubes	Good	Depth about 50 ft.
Franklin & Assoc., 1990	U.S.	MSW				30		Estimate	Poor	Estimate based on component densities & relative vol.
Galante et al., 1991	S.E. PA	79% MSW 16% Sludge 5% Misc.	Fresh	Cat 826; 8-10 ft lifts		63-70		Lined Test Pits	Very Good	
Ham, et al., 1978	Madison, WI	MSW	Fresh	Cat 950B 4 ft lifts	38.2	41	30	Surveyed	Good	Density values are for waste only; no daily cover included.
Landva et al., 1984	Calgary					78-91		Test Pits	Good	Testing done in 1983-84.
	Edmonton					64-81		•	•	
	•					57-69		•	•	
	Mississauga					68-85		•	•	
	Red Deer					73-82		•	•	
	Vancouver					54-77		•	•	
	Waterloo					66-82		•	•	
	Winnipeg					54-73		•	•	
Merz & Stone, 1962	Pomona, CA	Soil:MSW (by vol.)								
	Cell 1	0:1	Fresh	(i) 1 18 ft lift; wetted to refusal	167.1	58.6 (Refuse only)	22	Surveyed	Good	
	Cell 2	1:6	Fresh	(ii) 4 4 ft lifts; Stand. Compact'n	51.9	45.3	29.8	Surveyed	Good	Compaction is sub-standard today
	Cell 3	1:4.8	Fresh	(iii) same as (ii) but no H2O added	32.5	38.6	29.1	Surveyed	Good	
	Cell 4	0:1	Fresh	(iv) 1 18 ft lift; min compaction	79.5	22.7 (Refuse only)	12.65	Surveyed	Good	

18 of 26

REFERENCE #5

TABLE II - UNIT WEIGHT DATA

REFERENCE	LOCATION	WASTE TYPE	WASTE AGE	PLACEMENT METHOD	MOISTURE CONTENT (%)	UNIT WEIGHT TOTAL (pcf)	UNIT WEIGHT DRY (pcf)	TEST METHOD	RELIABILITY	COMMENTS
	Cell 5	1:4.1	Fresh, mixed with soil	(v) 1 18 ft lift; Stand. compact'n	41.7	46.5	32.9	Surveyed	Good	
Natarajan & Rao, 1977	Bombay, India	MSW				Ave=84 S.D=15	Ave=50 S.D=23	"Undisturbed" Samples	Good	6 Samples
Oweis & Khera, 1986	NJ	MSW	Fresh			42		Based on pore press. in subs	Fair	
		MSW	"Older"			62		Same	Poor	Ave over 100 ft depth
						70-80		Volume Estimates	Poor	
Pacey, 1982	Mt. View, CA	MSW	Fresh		51	48	32	Full-Scale Field Test	Good	Six 100 x 100 ft, 50 ft deep Test Cells.
			•		47	47	32	•	•	
			•		43	44	31	•	•	
			•		35	43	32	•	•	
			•		41	43	30	•	•	
			•		35	44	33	•	•	
Pfeffer, 1992		MSW	Fresh	1-1.5 ft lifts D-9 Dozer	23.6	45	34	Full-Scale Field Test	Good	Test reported in 1969; do not know how dry unit weight was calculated.
					35.4	44	28	•	•	
					53.2	49	22	•	•	
Richardson & Reynolds, 1991	Central Maine	MSW	1-2 yrs			Ave=96		12 Test Pits	Good	
Sargunan et al., 1986	Madras, India	MSW	10-50	Uncompacted	30-48	34-43		"In-situ Tests"(?)	Fair	
Schumaker, 1972 (From Oweis & Khera, 1986)				Poor		18.5			Fair	Do not have details on measurement technique.
				Moderate		29.6-37			•	
				Good		99.6			•	
Sharma et al., 1990	Richmond, CA	MSW & Liquids	?-40			46		Surveyed	Fair	MSW to daily cover ratio = 6:1
Siegel et al., 1990	S. CA	MSW	6-40 yrs		10-45		60-108	13 cm Acrylic Tubes	Fair	Samples depths = 15-82 ft Soil content = 20 to 95%
Stone, 1975		MSW No soil	Fresh	Stand. Compact'n no Soil added	29-46	35-46	26-34	Surveyed	Fair	
Stone & Friedland, 1969	U.S.					Ave=45 S.D.=18		National survey	Poor	Results of survey of 103 U.S. Operators.

19 of 26

versus average normal stress. This was done by plotting back-calculated pairs of c and ϕ against normal stress (see Figure 6) which resulted in sets of lines having y-intercepts equal to c and slopes equal to $\tan(\phi)$. The average normal stress along the failure surface was assumed to be the normal stress at which the c-ϕ lines intersected one another (point B). The back-calculated value of c resulting when ϕ is set to zero is the average shear mobilized along the failure surface (point A on Figure 6). The average normal stress thus determined was checked by estimating the location of the failure surface and calculating the average normal stress based on the reported unit weight of the waste and any applied loads. In general, the two values of average normal stress were in agreement.

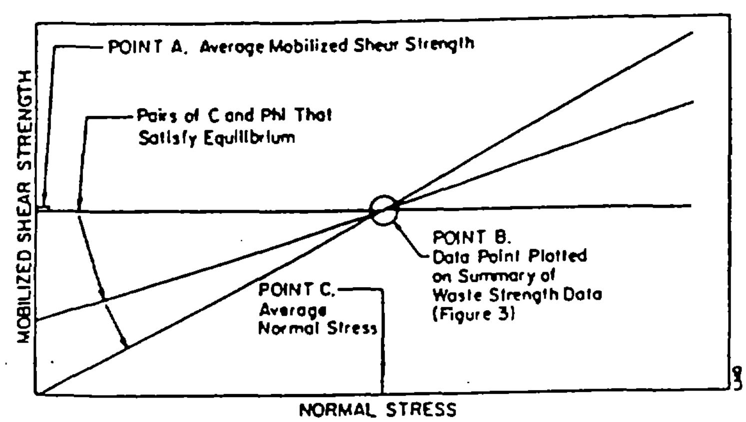


FIGURE 6. Method of Analyzing an Individual MSW Strength Case History (after Howland & Landva, 1992)

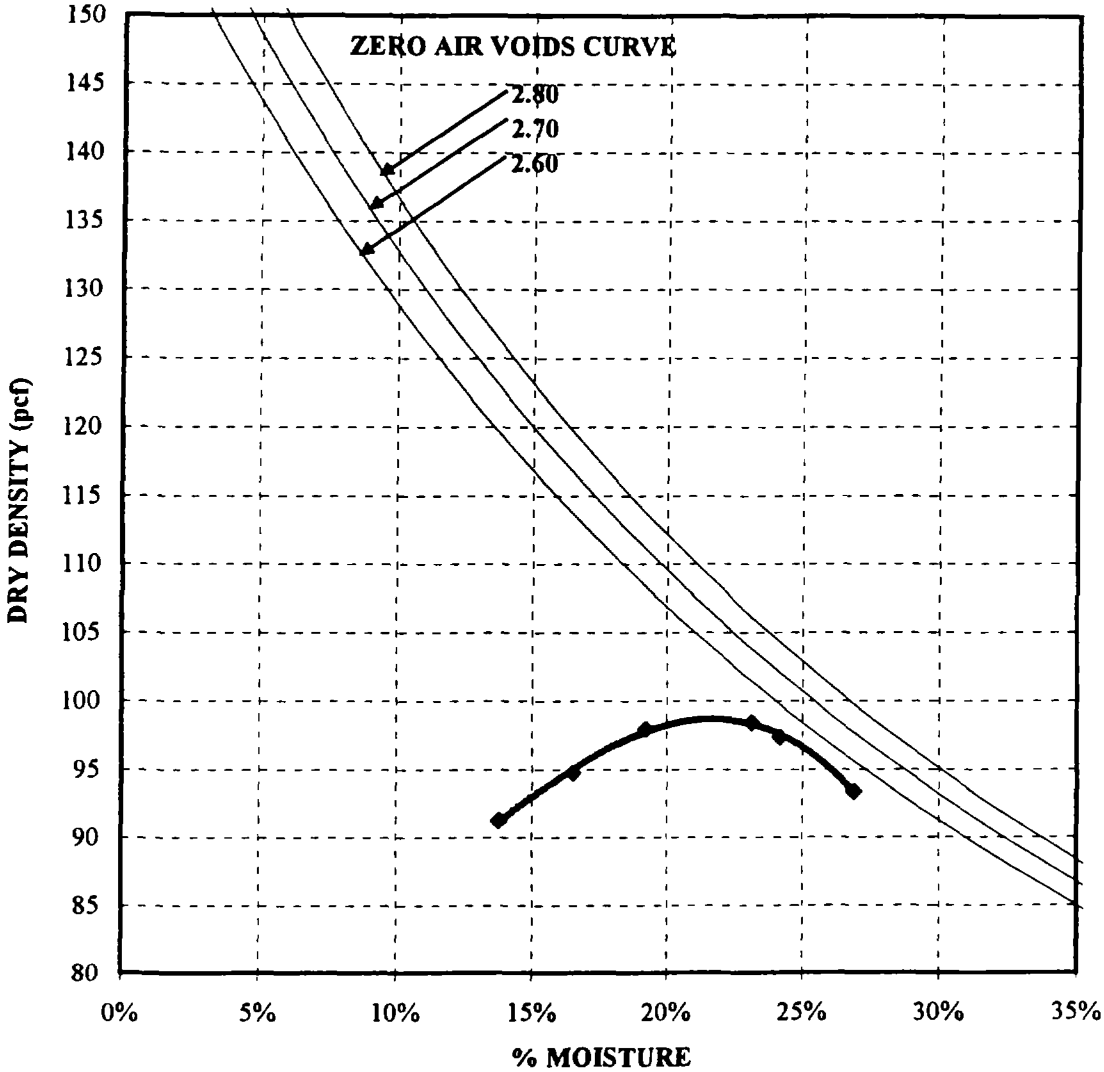
The MSW strength data determined as described above are summarized in Figure 7. Included on Figure 7 is a line defining the strength envelope used by the authors in their design. This line, defined by c = 200 psf and ϕ = 23°, represents the lower bound of the data. The values suggested by Jessberger and Kockel (1991) are shown by the broken line in Figure 7.

Discussion of Shear Strength Data

The application of vane shear testing is not recommended for MSW because fairly homogeneous material is required for useful results (Jessberger & Kockel, 1991). For instance, the vane shear data obtained by Earth Technology varied from 1700 psf to 5000 psf. The wide range of values was believed to be the result of the vane shear device encountering pieces of asphalt and wood. Strength values obtained with penetration testing are also questionable for the same reason. Furthermore, there are no published correlations between refuse strength and blow counts (Mitchell & Mitchell, 1992).

Howland & Landva found that the results of back-analyses indicate a lower waste strength than the results of direct measurements. They speculated that this difference might be due to the peat-like fibrosity having a bigger effect on the small-scale direct measurements as opposed to the larger-scale associated with back-calculated values. Mitchell & Mitchell point out that, since back-calculated values are often obtained from slopes which did not fail, the resulting values of the Mohr-Coulomb strength parameters are conservative by an unknown amount. Singh and Murphy (1990) recommended that strength parameters chosen for use in stability studies should be "interpreted judgmentally in favor of least

MOISTURE-DENSITY CURVE
ASTM D 698



SAMPLE #:	LEMON LANE WEST	MAXIMUM DRY DENSITY (pcf)	98.50
DESCRIPTION:	Dark yellowish brown Silty Clay, trace sand, trace gravel (CL)	OPTIMUM MOISTURE (%)	21.50
		DELIVERED MOISTURE (%)	25.22

'NATIVE SOIL' →

LL:	35
PL:	22
PI:	13

DATE:	04/06/00
TECH:	NT
REVIEW:	RMW

CBS/LEMON LANE LANDFILL/IN
993-6573.0210

GOLDER ASSOCIATES INC.
CHERRY HILL, NEW JERSEY

USGS
Home Page
Zipcode Lookup page

$a_H = 0.1g$

NATIONAL SEISMIC HAZARD MAPPING PROJECT

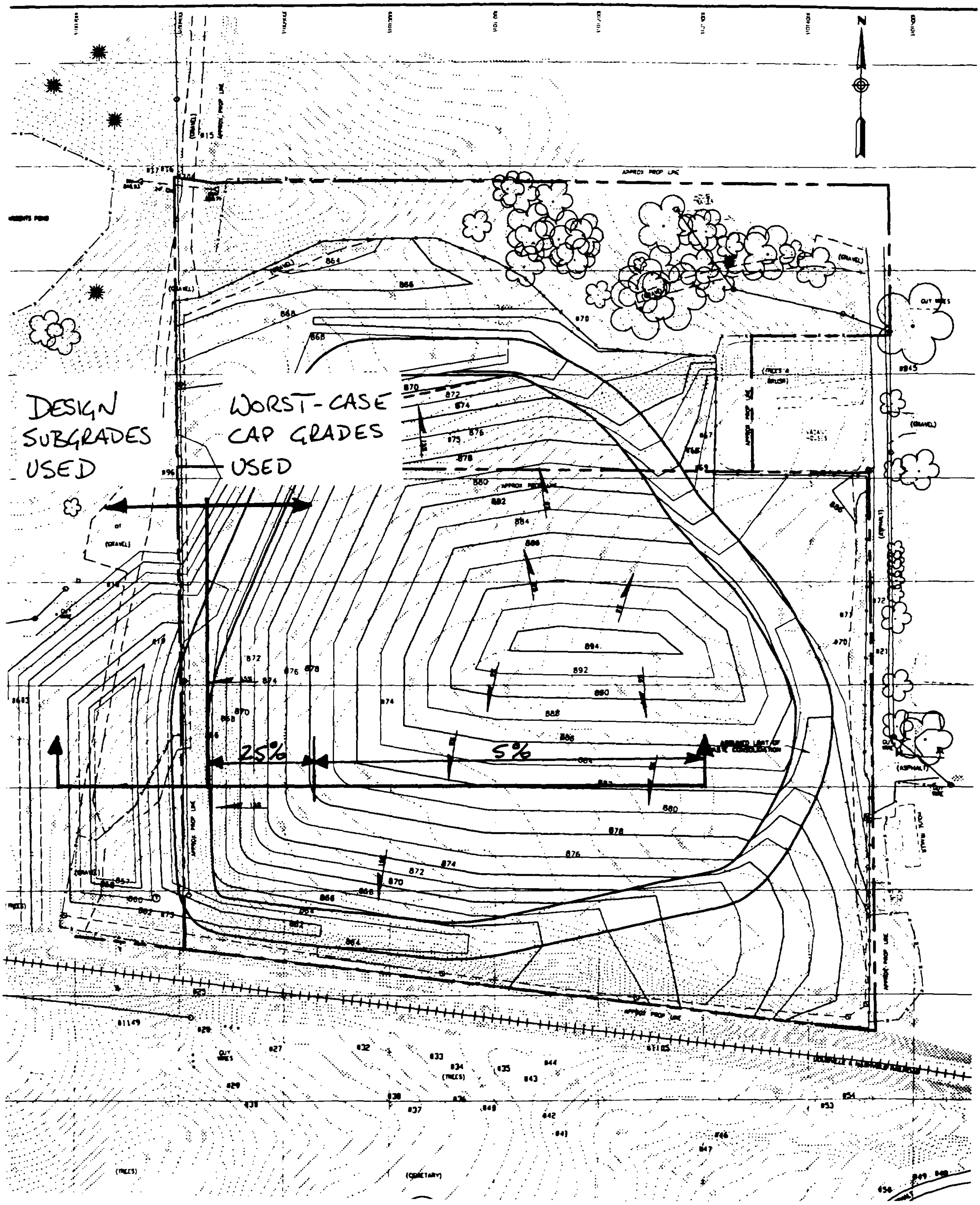
USGS, Central Region, Geologic Hazards Team
Golden, Colorado

```
The input zip-code is 47401.
ZIP CODE                        47401
LOCATION                        39.1543 Lat.  -86.5312 Long.
DISTANCE TO NEAREST GRID POINT  5.7506 kms
NEAREST GRID POINT              39.2 Lat.  -86.5 Long.
Probabilistic ground motion values, in %g, at the Nearest Grid point are:
             10%PE in 50 yr   5%PE in 50 yr   2%PE in 50 yr
   PGA          4.295000        6.891054       12.269340
0.2 sec SA     10.345160       16.320940       27.205641
0.3 sec SA      8.404608       13.493420       23.917431
1.0 sec SA      3.823350        6.286249       11.869810
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

The input zip-code is .
Zip code is zero and we go to the end and stop.

Reference #7

22 of 26


DESIGN SUBGRADES USED
WORST-CASE CAP GRADES USED
25%
5%
APPROX PROP LINE
894
892
890
888
886
884
882
880
878
876
874
872
870
868
866
864

Golder Associates

SUBJECT CBS: Lemon Lane Landfill : N-values		
Job No. 993-6573 Ref.	Made by MFH Checked DBW Reviewed [illegible]	Date 5/24/00 Sheet 1 of 3

Objective: To determine an average blow count for native soil based on subsurface information provided in reference 1 below. To correlate that N-number with soil property values

Reference: 1) Borings B-4 through B-8 obtained from Blasland + Bouck Engineers, Phase 1 Report, entitled, "Supplemental Hydrogeologic Investigation" November 1998. Boring logs, dated May 1984, Provided by CBS.

2) Foundation Analysis + Design, 3rd ed J. E. Bowles

Method: Review boring logs B-4 through B-8 and tabulate range of N-numbers for native soil (below fill). Ignore anomolous blow counts (i.e. N=80) in calculation of an average N value.

Boring #	N Range	N avg.	Depth Range
B-4	11-16	13.5	8'-12'
B-5	11-55	37	26'-43.5'
B-6	24-44	36	10.5'-21'
B-7	10-20	15	4.5'-10.5'
7I	14-34	27.2	4'-18.2'
B-8	10-32	19.4	26.5'-39'

Golder Associates

SUBJECT CBS : Lemon Lane Landfill : N-values		
Job No. 993-6573 Ref.	Made by MFH Checked DBW Reviewed	Date Sheet 2 of 3

Conclusion: N average = 25

N Range = 15 - 37, assume N = 15

According to reference 2 for a cohesive soil with a N-value of 15:

$q_u = 4$ Ksf

$$c = \frac{q_u}{2} = \frac{4\,ksf}{2} = 2\,ksf = 2000\,psf$$

$c = 2000$ psf

REFERENCE #10

Table 3-2 Empirical values for ϕ, D_r, and unit weight of granular soils based on the standard penetration number with corrections for depth and for fine saturated sands.

Description		Very loose		Loose		Medium		Dense		Very dense
Relative density D_r*	0		0.15		0.35		0.65		0.85	1.00
Standard penetration no. N			5–10		8–15		10–40		20–70	> 35
Approx. angle of internal friction $\phi°$†	25–30°		27–32°		30–35°		35–40°		38–43°	
Approx. range of moist unit weight γ, pcf (kN/m³)		70–100‡ (11–16)		90–115 (14–18)		110–130 (17–20)		110–140 (17–22)		130–150 (20–23)

* Depends on p_o ranging from 70 to 500 kPa. Low value of N corresponds to lesser p_o.

† After Meyerhof (1956). $\phi = 25 + 25D$, with more than 5 percent fines and $\phi = 30 + 25D$, with less than 5 percent fines. Use larger values for granular material with 5 percent or less fine sand and silt. See also Eq. (4-10) for estimate of ϕ.

‡ It should be noted that excavated material or material dumped from a truck will weigh 70 to 90 pcf. *Material must be quite dense and hard to weigh much over 130 pcf. Values of 105 to 115 pcf for nonsaturated soils are common.*

Table 3-3 Empirical values for q_u* and consistency of cohesive soils based on the standard penetration number.

Consistency		Very soft		Soft		Medium		Stiff		Very stiff		Hard
q_u, ksf (kPa)	0		0.5 (25)		1.0 (50)		2.0 (100)		4.0 (200)		8.0 (400)	
N, standard penetration resistance	0		2		4		8		16		32	
γ_{sat}, pcf (kN/m³)		100–120 (16–19)				110–130 (17–20)				120–140 (19–22)		

* These values should be used as a guide only. Local cohesive samples should be tested, and the relationship between N and the unconfined compressive strength q_u established as $q_u = KN$.

Assume $N = 16$

$q_u = 4\ \text{Ksf}$

$c = \frac{q_u}{2} = 2\ \text{Ksf} = 2000\ \text{psf}$

APPENDIX E

SETTLEMENT CALCULATIONS

Golder Associates

SUBJECT CBS, Lemon Lane Landfill - Settlement		
Job No. 993-6573 Ref.	Made by MFH Checked DW Reviewed	Date May 23, 2000 Sheet 1 of 5

Objective: To estimate the amount of settlement that will be experienced by the cap system, and determine the impact the settlement will have on it.

Method: The settlement will be calculated using the equation for secondary consolidation found in reference 1 page 279

$$S_s = C_\alpha \cdot H \cdot \log\left(\frac{t_2}{t_1}\right)$$

where: S_s = Secondary Settlement (ft.)

C_α = Coefficient of secondary compression

H = Depth of fill (ft.)

t_1 = Time at which primary consolidation is completed

t_2 = Time at which secondary consolidation is completed

References: 1) "Principles of Geotechnical Engineering," 3rd Edition B. Das

2) "Geotechnical Properties of Municipal Solid Waste and Their use in Landfill Design" J. Fassett, G. Leonards, P. Repetto

3) "Geotechnics of Waste Fills Theory and Practice" A. Landua, G. Knowles

4) "Figure 5 - Cap Cross Sections" Pre-Final Design Report, Golder Associates, May 2000

Assumptions: - The primary consolidation is assumed to have already occured.

- C_α is assumed to be 0.04 conservatively based on the following studies in reference #2

  Sowers (1973) $C_\alpha = 0.025$

  York (1977) $C_\alpha = 0.02 - 0.04$

- Depth of fill is assumed to be 15' based final grades presented on Figure 4, Final CAP Grades (Actual thickness is 11.4 feet, 15 ft selected for conservatism)
- Completion of secondary consolidation takes 25 years (300 months)
- t_1 is assumed to be 1 month

Calculations:

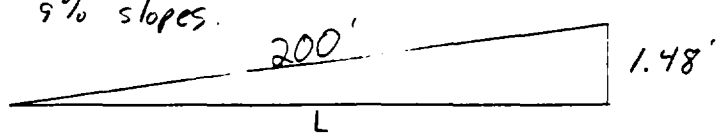
$$S_s = C_\alpha \cdot H \cdot \log\left(\frac{t_2}{t_1}\right)$$

$$S_s = (0.04)(15)\log\left(\frac{300}{1}\right)$$

$$S_s = 1.48'$$

What effect does the settlement have on the cap?

Examination of Reference 4: Max. slope length is 200' based on 9% slopes.



Golder Associates

SUBJECT CBS. Lower Lane Landfill - Settlement		
Job No. 993-6573 Ref.	Made by MFH Checked Reviewed	Date 5/23 Sheet 3 of 5

$$L = \sqrt{200^2 - 1.48^2}$$

$$L = 199.99$$

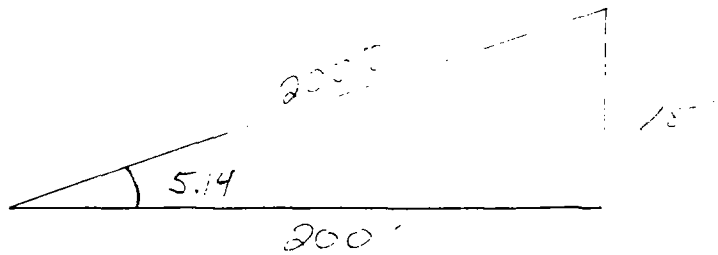
$$\text{Strain} = \frac{0.01}{200} = 0.00005$$

Conclusion: Based on the methodology and assumptions stated herein, the secondary consolidation of 1.48' after 25 years will not develop enough strain to effect the performance of the cap system. The reduction of the cap slope due to the estimated settlement is evaluated on the following page 4 of 5

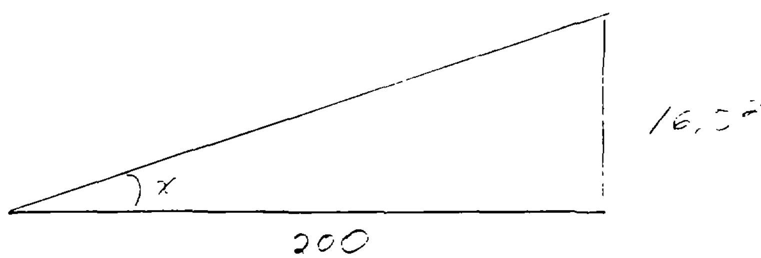
Golder Associates	SUBJECT CBS: Lemon Lane Landfill - Settlement	
Job No. 993-65.5	Made by MFH	Date May [illegible]
Ref.	Checked DEW	Sheet 4 of 5
	Reviewed [illegible]	

Slope reduction due to Settlement

9% [illegible] (Prior to Settlement)



Based on the secondary consolidation of 1.48' determined in the LLL Settlement Analysis the slope becomes:



$$\tan x = \frac{16.52}{200}$$

$$x = 4.72$$

slope = 8.2% after settlement

REFERENCE	SURCHARGE OR LOAD	COMPRESSIBILITY IMMEDIATE (%)	CONSTRAINED MODULUS	COMPRESSION INDEX	MOD. COMPR INDEX	SEC. COMPR. INDEX	MOD. SEC. COMPR. INDEX	TEST METHOD	MONITORING PERIOD (yr)	RELIABILITY	COMMENTS
Moore & Peddler, 1977			250-710 kPa Ave=450 kPa				0.06	Plate Load Tests in Lab		Fair	Waste tested in lab; very little compaction.
Oweis & Khera, 1990					0.26 0.08		0.24 0.02			Poor Poor	
Rao et al., 1977	1000 psf				0.1		0.13	Settlm't Plates	.27-.82	Fair	MSW depth not accurate; Mod. Sec. Compression not linear
Sargunan et al., 1986				0.44		0.0036-0.005		Oedometer		Poor	
Sheurs & Khera, 1980	6 ft fill				0.18			Survey	4-5	Good	
Sowers, 1968	10 ft fill						0.01		1.2-5.7	Good	
Sowers, 1973				2.75	0.46	0.45	0.075	Suggested rates		Fair	Values shown are for e-init. = 5
				0.75 Ave=1.75	0.125 Ave=0.29	0.15 Ave=.30	0.025 Ave=.05	Suggested rates		Fair •	
Stone, 1975	1 ft fill • •						0.168 0.022 0.039	Survey • •	0.37 0.44 1.1	Good • •	Cell 2 filled with material removed from Cell 1
Watts & Charles, 1990			520-1100 kPa Ave=780 kPa				0.1	Load tests & settlm't casing	3	Good	
			770-1025 kPa Ave=925 kPa				0.23	Same	1	Good	
Yen & Scalon 1975							0.07 0.07 0.06			Fair • •	Values from Druschel & Wardwell, 1991
York, et al. 1977					.08-.21		.02-.04			Fair	

Sheet 4 of 4

16

5 of 5

APPENDIX F

CONSTRUCTION QUALITY ASSURANCE PLAN

CONSTRUCTION QUALITY ASSURANCE PLAN

LEMON LANE LANDFILL

BLOOMINGTON, INDIANA

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Purpose and Scope

This Construction Quality Assurance Plan (CQAP) has been prepared by Golder Associates Inc. (Golder Associates) on behalf of CBS Corporation for the Lemon Lane Landfill in Bloomington, Indiana. The purpose of this CQAP is to describe the quality assurance program that will be implemented during construction of the landfill cap and associated stormwater management features in order to confirm and document that construction is completed in accordance with the intent of the Contract Drawings and Technical Specifications.

This CQAP describes the following elements:

- Responsibilities and authorities of all organizations and key personnel involved in the design and construction of the Remedial Action;
- Protocols for sampling and testing used to monitor construction;
- Identification of construction quality assurance (CQA) sampling activities including sample size, locations, and testing frequencies; and,
- Reporting requirements for CQA activities including summary reports, inspection data sheets, problem identification and corrective measures reports, design acceptance reports, and final documentation. In addition, provisions for final storage of all records are specified consistent with the requirements of the Consent Decree.

Details of materials, construction requirements, and procedures are included in the Technical Specifications, which are referenced by this CQAP.

This CQAP addresses construction quality assurance (CQA), which differs from construction quality control (CQC). In general, CQA refers to measures taken to assess if the installer or contractor is in compliance with the plans and specifications for a project. CQC refers to measures taken by the installer or contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project. This plan is independent of QC programs conducted by manufacturers and the Remedial Action Constructor and subcontractors, which are described in the Technical Specifications.

This CQAP addresses the construction of the landfill cap, stormwater management features, piezometers and placement of soil outside the limits of the cap. Specifically, this CQAP addresses the preparation of the geosynthetic soil subgrade (i.e., cap cushion soil), the geosynthetic components of the cap system, the cover soil layer placed directly above the geosynthetic, the geosynthetics components of the stormwater management features, the piezometers and associated penetrations through the geosynthetic cap. This CQAP also addressed the placement and compaction of soil that is required outside the limits of the landfill cap to facilitate drainage.

1.2 Construction Quality Assurance Program

The CQA program is a planned system of activities that provides confirmation and documentation that a project is constructed in accordance with the intent of the Contract Documents. It includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed work.

The basic components of the CQA program are:

- Preparation of a CQA Plan;
- Pre-construction review of project components;
- Conformance testing of geosynthetic and soil materials;
- Confirming and documenting survey control of final grades;
- Confirming and documenting testing of soil components during placement and compaction;
- Confirming and documenting construction of stormwater management features;
- Confirming and documenting construction of the piezometers;
- Preparation of Daily Reports;
- Review of technical and laboratory data;
- Final walk over and favorable review of the completed work; and,
- Compilation and presentation of a Final Record Documentation Report.

These CQAP guidelines provide for qualified personnel to monitor the progress and quality of construction. This program is intended to provide an objective overview of construction progress and identify potential deficiencies or problem areas during construction. The CQA program can also assist the Remedial Action Constructor in completing the project more efficiently by requiring compliance with quality control specifications before the project proceeds to the extent where substantial work may have to be redone in order to correct a defect.

The CQAP identifies the personnel involved in CQA, and describes roles and responsibilities of the associated parties, QA reporting and record storage requirements. The CQAP also calls for a narrative describing construction, test results, and record drawings to be compiled into a Construction Completion Report signed by a Professional Engineer, which certifies that the portions of construction covered by the CQAP were completed in general conformance with the Contract Drawings, Technical Specifications, and approved modifications.

2.0 PROJECT TEAM ORGANIZATION AND RESPONSIBILITIES

This section describes the organization and individual responsibilities during the Remedial Action.

2.1 CBS

CBS is responsible for the overall construction of the Remedial Action. CBS must comply with the requirements of the USEPA and demonstrate, by submission of construction QA documentation, that the facility was constructed as specified in the design. CBS will retain independent design, QA, and construction organizations to accomplish the work and will have the authority to hire and fire these organizations. CBS also has the authority to accept or reject QA plans, reports, and recommendations of the Quality Assurance Contractor, and the materials and workmanship of the Contractor or subcontractor.

2.2 USEPA, IDEM AND CITY OF BLOOMINGTON

The USEPA, Indiana Department of Environmental Management (IDEM) and the City of Bloomington (CB) are overseeing the completion of the landfill closure through the CERCLA program. It is the responsibility of the USEPA, IDEM and CB to review CBS's plans for compliance with the regulatory requirements for this site. The USEPA, IDEM and CB also have the authority to review all construction QA documentation during or after construction to confirm that procedures outlined in the approved CQAP were followed, and that the facility was constructed as specified in the design. These activities may involve on-site inspections or testing independent of the QA program.

2.3 CBS Site Representative

The CBS Site Representative is both directly responsible for the construction contract administration and for the management of all phases of this project for CBS. The CBS Site Representative acts as a liaison and is in direct communication with the Quality Assurance project staff, the Contractor, and Subcontractors. General responsibilities of the CBS Representative will include:

- Prepare an agenda for, preside at, and record project meeting minutes, including pre-construction and weekly progress meetings, substantial completion, or other meetings as necessary;

- Monitor and coordinate the Remedial Action Constructor's work in relation to the schedule and conformance to the Contract Documents;

- Document that the required QC testing has been performed in accordance with the Technical Specifications and report data to the Remedial Designer, and Quality Assurance Official (QAO);

- Receive and review shop drawings and other material submittals from the Remedial Action Constructor and submit to the Remedial Designer for review. Coordinate with the Remedial Action Constructor to incorporate the Remedial Designer review comments;

- Schedule and coordinate quality assurance monitoring activities with the QAO;

- Coordinate any proposed substantive changes with the Project Coordinator, Remedial Designer, QAO, and Remedial Action Constructor;

- Coordinate any design clarifications or interpretations with the Remedial Designer and Remedial Action Constructor;

- Prepare periodic construction progress reports for distribution to the project team; and,

- Maintain an on-site project record drawings and project file for storing of originals or copies of reports generated during construction.

2.4 Remedial Action Constructor

WRS Infrastructure and Environment, Inc., has been chosen by CBS as the Remedial Action Constructor. The selected Remedial Action Constructor is qualified to undertake the types of construction activities to be implemented, and completed a similar project at Neal's Landfill in Bloomington, Indiana in 1999 with essentially the same personnel.

The Remedial Action Constructor will assign a Project Superintendent as the responsible person in charge of all aspects of the project. The Project Superintendent will have a background in engineering or construction management with significant experience in construction and contract administration. The Remedial Action Constructor will be responsible for constructing the work in accordance with the intent of the Contract Documents and implementation of the Health and Safety Plan.

The Remedial Action Constructor will engage various subcontractors to implement the work, including a Geosynthetics Installer with extensive experience in installation, seaming, and field testing of the specified geomembrane and other geosynthetics components. The subcontractors will provide a field supervisor who will report directly to the Remedial Action Constructor Project Manager.

Upon completion of the project, the Remedial Action Constructor will provide record drawings to the CBS Site Representative and Remedial Designer for review.

2.5 Remedial Designer

Golder Associates is the Remedial Designer. The responsibilities of the Remedial Designer during Remedial Action include the following:

- Review all proposed design and specification changes;
- Provide clarifications to the Contract Drawings and Technical Specifications;
- Review submittals required by the Contract Drawings and Technical Specifications including quality control tests; and,
- Participate in the pre-construction, substantial completion, and weekly progress meetings (approximately every one to two weeks based on the level of activity) to review construction activities and conformance with the intent of the Remedial Design.

Design and specification changes will be transmitted through the CBS Site Representative, the QAO, and the Project Coordinator for review and approval. The Remedial Designer will evaluate proposed materials and construction changes during construction for compliance with the intent of the Contract Drawings and Technical Specifications.

2.6 Quality Assurance Official

The QAO will be responsible for overseeing and implementing this CQA program on a full-time basis. The QAO will perform the CQA tasks required by this CQAP and will confirm and document that the project construction has been completed in general conformance with the Contract Documents. Golder Associates will serve as the QAO during installation of the geosynthetic components of the cap and surface water management features. PSARA Technologies Inc. will serve as the QAO for construction of all other components of the Remedial Action. The QAO will have the authority to reject materials and workmanship provided by the Remedial Action

Constructor that are not in compliance with the Contract Documents. Responsibilities of the QAO for construction activities identified in this CQAP include the following:

- Review of the Contract Drawings, Technical Specifications, and related workplans to verify compliance with CQAP requirements;
- Work with the CBS Site Representative to review construction activities with the Remedial Action Constructor;
- Attend weekly project status meeting with government parties;
- Coordinate and schedule CQA testing with construction activities;
- Observe the construction quality control (CQC) operations;
- Review, in conjunction with the Remedial Designer and CBS Site Representative, corrective measures to be implemented during construction when deviations from the CQAP occur;
- Observe CQC activities to help ensure that testing and documentation are complete, accurate and in general accordance with the Contract Documents;
- Evaluate the soils, geosynthetics, and other testing laboratories for the project;
- Observe and document placement and compaction of fill and backfill;
- Observe and document geosynthetic material placement, non-destructive and destructive seam testing, and seaming and repair operations;
- Work with CBS Site Representative to determine that testing equipment used and tests performed are in accordance with the Technical Specifications and industry standards;
- Observe, document, and report on tests;
- Report any identified deficiencies not satisfactorily corrected to CBS Site Representative and Remedial Designer;
- Prepare daily quality assurance construction reports;
- Maintain an on-site project file for storing the originals or copies of all CQC reports and CQC data sheets and reports generated during construction;
- Verify performance of as-built surveying by the Remedial Action Constructor in accordance with the Contract Documents; and,
- Preparation of the Final Documentation Report at the completion of the project.

CONSTRUCTION ACTIVITIES

The following is a brief discussion of the Remedial Action Constructor's major remedial construction activities to be monitored by the QAO.

2.7 Earthwork

Earthwork activities include:

- Fill placement above consolidated waste material to create the cap cushion soil layer;
- Backfill placement outside the limits of the cap;
- Proof-rolling of the cap cushion soil layer prior to geosynthetics installation;
- Placement of protective cover and vegetative cover over the geosynthetics;
- Placement of riprap, and coarse aggregate;
- Installation of access roads; and,
- Installation of surface water management structures.

2.8 Geosynthetics

Geosynthetics installation activities include:

- Installation and seaming of the Geosynthetic Clay Liner (GCL) and textured geomembrane as part of the cap and surface water management features;
- Installation of "boot" seals around geomembrane penetrations for the piezometers and other penetration;
- Installation and seaming of geotextile components of the cap, access roads and surface water management features; and,
- Installation of the geocomposite drainage layer.

2.9 Drilling

Drilling activities include construction of piezometers.

2.10 Miscellaneous

In addition to the activities described above, additional miscellaneous activities are also required, including:

- Installation of new fencing and gates;
- Establishment of permanent vegetation on the completed landfill cap and other areas disturbed by construction activities; and,
- Installation of stormwater management features, retention basin, RCP culvert pipes and basin outlet structure.

3.0 QUALITY ASSURANCE DOCUMENTATION

The following sections present minimum requirements of the CQA monitoring and CQC testing documentation program to be performed by the QAO in conjunction with the Remedial Action Constructor. This monitoring and testing program is intended to supplement the Technical Specifications.

3.1 Earthwork

The earthwork CQA testing program consists of pre-construction and construction testing of native and imported soil such as fill, backfill, structural fill, vegetative layer, cushion soil, cap cover soil and coarse aggregate materials. The characteristics of these soil types are defined in the Technical Specifications. Prior to and during construction, each soil type will be evaluated to determine if it meets requirements. Soil samples will be obtained in accordance with American Society for Testing and Materials (ASTM) standards ASTM D75 and ASTM D420, and will be tested by a geotechnical testing laboratory approved by the Remedial Designer.

3.1.1 Pre-Construction Testing

Pre-construction testing will be performed on the imported materials to determine whether they meet requirements listed in the Technical Specifications. Soil samples will be provided from each proposed source. The specific tests to be performed, including testing frequency, for each material type are presented in Table 4-1.

TABLE 4-1
PRE-CONSTRUCTION TESTING MINIMUM FREQUENCIES[1]

Test and Method	Cap Cover & Cushion Soil (cy)	Fill/ Backfill Structural Fill (cy)	Vegetative Layer (cy)	Pea Gravel (cy)
Particle Size[2] (ASTM D422, C117, C136)	5,000	5,000	2,000	3,000
Atterberg Limits (ASTM D4318)	5,000	5,000	---	--
Moisture Content[3] (ASTM D2216 or D4643)	5,000	5,000	---	--
Standard Proctor (ASTM D698)	5,000 (cushion soil only)	5,000	---	--
pH (ASTM D4972)	---	--	2,000	---
Organic Content (ASTM D2974)	---	--	2,000	---
Specific Gravity (ASTM D854)	5,000	5,000	---	---
Soil Fertility (Baker or LaMotte Test)	--	--	2,000	--

[1] Specific frequency refers to one test per the presented volume or one per material type or source, whichever is greater.
[2] ASTM D422 is applicable for fill, protective cover, and vegetative cover. ASTM C117 and C136 are applicable to all other soil construction materials. Use the USCS for description and identification (ASTM D2488).
[3] Natural moisture content.

3.1.2 *Construction Testing*

The tests to be performed for each material type, including testing frequency, are presented in Table 4-2.

TABLE 4-2
CONSTRUCTION TESTING - MINIMUM FREQUENCIES[1]

Test and Method	Vegetative Layer/ Cover Soil	Cushion Soil/ Fill/Backfill[2]	Dense Graded Aggregate/Riprap	Structural Fill
In-Place Density (ASTM D2922)	----	4/acre/lift	--	1/100 linear feet of trench/lift
Water Content (ASTM D3017)	----	4/acre/lift	--	1/100 linear feet of trench/lift
Thickness[3]	4/acre	4/acre/lift	2/500 sf	1/100 linear feet of trench/lift

[1] Specific frequency refers to one test per the presented frequency or one per material type, whichever is greater.
[2] Backfill will be tested to a distance of 10 feet beyond the limits of the perimeter channel.
[3] Thickness shall be checked by field survey. Final quantities will be verified by as-built

In accordance with Section 02223 and 02224 of the Specifications, backfill and pipe structural fill materials shall be placed and compacted in maximum 12-inch lifts to achieve a minimum density of 95 percent of maximum dry density as determined by the Standard Proctor test. Similarly, in accordance with Section 02223 and 02224 of the Specifications, fill and cushion soil shall be placed and compacted in maximum 12-inch lifts to achieve a minimum density of 90 percent of maximum dry density as determined by the Standard Proctor test. Care shall be taken not to damage the pipe during compaction of backfill, or proofrolling. The moisture content of the fill and cushion soil shall be such that the specified density may be obtained. Puddling or jetting for compaction will not be permitted. If the Remedial Action Constructor makes reasonable efforts, as determined by the QAO, to achieve the specified percent compaction but cannot meet the 95% compaction requirement, an alternate percent compaction, agreed upon by the CBS Site Representative and Remedial Designer, may be utilized.

Compaction of cover soil above the geocomposite drainage layer shall be achieved by repeated passes as provided by the spreading equipment with a ground pressure of 5 psi or lighter or other method favorably approved by the CBS Site Representative. Such equipment shall be tracked and not have rubber tires.

3.1.3 Construction Monitoring

All earthwork will be monitored full-time to confirm and document that the construction is in general accordance with the Contract Documents. The Remedial Action Constructor will be responsible for establishing the design lines and grades. Visual observations or surveying, as appropriate throughout the construction process, will be conducted to evaluate whether the materials are placed to the lines and grades as shown on the Contract Drawings.

3.2 Geosynthetics

The CQA program for geosynthetics consists of reviewing the Geosynthetics Installer's QC submittals, material conformance testing, construction monitoring, and testing. The types of geosynthetics used in the construction of the remedy include geosynthetic clay liners (GCL), geomembrane non-woven geotextile, and geocomposite. The geosynthetic QC submittals and material conformance testing requirements are defined in the Technical Specifications. Prior to and during construction, these geosynthetics will be sampled and tested to determine if the materials meet the requirements as listed in the Technical Specifications. Testing will be performed by a Geosynthetics Accreditation Institute (GAI) accredited Geosynthetics Laboratory, as approved by the Remedial Designer.

3.2.1 Conformance Testing

Prior to geosynthetics installation, samples of the geosynthetics will be obtained for conformance testing by the QAO. The conformance testing minimum frequency will be at a rate of 1 per 100,000 square feet from material delivered to the Site, or one sample per lot, whichever results in the greater number of conformance samples. Samples will be taken across the entire width of the roll and will not include the first "wrap" or a minimum of 3 feet. The samples will be about 3 feet long in the machine direction by the roll width. The QAO will mark the machine direction, roll number, project specific information, and date the sample was obtained on the sample and forward the sample to the approved geosynthetics laboratory. The minimum required geosynthetic conformance tests are presented in Tables 4-3, 4-4, 4-5, and 4-6.

TABLE 4-3
GCL CONFORMANCE TESTING

Test	*Test Method*	*Frequency (sf)*[1]
GCL Thickness (dry)	(ASTM D1777)	1/100,000
Bentonite Content	(ASTM D5993)	1/100,000
Hydraulic Conductivity (at 3 psi confirming pressure)	(ASTM D5321)	1/100,000

TABLE 4-4
GEOMEMBRANE CONFORMANCE TESTING

Test	Test Method	Frequency (sf)[1]
Density	(ASTM D1505)	1/100,000
Carbon Black Content	(ASTM D1603)	1/100,000
Thickness	(ASTM D5199)	1/100,000
Tensile Properties	(ASTM D638)	1/100,000
Puncture Resistance	(ASTM D4833)	1/100,000
Carbon Black Dispersion	(ASTM D5596)	1/100,000
Tear Resistance	(ASTM D1004)	1/100,000

TABLE 4-5
GEOTEXTILE CONFORMANCE TESTING

Test	Test Method	Frequency (sf)[1]
Mass per unit area	(ASTM D5261)	1/100,000
Grab Tensile Strength and Elongation	(ASTM D4632)	1/100,000
Puncture strength	(ASTM D4833)	1/100,000
Mullen Burst	(ASTM D3786)	1/100,000
Trapezoidal Tear	(ASTM D4533)	1/100,000
Apparent Opening Size	(ASTM D4751)	1/100,000

TABLE 4-6
GEOCOMPOSITE CONFORMANCE TESTING

Test	Test Method	Frequency (sf)[1]
Thickness	(ASTM D5199)	1/100,000
Adhesion Strength	(ASTM F904 modified)	1/100,000
Transmissivity	(ASTM D4716)	1/100,000

[1] Specified frequency or one per lot, whichever is greater.

All conformance tests will be performed in accordance with the Technical Specifications. The QAO will review the test results and will report any nonconformance to the CBS REPRESENTATIVE, the Remedial Designer, the Remedial Action Constructor, and the Geosynthetics Installer.

3.2.2 Construction Monitoring and Testing

All geosynthetic components will be monitored during installation. The QAO will review surveying information throughout the construction process to evaluate whether materials are placed to the lines and grades as shown on the Contract Drawings.

The QAO will review the following Remedial Action Constructor's Geosynthetics Installer documentation:

- QC documentation recorded during installation;
- daily reports detailing the personnel present on-site, the progress of the work, the arrival of materials, and any problems encountered; and

- subgrade surface acceptance certificates for each area to be covered by the geosynthetics, signed by the Geosynthetics Installer's Superintendent and the Remedial Action Constructor.

The QAO will observe and document the following items related to geosynthetics installation:

- delivery and unloading of geosynthetic materials to the Site to verify that the materials are in good condition and properly labeled;
- geosynthetic storage area shall be uniform and free of possible sources of damage, such as mud, dirt, debris, and dust;
- geosynthetic packaging identification slips for verification and generation of an on-site materials inventory;
- subgrade conditions prior to geosynthetics installation. Verify that any identified deficiencies (e.g., surface irregularities, loose soil, protrusions, in-place construction stakes, excessively soft areas, stones, desiccation cracks) are corrected;
- lines and grades have been verified by the Remedial Action Constructor's surveyor;
- handling of geosynthetic materials from storage to the work area;
- temporary and permanent anchoring of geosynthetics; and,
- required overlap distances are maintained.

3.2.3 GCL Monitoring

During shipment and storage, the GCL shall be wrapped in protective heavy-duty plastic or similar protective covering to prevent damage. Upon arrival to the site, the QAO Engineer will inspect the material for damage. Rolls found to be damaged will be rejected. Materials will be stored in a dry place free from disturbance and protected from moisture, soil, mud, dust, debris, traffic and vandalism.

Subgrade Condition

Before GCL placement, the QAO shall confirm that the subgrade surface is in an acceptable condition by walking the prepared subgrade with the GCL installer and reviewing the subgrade acceptance certification prepared by the installer. Foreign materials and protrusions shall be removed. Cracks and voids shall be filled and the surface smooth shall be smooth and uniformly sloping. The receiving soil surface shall be compacted in accordance with the specification requirements.

Prior to installation, the QAO shall confirm and document that the grades upon which the GCL is to be deployed is in agreement with those presented on the Contract Drawings, or are acceptable to the Remedial Designer, if they differ from the proposed grades. A professionally licensed surveyor in the State of Indiana shall survey these grades and copies of the survey shall be provided to the QAO for review.

Installation

Installation of the GCL shall be performed with great care to prevent damage to the underlying cushion layer and the GCL itself. Heavy construction equipment shall not be operated directly on the GCL.

The following will be confirmed and documented by the QAO during the installation of the GCL:

- Placement of GCL is in accordance with the construction specifications;
- Materials is not damaged during deployment;
- Only GCL being placed that day will be unwrapped;
- Geomembrane shall be placed immediately upon the GCL;
- GCL shall be kept dry and not be installed in standing water or during any precipitation or high winds;
- Overlapping of GCL is in accordance with specifications;
- No soil or debris shall be entrapped in the overlapping zone;
- No hydrated edges of previously placed GCL are present at overlap of new work areas;
- Rolls deployed match the roll numbers of the manufacturer's quality control testing;
- GCL shall be inspected continuously for damage and shall be repaired or replaced, if defected, and,
- Placement of overlying materials shall be performed without damage to GCL.

3.2.4 Geomembrane Monitoring and Testing

During installation, the QAO will observe the Remedial Action Constructor's geomembrane deployment, trial seams, field seams, non-destructive and destructive seam testing, and repairs to document that the installation is in general accordance with the Technical Specifications.

Deployment – The QAO will verify that only favorably reviewed materials are used, that each panel is given a unique panel number, geomembrane is not placed during inclement or other unsuitable weather conditions, the geomembrane is not damaged during installation, and anchoring is performed in accordance with the Technical Specifications and Contract Drawings.

Trial Seams – The QAO will verify that seaming conditions are adequate, tests are performed at required intervals, specified test procedures are followed, and that retests are performed in accordance with the Technical Specifications. The Geosynthetics Installer will perform pre-weld testing (trial seaming) at the beginning of each crew shift and immediately following any work stoppage of 30 minutes or more or changes in seaming process. Seaming operations will not commence until the QAO has determined that the seaming process is meeting the specification requirements and is acceptable. Visual observation is required on the trial seam by the QAO, a minimum of 5 feet long on the geomembrane material. The QAO will mark the test weld with date, ambient temperature, welding machine number, welding technician initials, machine temperature, and speed. For extrusion welding, the QAO will record the nozzle and extrusion settings. The trial seam sample will be archived by the QAO at the Site. The QAO will record the trial seam test results as passing or failing.

Field Seaming – The QAO will verify that only favorably reviewed equipment and personnel perform welding, all welding is performed under suitable conditions as per the specifications, specified overlaps are achieved, seams are oriented in accordance with project requirements, and that grinding techniques and extrudate meet project requirements for extrusion welding. The QAO will record pertinent information pertaining to field seaming.

Non-Destructive Seam Continuity Testing – The QAO will verify that all seam lengths are non-destructively tested by the Remedial Action Constructor in accordance with the Technical Specifications. If the seam cannot be tested, the QAO will observe cap strip operations and verify that test equipment and gauges are functioning properly and that test procedures are in accordance with the project requirements. The QAO will verify that all failing seam lengths are repaired and re-tested until passing results are achieved. The QAO will record all pertinent data relating to non-destructive testing.

Destructive Seam Testing - The Remedial Action Constructor's Geosynthetic Installer will furnish destructive testing samples of the field seamed geomembrane in accordance with the Technical Specifications, at locations selected by the QAO. The samples will be taken and prioritized as follows:

- all areas identified as suspect during seaming or non-destructive testing/monitoring;
- a minimum of one sample for each geomembrane seamer;

- a minimum of one sample for each representative working conditions (e.g., weather conditions); and
- a minimum of one sample for every 500 feet of seaming.

Each destructive sample will, at a minimum, measure 12 inches by 48 inches in length with the seam centered lengthwise. Two specimens, one from each end of the sample, will be cut and tested for peel and shear strength in the field by the Remedial Action Constructor using a calibrated field tensiometer capable of quantitatively measuring peel and shear strengths, in accordance with the Technical Specifications. The installer shall provide the test results to the QAO upon completion of the tests.

If the specimen fails, the Geosynthetic Installer will provide additional test samples 10 feet from the point of the failed test in each direction for repeat of the field test procedure. If these additional tests fail, then the procedure will be repeated until the length of the failed seam is established. Once the field tests have passed, the remainder of the sample shall be divided into three equal sections and distributed as follows:

- one sample to the QAO's Geosynthetic Laboratory for testing;
- one sample to the installer; and
- one sample for Site Archives.

Each sample shall be subject to the following tests:

- Seam shear strength (five specimens) - ASTM D3083;
- Seam peel strength (five specimens) - ASTM D413.

A minimum of four of the five samples must meet the minimum field seam properties listed in the Technical Specifications. Both tracks of a double-track fusion weld will be destructively tested for peel and one track tested for shear.

Failing laboratory tests will be subject to additional testing until a passing sample is found. The Geosynthetic Installer will take another destructive sample 10 feet from the point of the failed test in each direction and the field test procedure will be repeated. If subsequent tests fail, then the procedure is repeated until the length of the failed seam is established. Once the field tests have passed, a second sample will be taken between the passing specimens and tested by the CQA Geosynthetic Laboratory. Failed seams will be tracked according to the welding apparatus and the machine operator. Samples taken as a result of failed tests will not be counted toward the total number of destructive tests required. All failed field seams must be documented to be bounded on both sides by passing destructive tests. Laboratory destructive testing results will govern the acceptability of seams.

The Geosynthetics Installer shall be responsible for patching all areas cut for test samples and for non-destructive testing (e.g. vacuum box, etc.) in accordance with the Technical Specifications. The QAO will observe this work and record all test locations, results, actions taken in conjunction with destructive test failures, and repairs.

Repairs – The QAO shall observe and document that all materials, techniques, and procedures used for repairs are favorably reviewed in advance. The QAO will verify that all repairs are marked, recorded, repaired, tested, and that wrinkles are addressed, prior to being covered by other materials. The QAO will record pertinent data relating to the locations of defects and repairs.

3.2.5 Geotextile and Geocomposite Monitoring

During geotextile and geocomposite installation, the QAO will observe the Remedial Action Constructor's deployment, field seaming, and repairs and document whether the Remedial Action Constructor's installation is in accordance with the Technical Specifications.

Deployment - The Remedial Action Constructor will verify that the underlying layers are clean and free of deleterious materials prior to deployment, anchoring is achieved as specified, methods are used to minimize wrinkles, and underlying layers are protected during cutting of materials.

Seams - The Remedial Action Constructor will verify sufficient seam overlap and that the specified seam procedures are followed as required in the Technical Specifications. The Remedial Action Constructor will verify that horizontal seams are positioned at least 5 feet from all slopes steeper than 10 percent unless favorably reviewed by the QAO.

Repairs - The Remedial Action Constructor will verify, as observed by the Quality Assurance Official, that all repairs are performed in accordance with project specifications.

Protection - Geotextiles and geocomposites shall be covered within 15 days following placement. The Remedial Action Constructor will place materials in a manner to prevent damage to the geosynthetics and underlying materials. The Remedial Action Constructor will conduct his operations so that a minimum thickness of soil separates the geosynthetics from the tracks or wheels of construction equipment (depending on contact pressures), minimal slippage of the geosynthetics occurs on the underlying materials and that no excess tensile stresses occur in the geosynthetics. No traffic shall be allowed on geosynthetics without at least 3 feet of cover, unless low ground pressure equipment (5 psi) is used which may be allowed with a minimum of 1 foot of cover soil.

3.3 Piezometers

The following describes the CQA procedures to be implemented during the Remedial Action Constructor's installation of the piezometers. A total of six piezometers shall be installed. The location are presented on the Contract Drawings may be relocated based on accessibility and if difficulty in drilling is encountered, and if authorized by the CBS Site Representative and Remedial Designer.

The QA program for drilling will consist of full-time monitoring of the drilling operations. The QAO will observe the following activities during the Remedial Action Constructor's installation of the piezometers:

- Start and completion dates;
- Piezometer locations;
- Type of drilling rig and equipment;
- Logging of material types encountered during drilling;
- Measurement of the total drilling depth;
- Measurement of depth to encountered liquids, as applicable;
- Measurement of depth to bottom of the piezometer;
- Measurement of the perforated and solid sections of piping and well screens;
- Measurement of thickness of all components of the piezometers;
- Measurement of the installed dimensions of pipe above and below grade; and,
- Monitoring of the protective casing and boots.

4.0 RECORDS AND REPORTING

4.1 Contract Drawings

The Remedial Action Constructor Superintendent and the CBS Site Representative will each maintain on the Site one clean set of the Contract Drawings, Remedial Design Report, Technical Specifications, and other reports pertinent to the construction of the remedy, along with a record of all proposed, pending, and approved changes and clarifications to the Contract Documents. Additionally, the Remedial Action Constructor will maintain at all times one set of marked-up Record Drawings indicating progress of construction.

4.2 Contract Submittals

Submittals required by this CQAP and the Technical Specifications will be logged in at the time of receipt by the CBS Site Representative. A record of the submittal and review form indicating favorable review or rejection of the submittal will be kept on file at the office of the Remedial Designer. A copy indicating the final status will be returned to the Remedial Action Constructor for his files.

4.3 Daily Records

The QAO will keep records of construction and testing activities which, in conjunction with the Remedial Action Constructor's submittals and as-built drawings, will enable preparation of Record Drawings and the Construction Completion Report.

Daily Summary Reports will be numbered sequentially and will include the following:

- Date and project name;
- Weather conditions, including daily high and low temperature, wind conditions, and precipitation;
- General description of work activities at the Site;
- Description of work completed for the day, referencing stationing and grid coordinates as appropriate;
- Identification of areas worked including lift number, panel number, and/or seam number;
- Reduced-scale drawings or sketches showing work completed;
- Summary of test samples taken, with locations and elevations as appropriate;

- Summary of QC test results, provided to the QAO by the installer, compared with Specification requirements and indication of pass or fail status for the samples;
- Test equipment calibrations, unless recorded in other field notebooks;
- List of off-site materials received;
- Summary of QA and QC procedures used for the day and list of CQA personnel on-site; and,
- Problems encountered and resolutions reached.

4.4 Construction Problem and Corrective Measure Reports

A problem is defined herein as material or workmanship that apparently does not meet the requirements of the Contract Documents. Construction Problem and Corrective Measures Reports will be cross-referenced to specific monitoring and testing data sheets where the problem was identified. Construction Problem and Corrective Measures Reports shall be numbered sequentially and include the following information:

- Detailed description of the problem;
- Location and probable cause of the problem;
- How and when the situation was identified;
- How the problem was corrected or resolved;
- Any measures taken to prevent similar problems in the future; and
- Signatures of QAO, CBS Site Representative, and Remedial Action Constructor Superintendent.

4.5 Photographic Records

The QAO will take photographs identified by date, time, location, and name of person taking the photograph. Photographic record sheets will be completed to organize the photographs. Such sheets will be numbered sequentially and will include the following information:

- The date, time, and location where the photograph was taken and weather conditions;
- The size, scale, and orientation of the subject matter photographed;

- Location and description of the work;
- The purpose of the photograph; and,
- Initials of the photographer.

4.6 Final Documentation Report

Within 30 days of completion of construction, the QAO, Remedial Designer, and CBS Site Representative will complete the Construction Completion Report for the project. The report, submitted to USEPA, will certify that, based on observation of the Remedial Action Constructor's work and on evaluation of furnished test results and other information, the Remedial Action Constructor's work has been completed in general conformance with the Contract Drawings, Technical Specifications, with any significant exceptions noted. The report will include the following:

- Narrative description of construction activities completed at the Site;
- Description of material deviations from Contract Document requirements and justification for such changes;
- Description of CQA testing procedures;
- Summary of CQA test data including copies of all soil and geosynthetics monitoring and test data sheets, including seaming log, repair log and subgrade acceptance forms;
- Maps and drawings showing CQA test locations;
- Descriptions of procedures used by the Remedial Action Constructor to rework or repair areas with failing CQA test results;
- Color photographs of major project features;
- As-built plans and details of the completed construction, prepared by the Remedial Action Constructor;
- Certification statement for portions of the work monitored by the QAO or CBS Representative of completion of construction in general accordance with the Contract Documents.

4.7 Records Storage

Throughout the construction, all original documents or copies will be kept in an organized file on-site. All records and documents relating to the Remedial Action will be preserved and retained for a minimum of 10 years following receipt from USEPA of a Certificate of Completion of the Work. At the close of this 10-year period, documents may be destroyed with USEPA concurrence in accordance with the procedures outlined in the Consent Decree.

5.0 PLAN MODIFICATION PROCEDURE

Should this CQAP require modification, the proposed change will be submitted in writing to the Remedial Designer and CBS representative for review. If the proposed modification is deemed to be appropriate, a letter requesting approval of the change will be submitted to the USEPA. An addendum will be attached to all copies of the CQAP following receipt of approval from USEPA.

\\gai_mtl1\project\document\projects\993-6573\prefinal\report\cqaptext2.doc

APPENDIX G
TECHNICAL SPECIFICATIONS

LEMON LANE LANDFILL
TECHNICAL SPECIFICATIONS FOR CONSTRUCTION

TABLE OF CONTENTS

Note: Items shown in bold are included in this Final Design Submittal. Non bolded items were previously submitted as part of the previous design submittal.

DIVISION 1 - GENERAL REQUIREMENTS

SECTION

DIVISION 2 - SITEWORK SPECIFICATIONS

SECTION

SECTION 02223

BACKFILL AND FILL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, equipment, tools and appurtenances required to complete portions of the Work requiring backfill and fill. The work of this Section includes the placement, grading, and compaction of backfill and fill materials, and other related and incidental work within the designated areas, and as required, for the construction of other work, as shown, specified, or required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

C. The CONTRACTOR is responsible for following all health and safety precautions applicable to trenches during backfilling of trenches.

D. CBS shall provide materials for fill and backfill, in accordance with this Specification.

1.02 DEFINITIONS

A. Fill: Soil material placed above consolidated waste within the cap footprint. Soil material for use as the 12 inch prepared subgrade layer for the geosynthetic cap is referred to as cap cushion soil as outlined in Section 02224 of these Specifications.

B. Backfill: Soil material placed outside of the limits of waste consolidation for the purpose of grading.

C. Structural Fill: Soil material placed within trenches above pipe elevation, or in other locations presented on the CONTRACT DRAWINGS.

1.03 PROTECTION OF PEOPLE AND PROPERTY

A. The CONTRACTOR shall plan and execute the Work so as to prevent damage to existing structures, safeguard people and property, minimize dust, minimize traffic inconvenience, protect structures to be installed, and provide safe working conditions.

B. Work shall be performed in accordance with all applicable health and safety and OSHA regulations and in accordance with the CONTRACTOR's Site-specific Health and Safety Plan.

PART 2 - PRODUCTS

2.01 GENERAL

A. All imported materials from off-Site borrow areas shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL prior to use. The QUALITY ASSURANCE OFFICIAL and/or CBS REPRESENTATIVE may visit the proposed borrow areas.

B. All imported material shall be obtained from an environmentally clean off-Site borrow source that is favorably reviewed by the CBS REPRESENTATIVE. CBS shall submit evidence (i.e., analytical test results) per Sampling and Analysis Plan contained in the RD/RA Work Plan that the off-Site materials are free from chemical and organic contamination. CBS may at any time collect samples of imported materials for testing at CBS's expense. Any contaminated materials from off-Site sources that are placed shall be removed and replaced with suitable materials.

C. No frozen materials shall be used for backfill, structural fill, fill, or any other materials specified herein. All materials shall be free from organic materials, wood, trash, and all deleterious and objectionable materials which may be degradable or which cannot be properly compacted. Imported materials shall not contain rock fragments, broken concrete, masonry rubble greater than the maximum dimensions specified in Articles 2.02 through 2.04 herein, as appropriate, or other similar materials. It shall have physical properties such that it can be readily spread and compacted. Snow, ice, and frozen soil shall be removed from backfill and fill material prior to placement.

D. Spoils from trench excavation will only be acceptable as backfill based on requirements of Article 2.01B above. No spoils from waste excavation, as outlined in Section 02221 of these Specifications, will be permitted as backfill beyond the limits of the geosynthetic cap.

E. Fill may be required above the waste surface to achieve suitable top of waste grades. This fill may be obtained from off-Site borrow or may be material available on-Site from the Work of other Sections. Materials proposed for use as fill shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL prior to use. Fill shall be in accordance with Article 2.02 herein.

F. Backfill may be required outside the limits of waste consolidation around the perimeter of the Site. This backfill may be obtained from off-Site borrow or may be material available on-Site from the Work of other Sections.

G. Soil material for use as the 12 inch prepared subgrade layer for the geosynthetic cap is referred to as cap cushion soil as outlined in Section 02224 of these Specifications.

2.02 FILL

A. Fill shall be a natural soil material and shall be free of organic materials, wood, trash, debris, and all deleterious and objectionable materials which may be compressible or which cannot be properly compacted.

B. Fill material may be obtained from the adjacent Site borrow source, or may be imported from an off-Site source. If sufficient quantitative of Hypalon bedding material remain following cap subgrade and cover soil placement, this material may be used as fill. Fill shall not contain rock over 3 inches in greatest dimension. The QUALITY ASSURANCE OFFICIAL shall favorably review all fill material prior to use.

C. The use of Fill shall be in accordance Article 2.01E herein and the requirements of other applicable Sections of these Specifications. If sufficient quantities of Fill are not available on-Site, CBS may obtain borrow from off-Site borrow sources owned by CBS or purchase from off-Site source.

2.03 BACKFILL

A. Backfill shall be a natural soil material and shall be free of organic materials, wood, trash, debris, and all deleterious and objectionable materials which may be compressible or which cannot be properly compacted.

B. If sufficient quantities of the existing Hypalon® bedding material remain following cap subgrade and cover soil placement, this material may be used as backfill. Backfill material may also be obtained from an off-Site borrow source approved by the QUALITY ASSURANCE OFFICIAL .

C. Backfill material shall not contain particles that are 3 inches in any dimension or greater.

2.04 STRUCTURAL BACKFILL

A. Structural Backfill shall be composed of non-organic, hard, durable soil or gravel material. This material shall be free of wood, trash, debris,and all deleterious and objectionable materials which may be compressible or which cannot be properly compacted.

B. Structural Backfill shall not contain rock over 3 inches in greatest dimension and no greater than 10% of materials that pass the No. 200 sieve. Alternative soil materials may be used if favorably reviewed by the Engineer.

2.05 TESTING

A. CBS shall, twenty-one (21) days prior to use of proposed materials, submit test results to the QUALITY ASSURANCE OFFICIAL indicating that the materials proposed for Fill, Backfill, and Structural Backfill comply with the Specifications for the various components of construction. Results of the following tests shall be provided for each type of material and each material source:

1.	Particle Size	ASTM D422
2.	Atterberg Limits	ASTM D4318
3.	Standard Proctor	ASTM D698
4.	Moisture Content	ASTM D2216 or D4643
5.	Specific Gravity	ASTM D854

C. CBS shall be responsible for quality control testing. Testing shall be performed by a specialized laboratory that has been favorably reviewed by the QUALITY ASSURANCE OFFICIAL. The frequency of testing shall be once per every 5,000 cubic yards of each material delivered or once per each material source, whichever is greater.

D. CBS shall submit to the QUALITY ASSURANCE OFFICIAL a minimum of 100 pounds of each proposed material from each proposed source. This bulk sample shall be representative of the proposed source.

E. The CONTRACTOR shall not proceed with use of the materials until the QUALITY ASSURANCE OFFICIAL has favorably reviewed the proposed materials.

F. If, in the opinion of QUALITY ASSURANCE OFFICIAL, the CBS proposed material is unsuitable for the proposed application, CBS shall submit the above test results for material of another type or from another source for consideration.

G. The QUALITY ASSURANCE OFFICIAL may at any time request the collection of samples of imported materials for additional analytical and/or index property testing at CBS's expense. Any imported materials from off-Site borrow sources found to not be in accordance with the Specifications, or found to be contaminated, shall immediately be removed and replaced with suitable materials.

PART 3 - EXECUTION

3.01 PRECAUTIONS

A. Portions of the Work requiring the placement of backfill and fill materials shall not be performed with frozen materials or over frozen materials, snow, ice, and/or uncompacted subgrades.

3.02 STORAGE

A. Stockpile satisfactory excavated and imported materials at a location favorably reviewed by the CBS Representative until required for backfill and fill

B. Locate and retain stockpiled soil materials in a location where the weight of the stockpiled materials will not create surcharge loading conditions on the excavation edges.

C. The CONTRCATOR shall comply with dust control requirements presented in Specification Section 01562.

3.03 PLACEMENT OF FILL AND BACKFILL

A. Fill and backfill material shall not be placed until the subgrade has been inspected in place and favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Subgrades to receive fill or backfill shall be compacted and shall appear firm, stable and unyielding, as determined by the QUALITY ASSURANCE OFFICIAL. Areas where receiving subgrades exhibit an unstable condition, such as excessive pumping or movement under the weight of the compaction equipment, shall be excavated, moisture conditioned or otherwise stabilized in a manner acceptable to the QUALITY ASSURANCE OFFICIAL, prior to placement of fill or backfill.

B. Any uncompacted subgrade to receive fill or backfill shall be proof-rolled prior to the placement of fill materials. Proof-rolling shall be performed with compaction equipment weighing at least 20 tons, unless otherwise approved by the QUALITY ASSURANCE OFFICIAL.

C. Fill and backfill with favorably reviewed materials conforming to the requirements of Part 2 herein.

D. Employ a placement method that does not disturb or damage other work.

E. Make gradual grade changes. Blend slope into level areas.

F. Place fill in relatively uniform lifts not exceeding 12 inches in compacted thickness.

G. Grading tolerance for fill materials shall be -0.0 to +0.1 feet.

3.04 PLACEMENT OF STRUCTURAL BACKFILL

A. Trenches: Placement of Structural Backfill in trenches shall not be done until such time as pipes and related Work has been favorably reviewed by QUALITY ASSURANCE OFFICIAL and as-built survey has been performed by the CONTRACTOR. The CONTRACTOR shall comply with the following trench backfill procedures:

1. Pipes shall be bedded and backfilled as required in the Contract Documents or as directed by the CBS REPRESENTATIVE. Care shall be taken to place and compact bedding material under pipe haunches to ensure continuous contact with, and support of, the pipe.

2. All trenches shall be backfilled as soon as possible, after the pipes have been installed to assure protection against damage.
3. Pipe trenches shall be bedded and backfilled to height of not less than 12 inches above the crown of the pipe with pea gravel, or equivalent coarse aggregate material as approved by the ENGINEER, in accordance with Section 02233 of these Specifications. Bedding material in pipe haunch zone shall be placed and worked around pipe to satisfaction of the ENGINEER and/or QUALITY ASSURANCE OFFICIAL. Care shall be taken not to dislodge or damage the pipe.
4. Structural Backfill shall be placed from the top of the pea gravel, or equivalent coarse aggregate material as approved by the ENGINEER, to the required subgrade elevations as shown on the Contract Drawings.
5. Trench bedding and structural backfill materials shall be uniformly placed in uniform lifts of 12-inch maximum compacted thickness. Provide compaction with a compaction effort as required by Article 3.05 herein. The method of compaction shall not damage the pipes. Each layer shall be compacted before the next layer is placed.

3.05 COMPACTION REQUIREMENTS

A. Pipe trench bedding and backfill material placed to a height of 6 inches above the crown of the pipe, shall be placed at the material's natural density resulting from placement by dumping/shoveling.

B. Fill material shall be placed and compacted to achieve a minimum density of 90 percent of maximum dry density as determined by the Standard Proctor test. If the CONTRACTOR makes reasonable efforts, as determined by the ENGINEER, to achieve the specified percent compaction but cannot meet the 90% compaction requirement, an alternate percent compaction, agreed upon by the ENGINEER, may be utilized.

C. Backfill material placed between the limits of the waste consolidation and ten (10) feet beyond the limits of the perimeter channel shall be placed and compacted to achieve a minimum density of 95 percent of maximum dry density as determined by the Standard Proctor test. Structural backfill material shall be placed and compacted to achieve a minimum density of 95 percent of maximum dry density as determined by the Standard Proctor test. Care shall be taken not to damage any piping or other buried utilities during compaction of the materials, or proof-rolling. The moisture content of the materials shall be such that the specified density may be obtained. Puddling or jetting for compaction will not be permitted. If the CONTRACTOR makes reasonable efforts, as determined by the ENGINEER, to achieve the specified percent compaction but cannot meet the 95% compaction requirement, an alternate percent compaction, agreed upon by the ENGINEER, may be utilized.

D. Backfill material not supporting structures or perimeter channels shall be placed and compacted in a maximum 12-inch lift. Compaction shall be performed to the satisfaction of the CBS representative.

3.06 FIELD QUALITY ASSURANCE/CONTROL

A. Testing of fill, backfill and structural fill materials shall be performed for each lift by an independent geotechnical laboratory employed by CBS and the results shall be submitted to the QUALITY ASSURANCE OFFICIAL for approval. Any areas that do not meet the requirements herein shall be reworked by providing additional compaction effort until acceptable test results are obtained. The CONTRACTOR shall not proceed with a new lift of material until the QUALITY ASSURANCE OFFICIAL has confirmed that the previous lift has attained the required density. The CONTRACTOR shall rework by wetting, drying, or recompacting backfill/fill material that is not in compliance with the compaction and moisture content requirements. At his sole convenience and expense, the CONTRACTOR may remove and replace fill materials with prior approval from the QUALITY ASSURANCE OFFICIAL.

B. During construction, tests on the in-place backfill and fill materials shall be made by an independent geotechnical testing laboratory employed by CBS, and this laboratory shall perform the following tests:

Property	ASTM Test Method	Frequency of Testing
1. Standard Proctor	D698	A minimum of one (1) test per 5,000 cubic yards per source
2. Field Density	D2922	A minimum of four (4) tests per acre per lift and one per lift per 100 L.F of pipe trench.
3. Field Moisture	D3017	A minimum of four (4) tests per acre per lift and one per lift per 100 L.F of pipe trench.

C. In areas where the degree of compaction is not obtained or the uniformity of materials is not maintained in the opinion of the ENGINEER and/or QUALITY ASSURANCE OFFICIAL, additional tests and/or compactive effort will be made at no additional cost to CBS.

D. The CONTRACTOR shall be responsible for conducting any and all quality control testing necessary for the CONTRACTOR's purposes.

E. Quality assurance conformance testing, if required, shall be performed by the QUALITY ASSURANCE OFFICIAL in accordance with the Construction Quality Assurance Plan.

*****END OF SECTION*****

SECTION 02224

CAP COVER & CUSHION SOILS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, equipment, tools and appurtenances required to complete portions of the Work requiring cap cover and cushion soil placement. The work of this Section includes the placement, grading, and compaction of cover and cushion soil materials, material handling, and other related and incidental work within the designated areas and as required for the construction of other work, as shown, specified, or required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

C. CBS shall provide materials for cap cover and cushion soils in accordance with the requirements of this Specification.

1.02 DEFINITIONS

A. Cap Cover Soil: Cap cover soil is defined as the 18-inch soil layer atop the geosynthetic capping. This material shall also be placed directly above the geosynthetic liner in the retention basin.

B. Cap Cushion Soil: Cap cushion soil is defined as the 12-inch soil layer directly below the geosynthetic clay liner.

1.03 PROTECTION OF PEOPLE AND PROPERTIES

A. The CONTRACTOR shall plan and execute the Work so as to prevent damage to existing structures, safeguard people and property, minimize traffic inconvenience, protect structures to be installed, and provide safe working conditions.

B. All imported materials shall be obtained from an environmentally clean off-Site borrow source. CBS shall submit evidence (i.e., analytical test results) per Sampling and Analysis Plan contained in the RD/RA Work Plan that the off-Site materials are free from chemical and organic contamination. CBS may at any time collect samples of imported materials for testing at CBS's expense. Any contaminated materials from off-Site sources that are placed shall be removed and replaced with suitable materials.

C. Work shall be performed in accordance with all applicable health and safety and OSHA regulations and in accordance with the CONTRACTOR's Site-specific Health and Safety Plan.

PART 2 - PRODUCTS

2.01 GENERAL

A. All imported materials from off-Site borrow sources shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL prior to use. The QUALITY ASSURANCE OFFICIAL and/or the CBS REPRESENTATIVE may visit the proposed borrow areas.

B. No frozen materials shall be used for cover and cushion soils. All materials shall be free from organic materials, wood, trash, and all deleterious and objectionable materials which may be compressible or which cannot be properly compacted. Imported materials shall not contain rock fragments, broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and compacted. Snow, ice, and frozen soil shall be removed from fill material prior to placement.

2.02 CAP COVER SOIL

A. Cap cover soil material may be the existing Hypalon® bedding material or borrow material from an off-Site borrow source favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Borrow material proposed for use as cap cover soil shall be free of deleterious and organic matter, be non-plastic, and conform to the particle size requirements as specified in Article 2.02B hereinafter.

B. Cap cover soil material shall be with a maximum particle size of 1½ inches in any dimension and 10% to 25% passing the No. 200 standard sieve. Soils with a unified soil classification system (USCS) designated as SC, SM, SP-SM and SC-SM would be suitable for the cap cover soil layer. Modifications to these designation may be made if favorably reviewed by the ENGINEER.

2.03 CAP CUSHION SOIL

A. Cap cushion soil material may be the existing Hypalon® bedding material or borrow material from the off-Site borrow sources including those owned by CBS favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Borrow material proposed for use as cap cushion soil shall be free of deleterious and organic matter and conform to the particle size requirements as specified in Article 2.03B hereinafter.

B. Cap cushion soil material shall be substantially free of particles larger that are larger than 1 inch in any dimension within the upper 6 inches of the cap subgrade elevations, and in no case shall particles exceed 3 inches in any dimension. The approval of the cushion soil for geosynthetic shall be made by the QUALITY ASSURANCE OFFICIAL and the geosynthetic INSTALLER.

C. Cap cushion soil obtained from the borrow area on the adjacent western property, shall be a low plasticity clay material, with a USCS designation of CL. Modifications to this designation may be made if favorably reviewed by the ENGINEER. Provide granular soil meeting the requirements of these Specifications and favorable review by the QUALITY ASSURANCE OFFICIAL for use as cap cushion soil source in the event that the borrow soil becomes saturated due to precipitation.

2.04 TESTING

A. CBS shall, twenty-one (21) days prior to use of proposed materials, submit test results to the QUALITY ASSURANCE OFFICIAL indicating that the materials proposed for cap cover soil, cap cushion soil, and comply with the Specifications for the various components of construction. These test results shall include the following tests for each type of material and each material source:

1.	Gradation	ASTM D422
2.	Atterberg Limits	ASTM D4318
3.	Standard Proctor (cushion soil only)	ASTM D698
4.	Moisture Content	ASTM D2216 or D4643
5.	Specific Gravity	ASTM D854

B. CBS shall be responsible for testing. Testing shall be performed by a specialized laboratory that has been favorably reviewed by the QUALITY ASSURANCE OFFICIAL. The frequency of testing shall be once per every 5,000 cy of each material delivered or once per each material source, whichever is greater.

C. CBS shall submit to the QUALITY ASSURANCE OFFICIAL a minimum of 100 pounds of each proposed material from each source. This bulk sample shall be representative of the proposed source.

D. If in the opinion of the QUALITY ASSURANCE OFFICIAL, the CBS proposed material is unsuitable for the proposed application, the CBS shall submit the above certification for material of another type or from another source for consideration.

PART 3 - EXECUTION

3.01 PRECAUTIONS

A. Portions of the Work requiring the placement of cover and cushion soil materials shall not be performed with frozen materials or over frozen materials, snow, ice, and/or uncompacted subgrades.

3.02 STORAGE

A. Stockpile satisfactory excavated and imported materials at a location favorably reviewed by the CBS REPRESENTATIVE until required for placement. Place, grade and shape stockpiles to provide proper drainage. Install appropriate erosion and sediment control devices around stockpiles.

B. Locate and retain stockpiled soil materials in a location where the weight of the stockpiled materials will not create surcharge loading conditions on the excavation edges.

3.03 PLACEMENT

A. Prior to the placement of cap cushion soil materials, the top of waste/fill surface shall be proof-rolled with compaction equipment weighing at least 20 tons, in accordance with Section 02221. Areas which exhibit an unstable condition such as excessive pumping, movement, or sloughing during compaction shall be excavated, moisture conditioned, mixed with dry material, reworked and compacted at the CONTRACTOR's expense. The compacted surface shall be favorably reviewed by the CBS REPRESENTATIVE and/or Quality Assurance Official prior to placement of additional materials.

B. Place soil materials in uniform lifts not exceeding 12 inches in compacted thickness.

C. Employ a placement method that does not disturb or damage other work. Puddling will not be permitted.

D. Make gradual grade changes. Blend slope into level areas.

E. Grading tolerance for the cover soil and cushion soil shall be -0.0 to +0.1 feet.

F. Cap cover soil materials shall not be placed until the geosynthetic components and/or prepared subgrade (cushion soil) has been inspected in-place and favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

G. Placement of the cap cover soil shall be with low ground pressure equipment (5 psi contact pressure) with a minimum of 12 inches of soil material between the equipment and the geosynthetics.

3.04 COMPACTION REQUIREMENTS

A. Cap Cover Soil:
   1. Compaction of the cap cover soil above the geocomposite drainage layer, shall be achieved by repeated passes as provided by the spreading equipment or other method favorably approved by the QUALITY ASSURANCE OFFICIAL.
   2. Compact equipment shall be tracked and not have rubber tires.

B. Cap Cushion Soil:

1. Compaction of the cap cushion soil shall be to 90% of the maximum Standard Proctor dry density. The compaction of this cap cushion soil shall be measured at a frequency of four test locations per acre.
2. Prior to the placement of initial component of the geosynthetic cap, i.e. the GCL, the surface of the cap cushion soil shall be proof-rolled with smooth drummed compaction equipment weighing at least 20 tons, unless otherwise approved by the QUALITY ASSURANCE OFFICIAL. This proofrolling shall create a smooth unyielding surface, free from pockets, holes, sudden grade changes or discontinuities which could cause bridging. Compaction equipment shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL prior to use.

3.05 FIELD QUALITY ASSURANCE/CONTROL

CBS shall be responsible for conducting any and all quality control testing necessary. Ensure that materials placed do not exceed maximum thicknesses as required by the Contract Documents. CBS Site Representative will verify periodically.

*****END OF SECTION*****

SECTION 02225

TOPSOIL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, equipment, tools and appurtenances required to complete portions of the Work requiring the placement of topsoil. The work of this Section includes the placement, and grading of the topsoil material, material handling, and other related and incidental work within the designated areas and as required for the construction of other work, as shown, specified, or required by the Contract Documents.

B. The material to be used as topsoil will be provided by CBS in accordance with the requirements outlined in Part 2 herein.

C. All imported materials shall be obtained from an environmentally clean off-Site borrow source that is favorably reviewed by the QUALITY ASSURANCE OFFICIAL. CBS shall submit evidence (i.e., analytical test results) in accordance with the Sampling and Analysis Plan contained in the RD/RA Work Plan that the off-Site materials are free from chemical and organic contamination. Any contaminated materials from off-Site sources that are placed shall be removed and replaced with suitable materials..

D. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Soil material used as the topsoil shall be loam as defined by the U.S. Department of Agriculture (USDA) textural classification chart and shall be suitable to support vegetative growth. If alternate USDA gradations are submitted for use, they shall be favorably reviewed by QUALITY ASSURANCE OFFICIAL prior to use.

B. The topsoil shall not contain stones, lumps, roots, or similar objects larger than 2 inches in any dimension.

C. The topsoil shall have a pH between 5.8 and 7.6.

D. Provide a material for the topsoil that has a minimum organic content of 2.75 percent by weight and a maximum organic content of 5 percent by weight.

E. Soil material used as the topsoil must be capable of sustaining vegetation as specified in Section 02936 of these Specifications.

2.02 TESTING

A. Twenty-one (21) days prior to use of proposed materials, CBS shall submit test results to the QUALITY ASSURANCE OFFICIAL indicating that the material proposed for the topsoil complies with the Specifications for the various components of construction. This certification shall include the following tests for the material and the material source(s):

1.	Particle Size	ASTM D422
2.	pH	ASTM D4972
3.	Organic Content	ASTM D2974
4.	Soil Fertility	Baker or LaMotte Test

B. CBS shall be responsible for testing. Testing shall be performed by a specialized laboratory that has been favorably reviewed by the QUALITY ASSURANCE OFFICIAL. The frequency of testing shall be once per every 2,000 cubic yards of material delivered or once per each material source, whichever is greater.

C. CBS shall submit to the QUALITY ASSURANCE OFFICIAL a minimum of 100 pounds of each proposed material from each source that is proposed for use. This bulk sample shall be representative of the proposed source.

D. If in the opinion of the QUALITY ASSURANCE OFFICIAL, CBS's proposed material is unsuitable for the proposed application, CBS shall submit the above certification for material of another type or from another source for consideration.

E. The QUALITY ASSURANCE OFFICIAL may at any time request the collection of samples of imported materials for additional analytical and/or index property testing at CBS's expense. Any imported materials from off-Site borrow sources found to not be in accordance with the Specifications shall immediately be removed and replaced with suitable materials.

PART 3 - EXECUTION

3.01 PLACEMENT

A. This item shall consist of the placement of the topsoil in all designated areas as shown on the Contract Drawing and in areas disturbed by construction activities.

B. No topsoil material shall be placed until the cap cover soil placement (or backfill, fill, etc.) is complete and favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

C. The topsoil shall be placed in a single, 6-inch thick lift. The tolerance for the thickness of the topsoil is -0.0 to +0.2 feet.

D. The CONTRACTOR shall take care to ensure that underlying soil remains intact and does not become mixed with the topsoil during installation.

E. For portions of the topsoil placed in areas designated to receive the geomembrane cap, as shown on the Contract Drawings, the material shall be placed and graded with low ground pressure (contact pressure less than or equal to 10 psi) equipment.

*****END OF SECTION*****

SECTION 02233

AGGREGATE MATERIALS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, equipment, tools and appurtenances required to complete the work of furnishing and placing aggregate materials for access roads, trench bedding/backfill, manhole bedding, toe/slope drains, aprons, channel/ditch lining, passive gas vent backfill, and as otherwise shown on the Contract Drawings.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

C. The CONTRACTOR is responsible for following all health and safety precautions applicable to trenches during backfilling of trenches.

D. CBS shall provide coarse aggregate materials in accordance with this Specification.

PART 2 - PRODUCTS

2.01 MATERIAL

A. The materials shall be environmentally clean, sound, tough, durable, crushed stone or gravel as required by this Section, not lumpy, and free from slag, cinders, ashes, rubbish, ice, and deleterious and organic materials.

B. All aggregate materials shall be obtained from an environmentally clean off-Site borrow source that is favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Any contaminated materials from off-Site sources that are placed shall be removed and replaced with suitable materials.

C. Aggregate materials shall be stored at a location favorably reviewed by the CBS REPRESENTATIVE. The CONTRACTOR shall be responsible for maintaining the aggregate materials to be free of contamination, and any aggregate materials determined by the QUALITY ASSURANCE OFFICIAL to be contaminated shall not be used for the required construction activities.

D. Aggregate material as required for passive gas vent backfill, and as otherwise shown on the Contract Drawings, commonly referred to as AASHTO No. 57, shall be crushed stone conforming to the following gradation requirements:

US Standard Sieve Size	Percent Passing By Weight
1-½ inch	100
1 inch	95-100
½ inch	25-60
No. 4	0-10
No. 8	0-5

E. Aggregate material for access road surfacing and as shown on, or otherwise specified in, the Contract Documents, shall be what is commonly referred to as Dense Graded Aggregate, shall be non-plastic, broken or crushed stone, and shall conform to the following gradation requirements:

US Standard Sieve Size	Percent Passing By Weight
1½ inch	100
¾ inch	55-90
No. 4	25-60
No. 50	5-25
No. 200	3-12

F. Aggregate material as required for the trench bedding/initial backfill, culvert bedding, and as otherwise called for on the Contract Drawings, shall be naturally rounded gravel commonly referred to as pea gravel, and shall conform to the following gradation requirements:

US Standard Sieve Size	Percent Passing By Weight
3/4 inch	100
1/8 inch	0-10
No. 8	0-3

2.02 TESTING

A. CBS shall, twenty-one (21) days prior to use of proposed materials, submit to the QUALITY ASSURANCE OFFICIAL for review, test results indicating that the materials proposed for use as trench bedding meets the requirements of Article 2.01F herein. This shall include, at a minimum, particle size testing in accordance with ASTM C136 for each type of aggregate material and source.

B. CBS shall be responsible for testing. Testing shall be performed by a specialized laboratory that has been favorably reviewed by the QUALITY ASSURANCE OFFICIAL. The frequency of testing shall be once per every 5,000 cubic yards of each material delivered or once per each material source, whichever is greater.

C. CBS shall submit to the QUALITY ASSURANCE OFFICIAL a minimum of 100 pounds of each proposed material from each source that is proposed for use. This bulk sample shall be representative of the proposed source.

D. CBS shall not proceed with the use of the materials until the QUALITY ASSURANCE OFFICIAL have favorably reviewed the proposed materials.

E. If in the opinion of the QUALITY ASSURANCE OFFICIAL, CBS's proposed material is unsuitable for the proposed application, CBS shall submit the above test results for material of another type or from another source for consideration.

F. The QUALITY ASSURANCE OFFICIAL may at any time request the collection of samples of imported materials for additional analytical and/or index property testing at CBS's expense. Any imported materials from off-Site sources found to not be in accordance with the Specifications, or found to be contaminated, shall immediately be removed and replaced with suitable materials..

PART 3 - EXECUTION

3.01 STORAGE

A. Stockpile satisfactory excavated and imported in a location favorably reviewed by the CBS REPRESENTATIVE until required for placement. Place, grade and shape stockpiles to provide proper drainage. Install appropriate erosion and sediment control devices around stockpiles.

B. Locate and retain stockpiled soil materials in a location where the weight of the stockpiled materials will not create surcharge loading conditions on the excavation edges.

C. The CONTRACTOR shall comply with the dust control requirements of Specification Section 01562.

3.02 PLACEMENT

A. Aggregate materials shall be placed in uniform layers to the lines, depths, and grades in areas as shown on the Contract.

B. Placement of aggregate materials shall be performed by the CONTRACTOR in a manner such that the material is kept clean and free of foreign materials.

C. Placement of aggregate materials for access roads and benches shall be performed by the CONTRACTOR in a manner such that the material is graded to blend in with existing grades to prevent surface water ponding or erosion. In particular, the aggregate materials for the access roads and benches shall be confined on the edges to prevent push-out of the material.

D. When backfilling with aggregate materials, the CONTRACTOR shall employ a placement method that does not disturb or damage other work.

E. When backfilling with aggregate materials around piping, the material shall be forced under the lower quadrant (haunching) of the pipe, without raising the grade of the pipe. Care shall be taken to place and compact pipe bedding material under pipe haunches to ensure continuous contact with then pipe.

*****END OF SECTION*****

E. The QUALITY ASSURANCE OFFICIAL may at any time collect samples of imported materials for additional analytical and/or index property testing at CBS's expense. Any imported materials from off-Site sources found to not be in accordance with the Specifications, or found to be contaminated, shall immediately be removed and replaced with suitable materials at the CONTRACTOR's expense with no time extensions in the Construction Schedule granted.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All vegetation shall be mechanically cleared from the ground surface so as to minimize regrowth of vegetation through the stone riprap.

B. Stone riprap shall be placed to the thicknesses and grades indicated on the Contract Plans.

C. Placement of stone riprap and associated grading shall be performed by the CONTRACTOR in compliance with the Contract Documents, permit(s), Specifications, and Contract Drawings, and as required to blend in with existing or proposed surrounding existing grades and to prevent surface water ponding or erosion.

D. Stone riprap shall be placed in a manner that will not damage underlying geosynthetics or other facilities. Stone riprap shall not be dropped from a height exceeding three feet. Dump-rolling of riprap over geotextile-lined slopes, channels, etc. is prohibited.

E. The tolerance in stone riprap thickness in place shall be 0.0 feet to plus 0.25 feet.

F. If in the opinion of the QUALITY ASSURANCE OFFICIAL, the underlying geosynthetics have been damaged, the CONTRACTOR shall carefully remove the riprap material and expose the geosynthetics for examination by the QUALITY ASSURANCE OFFICIAL. If the QUALITY ASSURANCE OFFICIAL observes damage appropriate repair to the geosynthetics will be performed at the CONTACTOR's expense.

*****END OF SECTION*****

SECTION 02276

RENO MATTRESSES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, equipment, tools and appurtenances required to complete the work of furnishing, placing the Reno mattress baskets, and backfilling the Reno mattresses with rock as shown, specified or required.

B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

C. CBS shall provide aggregate material for Reno mattresses construction.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit, to the QUALITY ASSURANCE OFFICIAL for prior favorable review, certification that the material proposed for use as Reno mattress rock and wire meets the requirements of Article 2.01 herein.

B. Coordinate a visit to borrow source, if requested, by the QUALITY ASSURANCE OFFICIAL.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Reno Mattress Baskets

1. The Reno mattresses shall be the size called for on the Contract Drawings.
2. All wire used in the construction of galvanized Reno mattress baskets, including the tie wire, shall be equal to or shall exceed Federal Specification QQ-W-46lh, wire, steel, carbon including the following specific requirement: Finish 5, Class 3 weight of zinc coating.
3. Wire used in the construction of galvanized Reno mattresses, with a Reno mattress thickness of 12-inches or greater, shall meet the following diameters:
    a. Mesh Wire: Nominal 0.12 ± 0.004-inches or approximately U.S. 11 gauge.
    b. Selvedge Wire: Nominal 0.150 ± 0.004-inches or approximately U.S. 9 gauge.
    c. Tie Wire: Nominal 0.093 ± 0.004-inches or approximately U.S. 13 gauge.
    d. All testing of wire diameters shall be prior to fabrication.

4. Tie wire shall be supplied for securely fastening all edges of the Reno mattress baskets and diaphragms. Tie wire shall be included in sufficient quantity for tying all Reno mattress baskets as specified in Article 3.01 herein, or in accordance with the manufacturer's specifications, whichever is more stringent. No other wire except for the type supplied with the Reno mattresses shall be used.
5. Mesh opening of the Reno mattresses shall be approximately 3¼-inch x 4½-inch and shall be fabricated in a uniform hexagonal shaped, double twisted, non-raveling pattern.
6. All cut edges of the mesh shall be securely attached to the selvedge wire by a minimum of two complete turns of the mesh wires around the selvedge wire.
7. Reno mattress baskets furnished by the manufacturer shall be of uniform size and subject to a ±5% dimensional tolerance. All wire used, including tie wire, shall be certified by mill test reports showing compliance with this Section.

B. Reno Mattress Rock

1. Reno mattress rock shall be clean, sound, tough, and durable, subangular, subrounded or round stone, not lumpy, and free from slag, cinders, ashes, rubbish, or other deleterious material.
2. CBS shall maintain a uniform gradation of rock with a minimum diameter of 4 inches and a maximum diameter of 6 inches. Gradation control shall be by visual inspection of by the QUALITY ASSURANCE OFFICIAL.
3. Reno mattress rock shall be stored in designated areas approved by the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR is responsible for maintaining the rock free of contamination, and any rock determined by the QUALITY ASSURANCE OFFICIAL to be contaminated by visual means and methods, shall not be incorporated into the Work.

C. Geotextile

1. Geotextiles shall be placed adjacent to, or beneath, Reno mattress structures as shown in the Contract Drawings.
2. The geotextile shall be the type as specified and described in Section 02595 of these Specifications. Overlap/seam the geotextile in accordance with Section 02595.

2.02 TESTING

A. The CONTRACTOR shall submit to the QUALITY ASSURANCE OFFICIAL a minimum of 100 pounds of each proposed material from each source that is proposed for use.

B. The CONTRACTOR shall not proceed with use of the materials until the QUALITY ASSURANCE OFFICIAL have favorably reviewed the proposed materials for compliance as per the Contract Documents.

C. If in the opinion of the QUALITY ASSURANCE OFFICIAL, the CONTRACTOR's proposed material is unsuitable for the proposed application, the CONTRACTOR shall submit a sample of material of another type or from another source for consideration.

PART 3 - EXECUTION

3.01 PLACEMENT

A. The Reno mattresses shall be placed to the lines, depths and grades as shown on the Contract Drawings and shall be in strict accordance with these Specifications.

B. All tying of the Reno mattresses in each step of construction shall be done in the following manner:

1. Cut a length of tie wire approximately 5 feet long, secure the wire at one end by looping and twisting together, then proceed tying with a double loop (made at the same point) every 4 to 5-inches apart, pulling the basket pieces tightly together. Secure the end of the wire by again looping and twisting.
2. Assemble baskets by unfolding on a hard flat surface and stamping out all kinks. Fold up the front, back and end panels and fasten together with the projecting heavy gauge wire by twisting it around the selvedge wire two (2) complete turns. Fold the diaphragms up and secure in the same manner. All end panels and diaphragms are then tied to the sides.
3. Reno mattress baskets shall be placed in position empty and shall be tied together each to its neighbor along all contacting edges in order to form a continuous connecting structural unit.
4. When the assembled empty baskets have been installed, the Reno mattress rock shall then be placed in the following manner. The Reno mattress baskets may be filled by machine in maximum 12-inch layers, however, the rock must be manipulated by hand to accomplish a maximum density and a minimum amount of voids. Care shall be taken when placing the stone into the baskets to ensure that the baskets are not damaged or bent. Edges of baskets and diaphragms may be protected by tying steel reinforcement to the baskets or other suitable means. Care shall be taken that the individual cells do not bulge outward and that the rows are straight, level and have square corners.
5. When each basket has been filled to its maximum, which is slightly higher than the sides, and the surface leveled with a minimum amount of voids, the lids shall be pried down and over with a bar or lid closing tool until the edge of the lid and the edge of the basket are together. It should require a light stretching in order to bring the two basket pieces together. The heavy projecting wire on the lid shall then be twisted around the heavy wire on the sides, two complete turns and the lid shall then be tied to the sides and tops of the diaphragms in the same manner as the baskets are assembled. The lids of the Reno mattress baskets shall also be tied together, each to its neighbor along all contacting edges to ensure the formation of a

continuous connecting structural unit. Special attention shall be given that all projecting sharp ends are turned in.

6. Reno mattress baskets may be cut to form curves or bevels. Re-tying shall be in a manner to produce a closed cell and re-tying of the basket shall be in a manner as the assembly. Excess mesh wire shall be cut off or be tightly and neatly laced down.

3.02 QUALITY CONTROL

A. Proper construction of the Reno mattresses in accordance with the manufacturer's installation instructions, tying of all joints and filling of the baskets to the maximum density with a minimum amount of voids is critical to proper performance. The QUALITY ASSURANCE OFFICIAL shall observe the construction of all Reno mattresses. Reno mattresses which are not constructed and filled in accordance with the manufacturer's instructions and to the satisfaction of the QUALITY ASSURANCE OFFICIAL as well as in compliance with the Contract Documents, shall be repaired or removed and replaced by the CONTRACTOR at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02590

VFPE GEOMEMBRANE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all materials, labor, equipment, tools and appurtenances required to install the double-sided, textured, very flexible polyethylene (VFPE) geomembrane for the landfill cap as shown on the Contract Drawings. VFPE is a broad classification of materials which includes liner low-density polyethylene (LLDPE), low-density linear polyethylene (LDLPE), and very low density polyethylene (VLDPE).

B. Smooth VFPE may be used for lining areas outside the limits of the RCRA cap where slopes are less than 5%.

C. Installation of the VFPE geomembrane shall be completed by an experienced specialty SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

D. The CONTRACTOR shall have overall responsibility for the installation of the geomembrane. The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment, and supplies to be incorporated into the Work shall be described, including seaming plans, boots/sleeves/skirts for cap penetrations, installation procedures, quality control programs, and any other information needed to show the proposed method of conforming to the Contract Documents.

E. A pre-deployment meeting shall be held between the CONTRACTOR, Installer, CBS REPRESENTATIVE, and the QUALITY ASSURANCE OFFICIAL at least two (2) workdays prior to beginning the deployment of the VFPE geomembrane.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit the following information at the times indicated:

Prior to Shipping VFPE Geomembrane to the Work Site

1. Resumes of the Installer's supervisor, master seamer(s), and crew. The Installer shall have previous experience in the installation of VFPE materials. The supervisor will be required to provide satisfactory evidence demonstrating the successful completion of a minimum of 100 acres of smooth and textured VFPE geomembrane under the supervisor's previous supervision. The master seamer will be required to provide

satisfactory evidence demonstrating the successful installation of a minimum 50 acres of smooth and textured VFPE geomembrane seamed using similar types of seaming equipment. Additionally, the Installer must also demonstrate experience completing welds around geomembrane penetrations and in forming geomembrane covers and liners of other appurtenances. The VFPE geomembrane installation crew will be subject to favorable review by the QUALITY ASSURANCE OFFICIAL.

2. Shop Drawings shall include a panel layout diagram for the VFPE geomembrane; details and appurtenances related to the work specified herein, including pipe penetration/sealing procedures, anchor trench layout/design; and all welding processes and details. The VFPE panel layout diagram should be in sufficient detail to provide an accurate representation of the field seaming that will be performed. Any revision to the panel diagram shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL before implementation.
3. Provide the QUALITY ASSURANCE OFFICIAL with a written certification that all lots of the product to be delivered have been extruded from a favorably reviewed resin. This certification shall include the origin (resin supplier's name and resin production plant), identification (brand name and number), resin production date, and quality control certificates issued by the resin supplier. No material will be permitted to be stored on Site until this certification has been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.
4. Provide Quality Control (QC) test results as described in Article 1.04 of this Section.
5. Provide the QUALITY ASSURANCE OFFICIAL with written certification that the welding rod meets the resin property requirements in Article 2.02 of this Section.
6. Provide the QUALITY ASSURANCE OFFICIAL with written certifications for the material to be used for boots, sleeves, and skirts for sealing the geomembrane around penetrations. Submit Shop Drawings for any prefabricated boots/sleeves/skirts and installation details for the boots/sleeves/skirts including proposed connections (i.e., welds, bands, etc.). No boot/sleeve/skirt shall be fabricated or shipped until the Shop Drawings are favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

<u>Prior to Installation</u>

1. Provide a schedule of operations, including means and methods of installation (including deployment), to the QUALITY ASSURANCE OFFICIAL.
2. The CONTRACTOR and Installer shall complete subgrade acceptance forms indicating that the subgrade meets the minimum conditions described in Part 3 of this Section.
3. Provide the QUALITY ASSURANCE OFFICIAL with certifications stating the geomembrane roll number, base resin type, and lot from which the geomembrane was produced.

During Installation, Submitted Daily

1. Daily construction progress reports clearly showing the VFPE geomembrane panels placed by date.
2. Daily weld test records, including welder startup testing.
3. Daily records of seam testing (non-destructive) for the VFPE geomembrane. Reports on seam testing must be submitted to the QUALITY ASSURANCE OFFICIAL within three (3) working days of seaming, or no further seaming work will be permitted to continue. No geocomposite, geotextile, or cover soil shall be placed until satisfactory test results for the geomembrane area covered have been submitted and favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

Upon Completion

1. As-built panel layout diagram indicating dates on which seams and repairs were performed to provide an accurate two-dimensional representation of the geomembrane panel layout. Provide five (5) signed copies of a survey prepared by a registered Land Surveyor in the State of Indiana locating the edge of the geomembrane and any areas where the panel layout pattern changes. Locations shall be measured to a tolerance of ± 0.1 foot. Both the limits of geomembrane survey information and the as-built layout information can be incorporated on a single drawing.
2. Summary and log of all laboratory quality control testing completed by the CONTRACTOR.
3. Summary and log of all field quality control work completed by the CONTRACTOR as described in Part 4 of this Section.
4. Certification by the CONTRACTOR and Installer that the material installation is complete and in accordance with these Specifications.
5. Statement of warranty from the CONTRACTOR and geomembrane manufacturer that the material is free from manufacturing defects and that when properly installed and maintained will not suffer significant deterioration due to normal weather aging. Warranty shall be in effect for five (5) years from the date of shipment.

B. The above-noted requirements shall apply to all shop-fabricated materials as well as those items specified for fabrication in the field.

1.03 PRODUCT HANDLING

A. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

B. The CONTRACTOR shall, during all periods of shipment, off-loading, transporting and storage, protect the geomembrane from mud, dirt, dust, debris and other possible sources of damage. The geomembrane shall be stored off the ground in a relatively dry, flat area of the Site.

C. If the QUALITY ASSURANCE OFFICIAL determine that the geomembrane material is damaged, the CONTRACTOR shall immediately make all repairs and replacements, at the CONTRACTOR's own expense.

1.04 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GEOMEMBRANE

A. Test the resin and VFPE geomembrane prior to shipment to ensure that the properties of the furnished product are in accordance with these Specifications. Samples shall be tested by the geomembrane manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of at least one (1) sample for every 50,000 square feet of material produced for supply to the Work, and at least one (1) per resin lot to demonstrate compliance with all tests, properties, and requirements of Articles 2.02 and 2.03 herein, with the exception of the coefficient of friction. Perform a single interface friction test per lot for the geomembrane material.

B. Upon delivery of the geomembrane to the Site, the CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing at a minimum frequency of one (1) per 100,000 square feet. Unless otherwise directed, samples taken will be 3 feet by the roll width and will not include the first 3 feet at the end of the roll. Samples of the geomembrane will be tested by a geosynthetics testing laboratory, selected by the QUALITY ASSURANCE OFFICIAL, and at CBS's expense for the following properties, as applicable:

1.	Density	ASTM D1505
2.	Carbon Black Content	ASTM D1603
3.	Thickness	ASTM D5199
4.	Tensile Properties	ASTM D638
5.	Puncture Resistance	ASTM D4833
6.	Carbon Black Dispersion	ASTM D5596
7.	Tear Resistance	ASTM D1004

C. The manufacturer, CONTRACTOR, and the QUALITY ASSURANCE OFFICIAL shall visually inspect all samples to assure the material is free of holes, blisters, undispersed raw material, and foreign matter.

D. The CONTRACTOR shall provide the QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. <u>No material shall be installed prior to furnishing the required test results and receiving favorable review.</u>

E. The QUALITY ASSURANCE OFFICIAL, at their discretion, may obtain additional random samples of the geomembrane material for further confirmatory testing. This testing will be at the expense of CBS. This testing may also include some or all of the properties specified in Article 2.03 herein, or other test methods, as appropriate. The CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, immediately replace the material with satisfactory materials without delay to the Work or additional cost to CBS.

G. Quality control during construction shall be performed in accordance with Part 4 of this Section.

PART 2 - PRODUCTS

2.01 RESIN

A. The VFPE geomembrane shall be manufactured from pure virgin, low-density polyethylene resin having a minimum density of 0.920 g/km^3 (after carbon black blending). No reclaimed polymer shall be added to the resin. Polymer recycled during the manufacturing process may be permitted if done with an appropriate cleanliness and if the recycled polymer does not exceed 2% by weight. The carbon black is to be pre-blended according to the specifications of the manufacturer.

2.03 VFPE GEOMEMBRANE

A. The manufacturer of the geomembrane shall have satisfactory experience in extruding high-quality VFPE materials. Submit the manufacturing company name, address, and employee contact with telephone number. The materials shall be formulated from the appropriate polymers and compounding ingredients to form a VFPE geomembrane material that meets all requirements for the specified end use of the product. The material shall be capable of being bonded to itself by thermal bonding in accordance with the manufacturer's recommendations and instructions and the seaming requirements of this Section.

B. Geomembrane material rolls shall be at least 10 feet in width. Each roll shall be identified by a roll number, lot number, and date of manufacture. Labels or tags used for such identification shall be durable. Any roll or portion of roll that cannot be identified shall not be used in the Work and shall be immediately removed from the Site by the CONTRACTOR.

C. Geomembrane shall conform to the absolute minimum values and requirements as outlined in Table 02590A herein.

Table 02590A

Property	ASTM Test Method	Specified Value**	Units
1. Core Thickness	D5199/D5994†	36	mils
2. Density (sheet)	D792/D1505	0.92	g/cm^3
3. Tensile Properties (each direction)	D638 Type IV		
a. Tensile Strength, Break		110	lb/in-width
b. Elongation, Break		350	%
4. Tear Resistance	D1004 Die C	22	lbs
5. Low Temperature Brittleness (max) (once per batch)	D746 Procedure B	-103	°F
6. Dimensional Stability (each direction, maximum)	D1204 212°F, 1 hour	±2	% change
7. Puncture Resistance	D4833	44	lbs
8. Carbon Black Content Allowable Range	D1603	2.0-3.0	%
9. Carbon Black Dispersion Acceptable Levels	D5596	Category 1 or 2	
10. Coefficient of Friction (one test for the Work)	D5321‡	20.5 (residual)	degrees

† A needle-point micrometer shall be used for field testing of textured VFPE geomembranes.

‡ Minimum interface friction angle between textured 40-mil textured VFPE geomembrane and geosynthetic clay liner or geocomposite. Confining pressures at 100, 250, and 500 psf. with saturated interface. Note that all three geosynthetic components can be tested in one series of tests.

** Minimum values unless otherwise noted.

PART 3 - EXECUTION

3.01 FIELD INSTALLATION

A. Based on the favorably reviewed textured VFPE geomembrane panel layout and installation diagrams and material certifications, the individual panels will be numbered and seams will be identified by the Installer during deployment by using the numbers of the panels which create the seam. Any variation from the panel diagram must be favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Should a variance be obtained, the CONTRACTOR shall modify the panel diagram to show the "As-Built" configuration. All overlaps for field seams shall be shingled in a downslope direction. All overlaps shall be a nominal 4 inches (typically, 6 inches) and, in all cases, such that seams may be destructively tested in all locations.

B. During installation, pedestrian and equipment activity on the geomembrane shall be kept to a minimum and restricted to that which is necessary for cap construction. Construction workers shall take precautions not to damage the geomembrane surface, including the use of smooth-soled footwear, avoidance of dragging tools across the geomembrane surface, and the use of large tools which have smooth base plates or shoes. Construction and other Site staff shall be informed of the restricted access to areas of geomembrane placement. No tracked or rubber-tired equipment or other equipment which may pose a risk of puncturing, tearing or otherwise damaging the geomembrane, or other geosynthetic, will be permitted directly on the exposed geomembrane or overlying geosynthetics. No ATVs (4-wheelers), garden type tractors, or other motorized equipment is allowed on the geomembrane. Small equipment such as vacuum pumps and generators may be operated on the geomembrane if placed on rub-sheets.

At no time during the geomembrane installation shall vehicles or construction equipment be operated on the geomembrane or the underlying GCL.

C. The QUALITY ASSURANCE OFFICIAL will provide one (1) representative to observe the installation of the geomembrane. If the CONTRACTOR wishes to concurrently perform two (2) or more activities which require observation by the QUALITY ASSURANCE OFFICIAL (i.e., pre-seaming preparation, seaming, vacuum testing, or seam testing), submit a request for additional representatives, in writing, to the QUALITY ASSURANCE OFFICIAL not less than three (3) full working days in advance of any such simultaneous construction activities.

D. At the end of each work day, the CONTRACTOR shall inform the QUALITY ASSURANCE OFFICIAL of his planned construction activities for the following work day.

E. Prior to the textured VFPE geomembrane installation, the CONTRACTOR and Installer shall approve the subgrade surface. No geomembrane shall be placed over unsuitable or unapproved subgrade. The CONTRACTOR shall furnish a subgrade acceptance form prior to the installation of each panel, indicating acceptance of the subgrade.

The QUALITY ASSURANCE OFFICIAL will also observe the completed subgrade. Do not proceed with installation of the geomembrane until the QUALITY ASSURANCE OFFICIAL have favorably reviewed the subgrade.

F. The CONTRACTOR shall maintain reports and copies shall be provided to the QUALITY ASSURANCE OFFICIAL daily. These reports will contain, at a minimum, the following items.

1. Weather conditions;

2. Areas worked;
3. Daily production;
4. Manpower on-Site;
5. Equipment used;
6. Type and results of quality control testing completed by the CONTRACTOR;
7. Problems encountered during construction; and,
8. Resolution of problems.

G. The QUALITY ASSURANCE OFFICIAL will visually observe all field seaming and panels as installed. Any questionable areas or observed changes in physical installation characteristics will be immediately called to the attention of the CONTRACTOR. Random samples of seams representing different conditions may be taken for testing to examine the weld and its effect, if any, on the adjacent material. The CONTRACTOR will assist the QUALITY ASSURANCE OFFICIAL in obtaining samples. Areas where field samples were taken shall be repaired by the CONTRACTOR at the CONTRACTOR's expense.

H. Perform quality control tests and procedures as described in Part 4 of this Section.

I. No excessive wrinkles or creases in the geomembrane will be permitted. Creases in the geomembrane must be cut out and the area repaired. Wrinkles must be walked out ahead of the geocomposite and cover soil placement or cut out and repaired.

J. No vehicles shall be permitted on the geomembrane or geocomposite prior to the placement of at least a 12-inch thickness of cover soil. Equipment with ground pressure less than 5 psi may travel on a minimum 12-inch thickness of cover soil.

K. Placement of the geomembrane shall be done such that a good fit (thermal expansion or contraction shall be considered), without bridging or excessive contraction, is provided. Excessive slack shall be avoided to minimize wrinkles during the placement of the geocomposite and cover soil.

L. The geomembrane shall not be installed when ambient temperatures are below 40°F or above 105°F maximum (as measured 18 inches above the geomembrane), during precipitation, or when winds exceed 20 mph, unless the CONTRACTOR has previously submitted acceptable evidence that the CONTRACTOR's performance standards can be maintained under these conditions. Trial seam and destructive testing frequencies may be increased at the discretion of the QUALITY ASSURANCE OFFICIAL if installation occurs under these circumstances at the CONTRACTOR's expense.

M. The CONTRACTOR shall use whatever methods deemed necessary to prevent water or wind from getting under partially installed geomembrane. This could include, but is not limited to, the installation of temporary dikes and sand bags along the exposed edges. Should, in the opinion of the QUALITY ASSURANCE OFFICIAL, excessive moisture become trapped below the membrane, or wind damage be incurred, the CONTRACTOR will remove and replace the damaged geomembrane as determined by the QUALITY

ASSURANCE OFFICIAL, at the CONTRACTOR's expense. If the underlying GCL becomes hydrated as a result of this excessive moisture, it shall also be removed and replaced in accordance with Specification 02593, Section 3.02 N.

N. All seams that cannot be subjected to quality control testing shall be capped.

O. Geomembrane panels shall be placed at lengths which avoid horizontal seams on the landfill areas. Should the Installer select to place geomembrane panels at lengths which do not cover the entire width of the landfill, the installer shall submit a detailed drawings of the proposed cap trench to the ENGINEER. Upon favorable review by the ENGINEER, the INSTALLER shall be permitted to construct the cap trench.

P. All geomembrane panels deployed on a given day shall be seamed before the end of the work day.

3.02 SEAMING METHODS

A. For the VFPE geomembrane, field seams shall be of one of the following types:

1. Double Fusion or Split Hot Wedge or Knife - A seam produced by melting the two intimate surfaces by running a hot metal wedge between the surface followed immediately by pressure to form a homogeneous bond. This seam has an integral air channel for non-destructive testing of the seam. All areas which are to become seam interfaces shall be free of dust, oil, dirt, and moisture.
2. Extrusion Weld - A seam produced by extruding molten VFPE resin between, or at the edge of, two overlapped VFPE panels. A bonded seam is completed when the heated resin is extruded and melts the adjacent sheet resin to form a homogeneous weld. All areas which are to become extrusion weld seam interfaces shall be properly ground and free of dust, dirt, oil, and moisture.

B. The VFPE geomembrane panels shall be staggered such that cross seams between panels are not continuous throughout the cover area. Panel layouts shall be such that no horizontal seams (cross seams) are constructed on slopes steeper than ten percent (10%). All field seams within an area of slope steeper than ten percent (10%) shall be made perpendicular, or near perpendicular, to the toe of the slope.

C. Prior to the geomembrane installation, the QUALITY ASSURANCE OFFICIAL will review the proposed methods for field seaming. Provide complete information with respect to proposed seaming methods to permit the QUALITY ASSURANCE OFFICIAL to evaluate the intended technique. No deviation from favorably reviewed seaming methods will be permitted.

D. The CONTRACTOR shall work closely with the QUALITY ASSURANCE OFFICIAL and assist same during performance of construction quality assurance testing and observance of testing performed by the CONTRACTOR. No consideration will be given for extra costs that may be incurred due to delays in testing being performed by the QUALITY ASSURANCE OFFICIAL or by the QUALITY ASSURANCE OFFICIAL observing and reviewing the testing being performed by the CONTRACTOR.

E. Field seams are to be minimized.

3.03 GEOMEMBRANE PENETRATIONS

A. An VFPE pipe boot and sleeve shall be installed in areas where the geomembrane caps must be penetrated by gas vents, wells, vaults, and any other feature as shown on the Contract Drawings.

B. Prior to constructing the boot or sleeve, the CONTRACTOR shall assure that the subbase material in the area of the penetration is properly compacted and that the area is clean. Take care to assure the geomembrane is not damaged.

C. Pipe boots/sleeves shall be fabricated to fit tightly around the outside diameter of the penetrating feature. If boots/sleeves are prefabricated, the Shop Drawings shall show dimensions or callouts indicating the fit. If the boots/sleeves are field constructed, the fit shall be made to the satisfaction of the QUALITY ASSURANCE OFFICIAL.

D. The size of the skirt which flares away from the penetrating feature shall be adequate to provide a 12-inch minimum overlap over the geomembrane or as satisfactory to the QUALITY ASSURANCE OFFICIAL.

3.04 COVERING THE GEOMEMBRANE

A. Within the cap area, the geomembrane shall be covered with a drainage geocomposite in accordance with Section 02598 of these Specifications. Passing destructive seam test results shall be obtained for geomembrane prior to covering with the geocomposite. In placing the geocomposite, no vehicles shall be driven on the geomembrane or the geocomposite.

B. Within channels/ditches and ponds to be lined by geomembrane and covered with a soil or aggregate material, the geomembrane shall first receive a nonwoven geotextile protective cover in accordance with the requirements of Section 02595 of these Specifications.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

4.01 REQUIREMENTS

A. Any changes in the proposed method of Work, SUBCONTRACTORs/Installers to be utilized, geomembrane resin, or geomembrane supplier must be favorably reviewed in advance by the QUALITY ASSURANCE OFFICIAL.

B. The QUALITY ASSURANCE OFFICIAL and the CONTRACTOR shall visually inspect all material to be included in the Work for transportation/storage damage and uniformity, and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

C. Trial Seams: At the start and midpoint of each work day, and after each break in seaming of 30 minutes or more, or after an equipment shutdown, a trial seam produced by each piece of seaming equipment and each operator shall be performed at or near the current work location. The trial seam shall be a minimum of 10 feet in length for self-propelled seaming devices, and a minimum of 3 feet for hand-held seaming devices. The material for the trial seam and test fixtures for making the field test shall be provided by the CONTRACTOR at no additional cost to CBS. Specimens 1-inch wide from the trial seams will be subject to shear and peel adhesion testing at the Site. A minimum of three (3) specimens will be tested for shear, and an additional three (3) specimens will be tested for peel. All specimens must be acceptable or the trail seams will be repeated until all specimens from a given trial seam are found acceptable. The testing shall be observed by the QUALITY ASSURANCE OFFICIAL. A trial seam will be considered a failure if:

1. In the shear test, the bonded thickness of the seam fails before the adjacent sheet material fails for one (1) or more of the three (3) test specimens tested from each trial seam.
2. In the peel adhesion test, the two sheets comprising the seam separate at the bond interface before tearing an individual sheet (not a film tearing bond) for one (1) or more of the three (3) test specimens tested from each sample.
3. Upon visual inspection, the weld shows:
   a. Excessive deformation or stepping of the bottom sheet when viewed in cross-section;
   b. Inadequate or excessively narrow or flat weld bead;
   c. Water blisters in weld bead;
   d. Misaligned weld bead (i.e., weld not reasonably centered with respect to overlap); or,
   e. Thinning of the sheet adjacent to the weld.

If a trial seam fails as described above, the entire round of testing shall be repeated. The seaming apparatus and seamer shall not be used for seaming until the deficiencies which caused the failures are corrected and two (2) consecutive successful trial seams are completed.

D. Destructive Samples: Random destructive samples shall be obtained by the CONTRACTOR at locations identified by the QUALITY ASSURANCE OFFICIAL. The samples will be taken and prioritized as follows:

1. Areas identified as suspect during seaming or non-destructive testing/monitoring;
2. A minimum of one sample for each geomembrane seamer;
3. A minimum of one sample for each representative working conditions (e.g., weather conditions); and,
4. A minimum of one sample for every 500 feet of seaming.

Each destructive sample will, at a minimum, measure 12 inches by 48 inches in length with the seam centered lengthwise. Two specimens, one from each end of the sample, will be cut and tested for peel and shear strength in the field by the CONTRACTOR using a calibrated field tensiometer, supplied by the CONTRACTOR, capable of quantitatively measuring peel and shear strengths.

Testing shall be conducted as follows:

1. The shear test shall be in accordance with ASTM D3083 with Article 9.3 of the ASTM standard modified to permit either Method A or Method B of ASTM D882. Also, a specimen 1-inch in width shall be used with a grip separation of four (4) inches plus the width of the seam. The seam is to be centered between the clamps. The rate of grip separation will be 2.0 inches per minute.
2. The peel adhesion test shall be in accordance with ASTM D413. That standard shall be modified to be: Strip specimen Type A, 90° peel, modified to utilize a specimen that is 1-inch in width and pulled at a rate of 2.0 inches per minute.

The QUALITY ASSURANCE OFFICIAL will record the test results on the geosynthetic data sheets. A total of four (4) samples will be collected. One (1) sample will be tested in the field by the CONTRACTOR and the other three (3) samples will be distributed as specified below. If the specimen tested in the field fails, the CONTRACTOR will provide additional test samples 10 feet from the point of the failed test in each direction for repeat of the field test procedure. If these additional tests fail, then the procedure will be repeated until the length of the failed seam is established. Once the field tests have passed, the remainder of the sample will be divided into three (3) equal sections and distributed as follows:

1. One (1) sample to the geosynthetics laboratory for testing;
2. One (1) sample to the QUALITY ASSURANCE OFFICIAL for its records; and,
3. One (1) sample for Site archives.

The laboratory shear test results shall be reported in "ppi" (pounds per-inch of width); the minimum shear strength shall be 56 ppi for 40 mil textured VFPE. The shear test will be considered a failure if the average of five (5) individual tests per sample is less than the minimum bonded seam strength, as specified. Similarly, the peel adhesion tests result shall also be reported in ppi in addition to reporting the type of break. The peel test will be considered a failure if:

1. The two sheets comprising the seam separate at the bond interface before tearing an individual sheet (either sheet delaminates from the other on the weld for two (2) or more of the five (5) test specimens tested per sample).
2. The failure occurs in the weld and the break strength is less than 40 ppi for 40 mil textured VFPE for two (2) or more of the five (5) test specimens comprising a single sample.

Failed destructive tests shall be tracked in accordance with the CQAP. A log shall be maintained by the QUALITY ASSURANCE OFFICIAL and the CONTRACTOR for the purpose of recording all destructive test results. In addition, if at any time the QUALITY ASSURANCE OFFICIAL has reason to believe that seaming is not of adequate quality, additional test strips (1-inch specimens) shall be obtained. These shall be promptly obtained, at locations identified by the QUALITY ASSURANCE OFFICIAL, by the CONTRACTOR at no additional cost to CBS and tested in accordance with this Section. If the test strip seams fail, the reason for the failure shall be resolved before any seaming of the geomembrane continues.

E. No geomembrane will be covered by the CONTRACTOR until such time as the QUALITY ASSURANCE OFFICIAL have reviewed the test results required by these Specifications. As a minimum, the pre-delivery testing, the daily log of trial seam results, QA destructive test laboratory results, Installer's QC destructive test results (laboratory and field), as-built drawings of the completed area, and the seams in place will be reviewed. The CONTRACTOR shall be responsible for the protection of the installed geomembrane.

F. Non-Destructive Testing: The QUALITY ASSURANCE OFFICIAL and the CONTRACTOR shall visually inspect all geomembrane seams. In addition, the CONTRACTOR shall test all seams along their entire length, in a manner favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Potential test methods are as follows:

1. Pressure Testing - All field seams made by a double hot wedge welding device shall be tested by applying air pressure to a sealed length of seam and monitoring the pressure over time. After making the seam between two adjacent geomembrane panels, each end of the air channel in the weld is to be sealed. Air is to be introduced from one end of the seam into the air channel, and pressurized to a minimum of 25 psig. The channel is then to be sealed and monitored for a period of at least 5 minutes with an air pressure gauge calibrated in 1 psi increments. The seam shall be considered passing if the pressure drop in 5 minutes is less than 4 psi; and, a pressure gauge shall be inserted into the far end of the air channel to check for continuity in the air channel. Alternately, the far end of the seam may be cut to relieve the air pressure. An audible rush of air shall serve as an indicator that the test represents the entire length of seam. Air channels that do not hold the minimum specified air pressure shall be further inspected to identify the location and nature of any unbonded sections of seam. The seam shall then be capped or removed and replaced and re-tested as appropriate.
2. Vacuum Box Testing - All field seams with the exception of double hot wedge seams shall be inspected for unbonded areas by applying a vacuum to a soaped section of seam. The vacuum shall be applied by a vacuum box equipped with a vacuum gage, a clear glass view panel in the top, and a soft rubber gasket on the periphery of the open bottom. The vacuum box shall be equivalent to the Series A 100 Straight Seam Tester as supplied by the American Parts and Service Company, 2201 West Commonwealth Avenue, P.O. Box 702, Alhambra, California 91802. A section of the

seam shall be wetted thoroughly with soapy water and the vacuum box shall be placed over the soaped seam section and the gasket sealed to the membrane. A minimum vacuum of 8 inches of Mercury (Hg) shall be applied to the box by use of a gasoline or electric driven power-vacuum pump apparatus for a period of not less than 10 seconds. If no bubbles appear after 10 seconds, the vacuum box may be moved to the next adjoining area with a minimum 3-inch overlap and the process shall be repeated. The applied vacuum will cause bubbles to appear over unbonded areas. Any unbonded areas shall be marked by the CONTRACTOR for repair by the CONTRACTOR. The repair will consist of rewelding the questionable weld area.

All inadequate seams or portions thereof shall be corrected in accordance with the method favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Should differences of opinion between the CONTRACTOR and the QUALITY ASSURANCE OFFICIAL develop during the installation relevant to seam integrity, the QUALITY ASSURANCE OFFICIAL may, at his discretion, obtain samples of the seams in dispute for field or laboratory testing. The CONTRACTOR will be responsible for patching the resulting void in accordance with the previously favorably reviewed procedures.

G. All welds shall be observed for traces of deformation to the cover panels. Any welds which, in the opinion of the QUALITY ASSURANCE OFFICIAL, have caused excessive deformation or show visual signs of overheating of the cover panels shall be repaired at the CONTRACTOR's expense, regardless of the result of any destructive testing on the seam. The deficient seam shall be cut out and the cover panels again overlapped and welded or over capped.

H. <u>Repairs:</u> The Installer shall repair all geomembrane panels and seams that are found to be unacceptable by the QUALITY ASSURANCE OFFICIAL. Repairs shall be performed by methods favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Repairs are eligible for non-destructive testing and destructive testing.

I. <u>Geomembrane Installation and Testing Report:</u> The CONTRACTOR shall provide a report to the QUALITY ASSURANCE OFFICIAL at the conclusion of the Work. The report shall include the following:

1. Complete identification of geomembrane cap system, including type of resin, material type, source, and thickness.
2. Pre-delivery inspection forms for geomembrane rolls.
3. Complete identification of field seaming system used including material, method, temperatures, seam width, and date of fabrication of field seams.
4. The quality control tests used as specified or directed.
5. Complete description of field sampling procedure, number of test specimens, size of test specimens.
6. Type of test machine used, grip separation, and crosshead speed.
7. Method of recording load and determining average load for destructive/laboratory test methods.

8. Peel and shear load values for individual specimens in pounds per inch of width, and also the average load value for each group of specimen. The date of each testing and the seam location from which sample was obtained.
9. Type of failure in the tests, that is, within the seam, within the sheet material, clamp edge or seam edge, for each individual specimen.
10. For non-destructive testing, type of non-destructive test, and number of apparent failures and repairs of seams. The number of apparent failures and repairs should be reported on a per 100 lineal feet of seam basis.
11. Log of all quality control work.
12. As-built drawings showing locations of geomembrane sheets, seams, and repairs.

*****END OF SECTION*****

SECTION 02593

GEOSYNTHETIC CLAY LINER

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all materials, labor, equipment, tools and appurtenances required to install the geosynthetic clay liner (GCL) for the landfill cap as shown on the Contract Drawings.

B. Installation of the GCL shall be completed by an experienced specialty SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

C. The CONTRACTOR shall have overall responsibility for the installation of the GCL. The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment, and supplies to be incorporated into the Work shall be described, including seaming plans, installation procedures, quality control programs, and any other information needed to show the proposed method of conforming to the Contract Documents.

D. A pre-deployment meeting shall be held between the CONTRACTOR, Installer, CBS REPRESENTATIVE, and the QUALITY ASSURANCE OFFICIAL at least two (2) workdays prior to beginning the deployment of the GCL.

E. The GCL shall be installed with great care in a manner that will not cause damage to the material. Deployment of all overlying materials shall be performed without damage to the GCL. At no time shall vehicles or construction equipment drive directly on the GCL.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit the following information at the times indicated for favorable review:

Prior to Shipping the GCL to the Work Site

1. Resumes of the Installer's supervisor and crew. The Installer shall have extensive, previous experience in the installation of GCL materials. The supervisor will be required to provide satisfactory evidence demonstrating the successful completion of a minimum of 100 acres of GCL under the supervisor's previous supervision. The GCL installation crew will be subject to favorable review by the QUALITY ASSURANCE OFFICIAL.
2. Shop Drawings shall include a panel layout diagram for the GCL; details and appurtenances related to the work specified herein including anchor

trench layout/design; and, seam overlap and related details. The GCL panel layout diagram should be in sufficient detail to provide an accurate representation of the field seams to be constructed. Any revision to the panel diagram shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

3. Provide the QUALITY ASSURANCE OFFICIAL with a written certification that all lots of the product to be delivered have been manufactured with high-quality sodium bentontite. This certification shall include the origin (supplier's name and processing plant), identification (brand name and number), and quality control certificates issued by the supplier. No material will be permitted to be stored on Site until this certification has been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.
4. Provide Quality Control (QC) test results as described in Article 1.04 of this Section.

Prior to Installation

1. Provide a schedule of operations, including means and methods of installation (including deployment), to the QUALITY ASSURANCE OFFICIAL.
2. The CONTRACTOR and Installer shall complete subgrade acceptance forms indicating that the subgrade meets the minimum conditions described in Part 3 of this Section.
3. Provide the QUALITY ASSURANCE OFFICIAL with certifications stating the GCL roll number and lot from which the GCL was produced.
4. Upon completion of subgrade preparation the surface upon which the GCL is to be deployed shall be surveyed by a Land Surveyor registered in the State of Indiana. This survey will provide documentation that cap subgrade is graded in accordance with the Contract Drawings.

During Installation, Submitted Daily

1. Daily construction progress reports clearly showing the GCL panels placed by date.

Upon Completion

1. As-built panel layout diagram indicating dates on which seams and repairs were performed to provide an accurate two-dimensional representation of the GCL panel layout. Provide five (5) signed copies of a survey prepared by a licensed, registered Land Surveyor in the State of Indiana locating the edge of the GCL and any areas where the panel layout pattern changes. Locations shall be measured to a tolerance of ± 0.1 foot.
2. Summary and log of all laboratory quality control testing completed by the CONTRACTOR.
3. Summary and log of all field quality control work completed by the CONTRACTOR as described in Part 4 of this Section.
4. Certification by the CONTRACTOR and Installer that the material installation is complete and in accordance with theses Specifications.

5. Statement of warranty from the CONTRACTOR and GCL manufacturer that the material is free from manufacturing defects and that when properly installed and maintained will not suffer significant deterioration due to normal weather aging. Warranty shall be in effect for five (5) years from the date of shipment.

1.03 PRODUCT HANDLING

A. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

B. The CONTRACTOR shall, during all periods of shipment, off-loading, transporting and storage, protect the GCL from mud, dirt, dust, debris, other possible sources of damage, and from moisture which might result in the hydration of the GCL. The GCL shall be stored off of the ground in a dry, flat area of the Site.

C. Each GCL roll shall be wrapped in a plastic protective covering during transportation, delivery, and storage on-Site. Great care shall be used in removing this plastic cover to ensure that the GCL is not accidentally cut, sliced, or punctured.

D. If the QUALITY ASSURANCE OFFICIAL determine that the GCL is damaged, the CONTRACTOR shall immediately make all repairs and replacements, at the CONTRACTOR's own expense.

1.04 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GCL

A. Test the GCL prior to shipment to ensure that the properties of the furnished product are in accordance with these Specifications. Samples shall be tested by the GCL manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of at least one (1) sample for every 50,000 square feet of material produced for supply to the Work, and at least one (1) per lot to demonstrate compliance with all tests, properties, and requirements of Articles 2.02 and 2.03 herein. Coefficient of interface friction and internal hydrated shear strength shall be tested at a frequency of one test per lot of GCL manufactured.

B. Upon delivery of the GCL to the Site, the CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing at a minimum frequency of one (1) per 100,000 square feet. Unless otherwise directed, samples taken will be 3 feet by the roll width and will not include the first 3 feet at the end of the roll. Samples of the GCL will be tested by a geosynthetics testing laboratory, selected by the QUALITY ASSURANCE OFFICIAL, and at CBS's expense for the following properties, as applicable:

1.	GCL Thickness (dry)	ASTM D1777
2.	Bentonite Content	ASTM D5993
3.	Hydraulic Conductivity	ASTM D5321

C. The manufacturer, CONTRACTOR, and the QUALITY ASSURANCE OFFICIAL shall visually inspect all samples to assure the material is free of holes, blisters, broken needles, and other foreign matter.

D. The CONTRACTOR shall provide the QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. <u>No material shall be installed prior to furnishing the required test results and receiving favorable review.</u>

E. The QUALITY ASSURANCE OFFICIAL, at their discretion, may obtain additional random samples of the GCL material for further confirmatory testing. This testing will be at the expense of CBS. This testing may also include some or all of the properties specified in Article 2.03 herein, or other test methods, as appropriate. The CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, immediately replace the material with satisfactory materials without delay to the Work or additional cost to CBS.

G. Quality control during construction shall be performed in accordance with Part 4 of this Section.

<u>PART 2 - PRODUCTS</u>

2.01 GEOSYNTHETIC CLAY LINER

A. The geosynthetic clay layer (GCL) shall consist of a layer of pure powdered sodium bentonite clay, which is sandwiched between two geotextiles. The upper geotextile (i.e., geotextile in contact with the geomembrane) shall be a non-woven polypropylene geotextile and the lower geotextile (i.e., in contact with the prepared subgrade soils) shall be a woven polypropylene geotextile.

B. The GCL shall have been manufactured by mechanically bonding the geotextiles using a continuous needle-punching process to push the geotextile fibers from one geotextile through the bentonite clay layer and into the opposing geotextile forming an interlocked bond. The finished GCL product shall be subjected to a magnetic field to locate and remove broken needles which may have become lodged within the material during needle-punching.

C. The CONTRACTOR shall obtain and install a GCL having the minimum properties, which meet or exceed the criteria values shown in Table 02593A herein. The CONTRACTOR shall provide certificates of analysis and fluid loss and free swell test results on the bentonite.

D. The CONTRACTOR shall not order, obtain or install any GCL material which has not been tested, met the specified criteria, and been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

E. GCL rolls shall be at least 10 feet in width and a minimum of 150 feet in length. Contractor shall be capable of providing rolls of up to 200 feet in length if required to eliminate GCL cross seams on slopes greater than 10%. Each roll shall be identified by a roll number, lot number, and date of manufacture. Labels or tags used for such identification shall be durable. Any roll or portion of roll that cannot be identified shall not be used in the Work and shall be immediately removed from the Site by the CONTRACTOR.

Table 02593A

Property	**ASTM Test Method**	**Specified Value****	**Units**
1. GCL Thickness (dry)	D1777	6.4	mm
2. Bentonite Content	D5993	0.75 at 0% moisture	lb/ft^2
3. Hydraulic Conductivity (at 3 psi confining pressure)	D5084	1×10^{-8} (max.)	cm/sec
4. Minimum Interface Friction(1)	D 5321	20.5 (residual)	degrees
5. Hydrated Internal Shear Strength(2)	D 5321	400	psf

(1) Minimum interface friction angle between the GCL (non-woven side) and 40-mil textured VFPE geomembrane. Confining pressures at 100, 250, and 500 psf. with saturated interface. GCL shall be saturated and consolidated for a minimum of 15 minutes before shearing. Note that all three geosynthetic components can be tested in one series of tests.

(2) Peak value measured at 200 psf (30 kPa) normal stress. One test per manufactured lot.

** Minimum values unless otherwise noted.

PART 3 - EXECUTION

3.01 SUBGRADE FOR GCL

A. The surface on which the GCL is to be placed shall consist of a compacted natural soil layer as specified in Section 02224 of these Specifications.

B. Prior to placement of the GCL, the subgrade shall be fine-graded, to the tolerances shown on the Contract Drawings, and compacted to the minimum specified density in accordance with Section 02224 of these Specifications.

C. Prior to the placement of the GCL, the surface of the cap cushion soil shall be proof-rolled with smooth drummed compaction equipment weighing at least 20 tons, unless otherwise approved by the QUALITY ASSURANCE OFFICIAL.

This proofrolling shall create a smooth unyielding surface, free from pockets, holes, sudden grade changes or discontinuities which could cause bridging. Compaction equipment shall not have rubber tires and shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL prior to use.

D. The installer shall provide a written certificate of subgrade acceptance for each area on which GCL is to be placed on a given day.

E. The QUALITY ASSURANCE OFFICIAL will also observe the completed subgrade. Do not proceed with installation of the GCL until the QUALITY ASSURANCE OFFICIAL have favorably reviewed the subgrade.

F. The installer shall not place GCL on subgrade areas that have become altered due to mechanical means, precipitation or desiccation. Any and all damage to the GCL subgrade shall be repaired by the CONTRACTOR prior to GCL installation.

3.02 FIELD INSTALLATION

A. The CONTRACTOR shall handle GCL materials/rolls in such a manner as to ensure they are not damaged in any way.

B. All required cuts in the GCL shall be made using a utility knife with a sharp blade. Blades shall be changed frequently to maintain suitable sharpness for cutting. Care shall be exercised to prevent alteration or damage to any underlying material during cutting. Used blades shall be carefully disposed of and not placed on geosynthetic surfaces.

C. During placement, care shall be taken not to entrap stones, other potentially damaging objects, or moisture under the GCL.

D. Under no circumstance shall equipment or other potentially damaging objects be dragged across exposed surfaces of the GCL.

E. Any GCL roll, panel, or portion thereof which is damaged by stones or other objects, or installation activities shall be replaced by the CONTRACTOR at no additional cost to CBS.

F. The CONTRACTOR shall not install GCL material on a saturated subgrade or on standing water. The GCL shall be installed in a way that prevents hydration prior to completion of the capping system.

G. The GCL shall not be installed during precipitation events or other conditions that may cause hydration of the GCL.

H. Any and all GCL that becomes hydrated, as determined by the QUALITY ASSURANCE OFFICIAL, shall be replaced by the CONTRACTOR at no additional cost to CBS.

I. All GCL that is placed during one day shall be covered by the geomembrane before the CONTRACTOR leaves the Site at the end of that day.

J. The CONTRACTOR shall not place geomembrane over any GCL that is hydrated.

K. The geomembrane panels placed over a GCL shall be seamed as soon as possible after each panel is placed, but, in any event, before the end of the day on which placed.

L. Any and all defects, including sample locations, in the geomembrane panels/seams overlying a GCL shall be immediately repaired.

M. Seams in GCL Panels:
   1. Horizontal seams shall not be constructed on slopes steeper than 10 percent.
   2. Finished seams, immediately prior to placement of the geomembrane layer, shall have panel overlaps of at least 6 inches along the sides of adjacent panels and at least 1 foot at the ends.
   3. Edges of GCLs shall be pulled taught to remove any wrinkles or creases in the seam areas.
   4. Seams/overlaps shall not be nailed or stapled to the subgrade.

N. Repair:
   1. Holes, tears, or mechanically damaged areas in the GCL shall be repaired by closing or removing the damaged portion and placing a GCL patch over the hole. Hydrated areas shall be cut away and removed, then patched. Such patch shall overlap all edges of the damaged area by 1 foot (minimum). Accessory clay material, to be obtained from the GCL manufacturer, shall be placed between the patch and the repaired area of the GCL.
   2. Prior to the installation of any patch, the CONTRACTOR shall remove any soil or other material that potentially may adversely affect the bond between the patch and the underlying GCL.
   3. All repairs shall be made at no additional cost to CBS, and no schedule delays.
   4. Patch materials shall not be nailed or stapled to the subgrade.

3.03 COVERING OF GCL.

A. The GCL shall be covered by the geomembrane on the same day it was deployed and the geomembrane shall be seamed that same day.

B. At no time shall driving of vehicle be permitted directly on the GCL during deployment of the overlying geomembrane.

C. If, in the opinion of the QUALITY ASSURANCE OFFICIAL, the GCL becomes damaged during installation of the overlying geomembrane, the geomembrane will be removed to allow repair or replacement of the GCL, at no expense to CBS.

D. Following placement of overlying geomembrane, the CONTRACTOR shall use whatever methods deemed necessary to prevent water or wind from getting under partially installed geomembrane. This could include, but is not limited to, the installation of temporary dikes and sand bags along the exposed edges. Should, in the opinion of the QUALITY ASSURANCE OFFICIAL, excessive moisture become trapped below the membrane, or wind damage be incurred, the CONTRACTOR will remove and replace the damaged GCL as determined by the QUALITY ASSURANCE OFFICIAL, at the CONTRACTOR's expense. If the underlying GCL becomes hydrated as a result of this excessive moisture, it shall also be removed and replaced.

E. The CONTRACTOR shall place the geocomposite and cover soil above the geomembrane in a timely fashion prior to hydration underlying GCL. If the GCL become hydrated prior to placement of the cover soil, it shall be replaced at no expense to CBS.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

4.01 REQUIREMENTS

A. Any changes in the proposed method of Work, SUBCONTRACTORs/Installers to be utilized, or GCL supplier must be favorably reviewed in advance by the QUALITY ASSURANCE OFFICIAL.

B. The QUALITY ASSURANCE OFFICIAL and the CONTRACTOR shall visually inspect all material to be included in the Work for transportation/storage damage and uniformity, and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

C. Repairs: The Installer shall repair all GCL panels and seams that are found to be unacceptable by the QUALITY ASSURANCE OFFICIAL. Repairs shall be performed by methods favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

D. GCL Installation and Testing Report: The CONTRACTOR shall provide a report to the QUALITY ASSURANCE OFFICIAL at the conclusion of the Work. The reports shall include the following:

1. Complete identification of GCL cap system, including material type, source, and thickness.
2. Pre-delivery inspection forms for GCL rolls.
3. The quality control tests used as specified or directed.
4. Log of all quality control work.
5. As-built drawings showing locations of GCL sheets, seams, and repairs.

*****END OF SECTION*****

SECTION 02595

GEOTEXTILE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to install geotextile(s) to reinforce new access road subgrades, to line channels/ditches, outlet aprons, and ponds, and as otherwise shown on the Contract Drawings. The geotextile material associated with the geocomposite drainage layer is specified in Section 02598 of these Specifications.

B. Installation of the geotextile(s) shall be completed by an experienced specialty SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

C. *The CONTRACTOR shall have overall responsibility for the installation of the* geotextile(s). The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment and supplies to be incorporated in the Work shall be described, including seaming/overlapping plans, installation procedures, quality control programs, and any other information needed to show the proposed means and methods for compliance and conforming to the Contract Documents.

1.02 SUBMITTALS

A. The CONTRACTOR shall furnish written certification from the manufacturer of the geotextile(s) attesting that the geotextile(s) meets the manufacturing requirements specified. Any geotextile found to have defects, rips, holes, flaws, deterioration or other damage shall be replaced by the CONTRACTOR at the CONTRACTOR's expense.

B. The CONTRACTOR shall submit Shop Drawings showing proposed installation methods including overlapping, seaming, and layout details.

1.03 PRODUCT HANDLING

A. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

B. The CONTRACTOR shall, during all periods of shipment and storage, protect the geotextile from direct sunlight, ultraviolet light, temperatures greater than 120°F, mud, dirt, dust, debris and other possible sources of damage. Geotextile rolls shall be wrapped in a heavy-duty protective covering until needed for installation.

C. If the QUALITY ASSURANCE OFFICIAL determines that the geotextile material is damaged, or has experienced excessive sunlight exposure (more than 15 days), the CONTRACTOR shall immediately make all repairs and replacements, at the CONTRACTOR's expense.

1.04 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GEOTEXTILE

A. Geotextiles shall be tested prior to shipment to ensure that the properties of the finished product are in accordance with the Specifications. Samples of geotextile materials shall be tested by the manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of one (1) sample for every 50,000 ft^2 of material produced for each lot and material type. The required material properties, test methods, values, and units are presented in Part 2 of this Section. In addition, one (1) sample 3 feet wide by the width of the roll, from each roll tested, will be retained by the manufacturer or CONTRACTOR for possible further testing until construction for which the geotextile is used is complete and favorably reviewed. Each sample of geotextile will have the machine direction, roll number, lot number, date of manufacture, and manufacturer name clearly marked on or attached to the sample.

B. Upon delivery of the geotextile to the Site, the CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing at a minimum frequency of one (1) per 100,000 square feet. Unless otherwise directed, samples taken will be 3 feet by the roll width and will not include the first 3 feet at the end of the roll. Samples of the geotextile will be tested by a geosynthetics testing laboratory, selected by the QUALITY ASSURANCE OFFICIAL, and at CBS's expense for the following properties, as applicable:

1.	Mass/Area	ASTM D5261
2.	Grab Tensile Strength and Elongation	ASTM D4632
3.	Puncture Strength	ASTM D4833
4.	Burst Strength	ASTM D3786
5.	Trapezoidal Tear Strength	ASTM D4533
6.	Apparent Opening Size	ASTM D4751

C. The manufacturer, CONTRACTOR, and QUALITY ASSURANCE OFFICIAL shall visually inspect all samples to assure the material is free of holes or foreign matter.

D. The CONTRACTOR shall provide the QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. No material shall be installed prior to furnishing the required test results and receiving favorable review.

E. The QUALITY ASSURANCE OFFICIAL, at his order, may request additional random samples of the geotextile for further confirmatory testing. This testing will be at the expense of CBS. This testing may also include all properties specified in Part 2 of this Section and need not be limited to the testing required by the manufacturer. The CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the CONTRACTOR will be responsible for replacing the material with satisfactory materials that meet all test requirements without delay to the Work and at CONTRACTOR's expense.

G. Quality control during construction shall be performed in accordance with Part 4 of this Section.

PART 2 - MATERIALS

2.01 10 OZ/SY NONWOVEN GEOTEXTILE

A. The nonwoven, needle-punched, polyester or polypropylene, geotextile to be used for channel, apron, ponds and ditch lining, or as otherwise shown on the Contract Drawings shall be Trevira Type 1135 (011/350), Amoco 4510, or equivalent, and shall conform to the following minimum requirements:

Property	**Requirements***	**Test Method**
Mass/Area	10 oz/sy	ASTM D5261
Trapezoidal Tear Strength	90 lbs	ASTM D4533
Grab Tensile Strength	230 lbs	ASTM D4632
Grab Tensile Elongation	50%	ASTM D4632
Burst Strength	500 lb/in^2	ASTM D3786
Puncture Resistance	130 lbs	ASTM D4833
Apparent Opening Size	#70 sieve	ASTM D4751

* Minimum values unless otherwise noted for manufacturer's quality control testing. All values minimum for field conformance testing.

2.02 WOVEN GEOTEXTILE

A. The woven polypropylene geotextile to be placed on the subgrade of new access roads shall be Mirafi 600X, Amoco 2006, or equivalent. Woven geotextile shall meet the following or minimum properties:

Property	Requirements*	Test Method
Grab Tensile Strength	300 lbs	ASTM D4632
Grab Tensile Elongation	15 %	ASTM D4632
Trapezoidal Tear Strength	120 lbs	ASTM D4533
Burst Strength	600 psi	ASTM D3786
Puncture Resistance	120 lbs	ASTM D4833

* Minimum values unless otherwise noted for manufacturer's quality control testing. All values minimum for field conformance testing.

2.03 WIDTH OF GEOTEXTILE ROLLS

A. All geotextiles shall be provided in rolls not less than 12 feet in width.

PART 3 - EXECUTION

3.01 SURFACES TO RECEIVE GEOTEXTILE

A. Any subbase or subgrade surfaces to receive a geotextile shall be cleared of sharp objects, boulders, stumps, debris, or any materials that may contribute to fabric punctures, shearing, rupturing or tearing to the satisfaction of the QUALITY ASSURANCE OFFICIAL.

B. Subbase or subgrade surfaces underlying areas planned to receive a 10 oz/sy, nonwoven geotextile or woven geotextile shall be graded smooth and then compacted.

C. Trench, channel, and slope drain excavations planned to receive geotextiles shall be visually observed and favorably reviewed by the QUALITY ASSURANCE OFFICIAL so that they meet the line and grade requirements, and as required by the Contract Documents, Specifications, and manufacturer's guidelines.

D. Geomembrane surfaces to receive a protective nonwoven or woven geotextile cover shall be as wrinkle-free as practicable. Geotextile shall not be placed over any geomembrane until the geomembrane has been visually observed and favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Geotextile shall no be placed over geomembrane with excessive wrinkling or waves.

3.02 INSTALLATION

A. The geotextile shall be placed in the manner and at the locations shown. Geotextile shall be laid smooth and free of tension, stress, folds, wrinkles, or creases.

B. Geotextile seams shall be overlapped a minimum of 6 inches prior to seaming. All geotextiles seams shall be joined by continuous sewing. Sewing will be performed using polymeric thread with chemical resistance properties equal to or exceeding those of the geotextile. The manufacturer shall certify, in writing, that the thread meets this requirement. Thread color shall contrast that of the geotextile.

C. Cover materials shall be placed or spread in a manner such that wrinkles, excessive tension, or other damage does not occur. Gravel surface courses and stone riprap shall not be dropped from a height exceeding 3 feet.

D. If nonwoven geotextile is damaged during any step of installation or placement of overlying materials, a piece of geotextile material shall be cut and placed over the damaged area and overlapped a minimum of 3 feet in each direction, and leistered around the edges, over undamaged material. For woven geotextile, the overlap shall be 6 inches in each direction and sewn as indicated in Article 3.02B.

3.03 PROTECTION

A. After installation, the CONTRACTOR shall visually inspect the geotextile to assure that no objects are present that could potentially harm the geotextile.

B. Any geotextile damaged during installation or during placement of cover material shall be replaced by the CONTRACTOR at the CONTRACTOR's expense.

C. The Work shall be scheduled so that, in general, the covering of the geotextile is accomplished within fifteen (15) calendar days after placement of the geotextile. Failure to comply with this requirement shall require replacement of the geotextile at the CONTRACTOR's expense. Geotextile placed as a geomembrane protection shall be typically covered immediately and, at the latest, covered within five (5) calendar days.

D. No equipment shall be operated directly on the geotextiles prior to the placement of overlying materials. Provide a minimum 12 inches of separation between any geotextile and low ground pressure equipment (5 psi) or 3 feet of separation when using equipment greater than 5 psi.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL

4.01 GENERAL

A. The CONTRACTOR, before installation begins, shall appoint an individual who is qualified and thoroughly experienced with work similar to the requirements specified herein, and who will be on-Site at all times during the installation, to represent the CONTRACTOR in all matters relevant to this Work. This appointment shall be subject to favorable review by the QUALITY ASSURANCE OFFICIAL.

B. Before installation begins, and at least weekly thereafter, more often if determined necessary by the QUALITY ASSURANCE OFFICIAL, project coordination meetings shall be held with the designated representative of the CONTRACTOR, Installer, and QUALITY ASSURANCE OFFICIAL to review the following information:

1. Progress of the work;
2. Adherence to the Specifications;
3. Adherence to the Construction Quality Assurance Plan, including the timely submission of the pertinent forms; and,
4. Planned work and methods for the ensuing week, including an estimate of the time remaining to completion of this Work.

This information shall be submitted to the QUALITY ASSURANCE OFFICIAL by the CONTRACTOR, in writing, during or before this meeting.

C. Any changes in the proposed method of work, SUBCONTRACTORs to be utilized or manufacturing must be favorably reviewed in advance by the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR assumes all responsibility relevant to providing an acceptable product and installation.

4.02 QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

A. The Installer and CONTRACTOR shall visually inspect all material to be included in the Work for transport damage and uniformity and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

B. The Installer and CONTRACTOR shall also visually inspect the material for any damage incurred as a result of handling or on-Site storage.

C. After the CONTRACTOR has completed each area of work and thoroughly inspected all installation and seaming, the QUALITY ASSURANCE OFFICIAL will visually observe all seams for continuity and quality. The QUALITY ASSURANCE OFFICIAL shall also observe the geotextile for transport, handling, or installation damage. Do not cover any geotextile prior to receiving favorable review from the QUALITY ASSURANCE OFFICIAL. All inadequate seams shall be repaired at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02598

GEOCOMPOSITE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to install the geocomposite drainage layer as shown on the Contract Drawings.

B. Installation of the geocomposite shall be completed by an experienced SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

C. The CONTRACTOR shall have overall responsibility for installation of the geocomposite. The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment and supplies to be incorporated in the Work shall be described, including seaming/overlapping plans, installation procedures, quality control programs, and any other information needed to show the proposed method of conforming to the Contract Documents.

D. During deployment of geocomposite, no vehicles or construction equipment shall drive directly on the geocomposite or on previously placed geosynthetics, as specified in Section 3.04 D of this specification.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit to the QUALITY ASSURANCE OFFICIAL all items described in subsequent sections as outlined by the following schedule:

<u>Prior to Delivery to the Site</u>

1. Shop Drawings including all geocomposite panel layouts and details of all work including details of all overlapping, tying, repairs, penetrations, and attachments.
2. Geocomposite manufacturer's specifications.
3. Certification stating geocomposite roll numbers and base resin type and lot from which the internal geonet was produced.
4. Geocomposite roll correlation list that clearly shows geonet roll number and geotextile roll number correlated to the geocomposite roll number.
5. Provide certification from the manufacturer that the geocomposite is in conformance with the testing and material requirements of this Section.

Prior to Installation

1. Submit to the QUALITY ASSURANCE OFFICIAL a schedule of operations including means and methods of installation.

During Installation Submitted Daily

1. Daily construction progress reports clearly showing geocomposite panels placed by date.
2. Summary and log of all laboratory quality control completed by the CONTRACTOR.
3. Certification from the CONTRACTOR and Installer that the geocomposite installed that day was satisfactorily completed in accordance with these Specifications.

After Installation

1. As-built record drawings.
2. Statement of warranty from the CONTRACTOR and geocomposite manufacturer that the material is free from manufacturing defects and that when properly installed and maintained will not suffer significant deterioration due to normal aging. Warranty shall be in effect for five (5) years from the date of installation.

1.03 PRODUCT HANDLING

A. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

B. The CONTRACTOR shall, during all periods of shipment and storage, protect the geocomposite from direct sunlight, ultraviolet light, temperatures greater than 120°F, mud, dirt, dust, debris and other possible sources of damage. The geocomposite shall be wrapped in a heavy-duty protective covering until needed for installation.

C. If the QUALITY ASSURANCE OFFICIAL determines that the geocomposite material is damaged or has experienced excessive sunlight exposure (more than 15 days), the CONTRACTOR shall immediately make all repairs and replacements, at the CONTRACTOR's expense.

1.04 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GEOCOMPOSITE

A. Geocomposites shall be tested prior to shipment to ensure that the properties of the finished product are in accordance with these Specifications. Samples of the geocomposite shall be tested by the manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of one (1) sample for every 50,000 square feet for each lot of material produced for delivery to Site. The interface friction test will be performed at a frequency of one test per lot of manufactured material. The required material properties, test methods, values, and units are presented in Part 2 of this Section.

B. Upon delivery of the geocomposite to the Site, the CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing. Testing shall be at a minimum frequency of one (1) sample per lot with a minimum of one (1) sample (3 feet long by the roll width) per 100,000 square feet of material delivered. Transmissivity testing shall be performed at a frequency of one test per lot. Samples will not include the first 3 feet at the end of the roll. Samples of the geocomposite will be tested by a geosynthetics testing laboratory, approved by the QUALITY ASSURANCE OFFICIAL, and at CBS's expense for the following properties:

1.	Thickness	ASTM D5199
2.	Adhesion Strength	ASTM F904 modified or D413
3.	Transmissivity (geocomposite)	ASTM D4716

C. The manufacturer, CONTRACTOR, and QUALITY ASSURANCE OFFICIAL, shall visually inspect all samples to assure the material is free of holes or foreign matter.

D. The CONTRACTOR shall provide the QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. <u>No material shall be installed prior to furnishing the required test results and receiving favorable review.</u>

E. The QUALITY ASSURANCE OFFICIAL, at his discretion, may request additional random samples of the geocomposite for further confirmatory testing. This testing will be at the expense of CBS. This testing may also include some or all of the properties specified in Article 2.02 of this Section and need not be limited to the testing required by the manufacturer. The CONTRACTOR shall assist the QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the Work and at CONTRACTOR's expense.

G. *Quality control during construction shall be performed in accordance with Part 4* of this Section.

<u>PART 2 - PRODUCTS</u>

2.01 MATERIALS

A. The geonet component of the geocomposite shall be manufactured from pure virgin high-density polyethylene resin (HDPE) satisfactory for the intended use, having a minimum density of 0.940 g/cm^3 (after carbon black blending). The pure virgin resin shall be mixed with two to three percent (2-3%) carbon black, pre-blended according to specifications of the manufacturer. The geonet component shall be manufactured with solid ribs of polyethylene.

B. The geotextile portion of the geocomposite shall be a minimum 6.0 oz/sy nonwoven polyester or polypropylene needle-punched geotextile, heat bonded to both sides of a geonet, designed and manufactured specifically for the purpose of liquid filtration and conveyance.

C. Provide the QUALITY ASSURANCE OFFICIAL with a written and signed certification from the manufacturers that the geonet portion of the product to be delivered has been extruded from a favorably reviewed HDPE resin satisfactory for the intended use. No material will be permitted to be shipped to Site until this certification has been delivered to the QUALITY ASSURANCE OFFICIAL.

2.02 MANUFACTURING

A. The manufacturer of the geocomposite shall be subject to favorable review by the QUALITY ASSURANCE OFFICIAL and have extensive experience in extruding geonet and bonding geotextiles with the geonet. The CONTRACTOR shall submit the manufacturing company, address, and name of contact, with telephone number, to the QUALITY ASSURANCE OFFICIAL. The geocomposite shall be formulated from the appropriate polymers and compounding ingredients to form a geocomposite that meets all requirements for the specified end use of the product.

B. Geocomposite rolls shall be a minimum of 6 feet in width. Each roll shall be identified by a lot number, roll number, and date of manufacture.

C. Geocomposite shall be manufactured and fabricated by companies regularly in the business of manufacturing geosynthetic drainage materials. The geocomposite and individual components (prior to fabrication) thereof shall possess the minimum properties as specified in Table 02598A herein. The final manufactured geocomposite shall be capable of providing high flow rates (therefore, high transmissivity) under the anticipated soil loads and in compliance with the requirements of Table 02598A.

TABLE 02598A

Property	ASTM Test Method	Specified Value**	Units
1. Flow Capacity			
a. Transmissivity[1] (Geocomposite) 750 psf & gradient of 0.10	D4716	$8.2. \times 10^{-4}$	m^2/sec
b. Permittivity (Top Geotextile)	D4491	1.3	$gal/min/ft^2$
2. Mechanical Properties			
a. Grab Tensile Strength (Top & Bottom Geotextile)	D4632	150	lbs
b. Apparent Opening Size (Top Geotextile)	D4751	70	U.S. Std. Sieve
c. Peak Tensile Strength (Geonet)	D5035	40	lb/in. width
d. Ply Adhesion (Geocomposite)	F904 modified or D413	1.0	lb/in.
e. Coefficient of Friction[2]	D5321	20.5	degrees
3. Material Properties			
a. Polyethylene Density (Geonet)	D1505	0.940	g/cm^3
b. Carbon Black Content (Geonet)	D1603	2.0-3.0	%
4. Dimensions			
Thickness (Geonet)	D5199	250 (min.)	mm
Mass/Area (Geotextile)	D5261	6.0 (min.)	oz/sy

(1) Transmissivity testing shall be performed using boundary conditions reflective of the field condition. The geocomposite shall be bounded by a moderately compacted sample of cap cover soil and a 40-mil textured VFPE geomembrane.

(2) Minimum residual interface friction between the geocomposite and 40-mil textured VFPE geomembrane. Confining pressures at 100, 250, and 500 psf. with saturated interface. Note that all three geosynthetic components can be tested in one series of tests.

** Minimum values unless otherwise noted for manufacturer's quality control testing. All values minimum for field conformance testing.

PART 3 - EXECUTION

3.01 GEOCOMPOSITE INSTALLATION

A. Install the geocomposite drainage layer over the favorably reviewed textured HDPE geomembrane to the lines and grades shown on the Contract Drawings in accordance with the manufacturer's recommendations. Do not cover the geomembrane until the geomembrane installation and test results for that area of work have been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

B. Protect the geomembrane during the installation of the geocomposite layer. No equipment shall be permitted to operate directly on any geomembrane or geocomposite at any time. In no way shall any tracked equipment or any other equipment which may pose a risk of puncturing, tearing, or otherwise damaging the geomembrane or geocomposite be permitted to operate directly on these materials. Provide a minimum 12 inches of compacted soil separation between the geocomposite and cover soil placement equipment as described in Section 02224 of these Specifications.

C. The CONTRACTOR and/or Installer shall supply and use a sacrificial smooth geomembrane to aid in the deployment and positioning of geocomposite panels over the textured geomembrane unless an alternate method has been favorably reviewed by the QUALITY ASSURANCE OFFICIAL, in accordance with Article 1.02 of this Section, prior to deployment.

D. The geocomposite shall be positioned by hand after being unrolled. Do not crease or fold over the geocomposite. The geocomposite shall not be placed in the horizontal direction (i.e., across the slope) on slopes steeper than 10 (horizontal):1 (vertical), except as part of a patch.

E. In the presence of wind, all in-place geocomposite rolls shall be weighted with sandbags or the equivalent, such sandbags shall be installed during placement and shall remain until replaced with cover material.

F. Adjacent rolls shall be overlapped a minimum of 4 inches and the geonet secured by plastic ties a minimum of every 5 feet along the roll length. Plastic ties shall be white or other bright and contrasting color for ease of inspection and shall be connected according to the manufacturer's recommendations. Metallic ties are not permitted. The upper geotextile sheets shall then be sewn along their entire length. The bottom geotextile sheets shall be overlapped without sewing. The geonet within the geocomposite, on cross-slope seams or end of panel seams, will be overlapped a minimum of 12 inches and securely fastened together with ties at maximum 12-inch intervals.

G. The geocomposite shall not be welded or otherwise physically attached to the geomembrane.

H. All connections shall be inspected and favorably reviewed by the QUALITY ASSURANCE OFFICIAL. The QUALITY ASSURANCE OFFICIAL will reject any connections deemed insufficient and require those joints to be redone at the CONTRACTOR's expense.

I. Repairs shall be made in accordance with the manufacturer's procedures and recommendations at the CONTRACTOR's expense. The CONTRACTOR shall submit proposed repair procedures for the favorable review of the QUALITY ASSURANCE OFFICIAL.

3.02 PROTECTION

A. After installation, visually inspect the geocomposite to assure that no objects are present that could potentially harm the geocomposite.

B. Any geocomposite damaged during installation or during placement of cover material shall be replaced by the CONTRACTOR at the CONTRACTOR's expense.

C. The Work shall be scheduled so that the covering of the geocomposite is accomplished within fifteen (15) calendar days after placement of the geocomposite. Failure to comply with this requirement shall require replacement of the geocomposite at the CONTRACTOR's expense.

D. No equipment shall be operated directly on the geocomposite prior to the placement of overlying materials. Provide a minimum 12 inches of compacted soil separation between any geocomposite and low ground pressure equipment (maximum 5 psi) or 18 inches of compacted soil separation when using equipment greater than 5 psi and less than 10 psi.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL

4.01 GENERAL

A. The CONTRACTOR, before installation begins, shall appoint an experienced individual thoroughly experienced with work similar to the requirements specified herein, and who will be on-Site at all times during the installation, to represent the CONTRACTOR in all matters relevant to this Work. This appointment shall be subject to favorable review by the QUALITY ASSURANCE OFFICIAL.

B. Before installation begins, and at least weekly thereafter, more often if determined necessary by the QUALITY ASSURANCE OFFICIAL, project coordination meetings shall be held with the designated representative of the CONTRACTOR, Installer, and QUALITY ASSURANCE OFFICIAL to review the following information:

1. Progress of the work;
2. Adherence to the Specifications;
3. Adherence to the Construction Quality Assurance Plan, including the timely submission of the pertinent forms; and,

4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work.

This information shall be submitted to the QUALITY ASSURANCE OFFICIAL by the CONTRACTOR, in writing, during or before this meeting.

C. Any changes in the proposed method of work, SUBCONTRACTORs to be utilized, geocomposite, geotextile, resin or manufacturing must be favorably reviewed in advance by the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR assumes all responsibility relevant to providing an acceptable product and installation.

4.02 QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

A. The Installer and CONTRACTOR shall visually inspect all material to be included in the Work for transport damage and uniformity and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

B. The Installer and CONTRACTOR shall also visually inspect the material for any damage incurred as a result of handling or on-Site storage.

C. After the CONTRACTOR has completed each area of work and thoroughly inspected all installation and seaming, the QUALITY ASSURANCE OFFICIAL will visually inspect all seams for continuity and quality. Do not cover any geocomposite prior to receiving favorable review from the QUALITY ASSURANCE OFFICIAL. All inadequate seams shall be repaired at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02605

STORM INLET

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and installing a precast concrete storm inlet as described herein and/or as shown, specified, and as otherwise required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

1.02 DESIGN REQUIREMENTS

A. Storm inlet shall be constructed of specified materials to the sizes, shapes and dimensions and at the locations shown on the Contract Drawings or as otherwise directed by CBS.

1.03 SUBMITTALS

A. The CONTRACTOR shall submit to the ENGINEER Shop Drawings and engineering data or precast storm inlet sections, reinforcement, and standard (typical) details showing joints and seals between storm inlet riser sections and pipes, or concrete materials

B. Submit to the ENGINEER in accordance with Section 01300 of these Specifications.

1.04 QUALITY ASSURANCE

A. Prior to delivery, all basic materials specified herein shall be tested and inspected by an approved independent commercial testing laboratory or, if approved by the ENGINEER, certified copies of test reports prepared by the manufacturer's testing laboratory will be acceptable. Provide test results and certification from the supplier that the products meet the requirements of these Specifications. All materials which fail to conform to these Specifications shall be rejected.

B. Upon delivery to the Site, the QUALITY ASSURANCE OFFICIAL or ENGINEER shall inspect storm inlet. Any materials which have been damaged in transit or are otherwise unsuitable for use in the Work shall be rejected, removed from the Site, and replaced with suitable materials at the CONTRACTOR's own expense.

PART 2 - PRODUCTS

2.01 MATERIALS AND CONSTRUCTION

A. Reinforcement: Steel reinforcement shall conform to the requirements of ASTM A615. Reinforcement shall be manufactured from new billet steel of American manufacturer, Grade 60, yield strength 60,000 psi, minimum.

B. Mortar: Mortar for storm inlet construction shall be sand-cement mortar composed of one (1) part Portland cement to two (2) parts clean sand conforming to ASTM C144.

C. Precast Concrete Storm Inlet:

1. Precast concrete storm inlet shall consist of precast reinforced concrete sections, flat slab top section, and a base slab section conforming with the typical detail as shown on the Contract Drawings.
2. Precast concrete storm inlet and/or associated piping will require geomembrane material as specified in Section 02590 to form a boot. The geomembrane shall be secured as shown on the Contract Drawings. The geomembrane boot shall extend a minimum of 12 inches from all outward facing sections to allow for proper seaming in accordance with Section 02590 and as shown on the Contract Drawings.
3. Precast storm inlet sections shall be manufactured, tested and marked in accordance with the latest provisions of ASTM C478.
4. The minimum 28-day compressive strength of the concrete for all sections shall be 4,000 psi.
5. The maximum allowable absorption of the concrete shall not exceed eight (8) percent of the dry weight.
6. The reinforcement in the wall sections, top section and base section shall consist of one line of steel and shall not be less than 0.17 square inch per lineal foot.
7. Each section of the precast storm inlet shall have not more than two holes for the purpose of handling and laying. These holes shall be tapered and shall be plugged with rubber stoppers or mortar after installation.
8. Joints of the storm inlet sections, if any, shall be of the tongue and groove type. Sections shall be joined using O-ring rubber gaskets conforming to the applicable provisions of ASTM C443, latest revision, or filled with an approved preformed plastic gasket meeting the requirements of Federal Specifications SS-S-00210, "Sealing Compound", Preformed Plastic for Pipe Joints," Type 1, Rope Form.

PART 3 - EXECUTION

3.01 PLACEMENT OF STORM INLET

A. Prior to placing precast concrete storm inlet, install subgrade bedding as shown on the Contract Drawings.

B. After favorable review of bedding by the ENGINEER or QUALITY ASSURANCE OFFICIAL, storm inlet shall be placed, and their inverts shall be established and verified.

C. Grates as indicated on the Contract Drawings shall be set at the required elevation and properly anchored and sealed to the storm inlet.

*****END OF SECTION*****

SECTION 02612

REINFORCED CONCRETE CULVERT PIPE (RCP)

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and installing reinforced concrete culvert pipe (RCP) as shown, specified, and as otherwise required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings, catalog cuts, and manufacturer's literature for all pipe and pipe fittings including information on coatings and linings, material specifications, dimensions, tolerances, and all related data. No material shall be installed prior to furnishing this required information and receiving favorable review.

B. The CONTRACTOR shall furnish the manufacturer's material certificates for all pipe, fittings, and accessories supplied under this Section demonstrating that the requirements of this Section have been met.

C. Submit to the ENGINEER in accordance with Section 01300 of these Specifications.

1.03 QUALITY ASSURANCE

A. Pipe installation shall be done by skilled workers. Each pipe laying crew shall have a pipe laying foreman.

B. Accurately install pipe to the lines and grades shown on the Contract Drawings, or as directed by the CBS REPRESENTATIVE, so that inverts are smooth.

C. A full circle shall be visible at the far end, when looking through pipes, unless bends are specified or shown on the Contract Drawings.

D. Deflections at joints are not permitted without prior approval from the ENGINEER.

E. The ENGINEER shall be notified whenever an existing pipeline location or other existing feature conflicts with the proposed locations of the Work.

F. Pipe and fittings of the same type shall be the products of a single manufacturer.

G. All piping shall be of the type and size as shown on the Contract Drawings and as described herein.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skidways in a manner to avoid shock. Avoid damaging the pipe and its coating or lining if present.

B. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the Work, use derricks, ropes, or other suitable equipment for lowering pipe into trenches. Take particular care to avoid damaging the pipes.

C. Store piping and related materials so as to cause the least possible interference with the Work, Site operations, streets, sidewalks, driveways, other thoroughfares, parking areas, delivery areas, business areas, and the public in general. Relocate such material and/or equipment which is creating an interference or inconvenience as directed by CBS REPRESENTATIVE. Relocate such material or equipment which is obstructing the Site or interfering or obstructing other operations or activities of the ENGINEER or the QUALITY ASSURANCE OFFICIAL.

D. The manufacturer's recommended procedures for pipe stacking shall be followed. When pipes are stacked for storage, the heaviest series of pipe shall be placed at the bottom.

E. If any defective pipes are discovered after being laid or placed, removal and replacement with a sound pipe will be required at the CONTRACTOR's expense.

PART 2 - PRODUCTS

2.01 REINFORCED CONCRETE PIPE

A. Reinforced concrete pipe shall conform to the requirements of AASHTO M170 for Standard Strength Reinforced Concrete Culvert Pipe for Class V Pipe unless otherwise designated on the plans. All pipe 24 inches in diameter or smaller shall be of the bell-and-spigot type. Pipes larger than 24 inches in diameter shall be tongue and groove or bell and spigot.

2.02 RUBBER RING GASKETS

A. Rubber ring gaskets shall conform to ASTM C443 and shall be tough, flexible, chemical-resistant material, and of such size and shape as to ensure satisfactory pipe joints when incorporated in the Work.

PART 3 - EXECUTION

3.01 INSPECTION

A. Each length of pipe and each fitting shall be carefully inspected prior to lowering into trench. All materials not meeting the requirements of these Specifications, or otherwise found defective or unsatisfactory by the ENGINEER and/or QUALITY ASSURANCE OFFICIAL, shall be rejected and immediately marked and removed from the Site by the CONTRACTOR. The CONTRACTOR shall provide suitable replacement materials, conforming to these Specifications, at no additional cost to CBS.

B. Bedding, subgrade, and other trench conditions shall be carefully inspected prior to laying pipe in each stretch of open trench. All conditions shall be made available to the QUALITY ASSURANCE OFFICIAL for inspection purposes, and the ENGINEER and QUALITY ASSURANCE OFFICIAL shall be further advised where, in the CONTRACTOR's opinion, unstable or otherwise deleterious conditions exist.

C. Each stretch of completed pipeline shall be observed and the direction and percentage of slope verified by the CONTACTOR, to the satisfaction QUALITY ASSURANCE OFFICIAL, prior to backfilling. Backfilling operations shall not be initiated prior to inspection and favorable review by the ENGINEER and the QUALITY ASSURANCE OFFICIAL.

3.02 LAYING OF PIPE

A. The laying of pipe shall begin at the downstream end of the pipeline. The lower segment of the pipe shall be in firm contact with the bedding throughout its full length. *Bell or groove ends of pipe shall be placed facing upstream.*

B. The pipe bedding shall be placed to conform to pipe shape and shall extend a minimum of 12 inches above the top of the pipe.

3.03 PIPE INSTALLATION

A. Pipes and fittings shall be carefully lowered into the trench.

B. Pipe and fittings shall be installed so that there will be no deviation at the joints and so that inverts present a smooth surface. Pipe and fittings which do not fit together to form a tight fitting joint are not permitted. RCP shall be joined using flexible watertight rubber gaskets conforming to ASTM C443.

C. Pipes shall be installed in the locations and to the required lines and grades as shown on the Contract Drawings and as provided in these Specifications, using a favorably reviewed method of control. Remove or relay all pipe laid contrary to the Specifications.

D. Excavate, support, and dewater pipe trenches in accordance with Sections 02140, 02150, 02220, and 02221 of these Specifications. Excavations shall be maintained free of water during the progress of the Work. All slides or cave-ins of the trenches or cuts shall be remedied to the satisfaction of the ENGINEER and the QUALITY ASSURANCE OFFICIAL.

E. Maintain cleanliness of installed pipe and fittings interiors throughout the work. Plug ends when pipe installation is not in progress. Remove all plugs as required to place pipe into operation. Drainage of construction excavations through new pipes is prohibited.

F. All adjustments to the line and grade of pipe shall be done by scraping away or filling in the bedding under the barrel of the pipe and not by blocking or wedging. Where additional bedding is required, it shall be provided at the CONTRACTOR's expense. In all cases, the trench under the joint shall be excavated and suitably shaped to permit an even bearing for the barrel of the pipe. The minimum depth of bedding, as shown on the Contract Drawings, shall be maintained at all times.

G. When unsuitable materials or conditions are encountered, excavate below grade until suitable foundation is encountered and the trench backfilled with compacted gravel or crushed stone foundation.

H. Favorable review by the ENGINEER is required prior to changing the location of any of the Work due to field conditions. Changes in pipe sizes are prohibited without prior written consent from the ENGINEER.

I. All installed piping shall form completely connected systems including connections to valves, equipment, structures, existing facilities, and appurtenances specified in other sections to result in a satisfactorily operating installation.

3.04 ADJUST AND CLEAN

A. All sections of piping found defective in material, alignment, grade, joints, or otherwise, shall be corrected to the satisfaction of the ENGINEER and/or QUALITY ASSURANCE OFFICIAL.

B. Leave all the pipes and connections watertight.

C. Upon completion of construction of pipelines and appurtenances, all pipelines shall be thoroughly flushed out with water and all temporary plugs shall be removed. Flushing shall be executed in such manner that dirt or other material will not be discharged into existing sanitary sewers or watercourses.

3.05 JOINING PIPE SECTIONS

Reinforced concrete pipe shall be joined using flexible water tight rubber gaskets conforming to ASTM-C443.

*****END OF SECTION*****

SECTION 02625

PASSIVE GAS VENT CONSTRUCTION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all labor, equipment, materials, tools, and appurtenances required to complete the work of furnishing and installing the passive landfill gas vents as shown on the Contract Drawings.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State, or Federal authorities having jurisdiction. The CONTRACTOR is responsible for identifying and obtaining all appropriate licenses, approvals, and permits to complete the work of this Section. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

C. Prior to the installation of the passive landfill gas vents, the CONTRACTOR shall identify and perform any necessary utility mark-outs.

D. Furnish and install HDPE pipe boots/sleeves and skirts, in accordance with Section 02590 of these Specifications, for use in areas where the geomembrane cap must be penetrated, as shown on the Contract Drawings.

E. The CONTRACTOR and other SUBCONTRACTORs shall coordinate the work of this Section with the work of other Sections, as required.

1.02 GENERAL

A. The approximate locations of the passive landfill gas vents are shown on the Contract Drawings. Exact locations will be determined and field verified by the CONTRACTOR and QUALITY ASSURANCE OFFICIAL before the installation of the passive landfill gas vents is initiated.

1.03 SUBMITTALS

A. Drilling methods are described in Article 3.03 herein. The CONTRACTOR shall describe in writing any requested alternative drilling method(s) based on the reported Site conditions. CBS and the QUALITY ASSURANCE OFFICIAL shall review the request and determine the suitability of the request.

B. Submit samples for proposed backfill materials in accordance with Sections 02233 and 01300 of these Specifications.

C. Submit manufacturer's catalog cuts for PVC pipe evidencing compliance with these Specifications.

D. Submit a Statement of Qualifications for the CONTRACTOR or SUBCONTRACTOR who will perform the installation. Include resumes of drilling crews and the superintendent.

E. Submit a complete list of all equipment to be used for portions of the Work described in this Section including proposed drill rigs and associated torque capacity. Submit an installation schedule and update it weekly during the Work.

F. No work shall be performed until the items required in Articles 1.03B, 1.03C, and 1.03D have been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

G. During drilling of each vent, maintain a detailed daily driller's report and submit daily to the QUALITY ASSURANCE OFFICIAL. The report shall give a complete description of all formations or material encountered, number of feet drilled, number of hours on the job, shutdowns, feet of casing set, and other pertinent data.

H. Upon completion of each vent, the CONTRACTOR shall submit to the QUALITY ASSURANCE OFFICIAL a report including the following:

1. Total depth of the completed well;
2. Depth or location of any lost drilling materials or tools;
3. Nominal hole diameter of the well bore and total depth;
4. Volume and amount of materials (including number of bags) used to fill the annular space;
5. Depth and description of the well casing and screen;
6. Protective casing, plug, cap size, and materials used;
7. Concrete, bentonite, or grout materials used and depths;
8. Number and location of centralizers used;
9. Weather conditions during installation;
10. Name of individual who prepared the report and members of the drilling crew; and,
11. Other pertinent data requested by the QUALITY ASSURANCE OFFICIAL.

I. Following completion of drilling each vent, the CONTRACTOR shall submit to QUALITY ASSURANCE OFFICIAL signed copies of the driller's log book including the following information:

1. Reference point (i.e., top of casing) for all depth measurements;
2. Depth at which each change of material occurs;
3. Identification of the material of which each stratum is composed;
4. Depth interval from which sample was taken;
5. Name of individual who prepared log and members of drilling crew;
6. Water use during drilling;
7. Penetration resistance during split-spoon sampling (if any);
8. Water levels encountered during drilling;
9. Drill rig type, make, and torque capacity;
10. Split-spoon hammer weight and fall; and,

11. Other pertinent data requested by the QUALITY ASSURANCE OFFICIAL.

J. The CONTRACTOR shall submit vent coordinates and top-of-casing elevations certified by a Land Surveyor licensed in the State of Indiana.

K. The CONTRACTOR shall supply written certification for the material to be used for the boots, sleeves and skirts, such as that required for the geomembrane under Section 02590 of these Specifications. Certification of these materials may be supplied as part of the requirements of Section 02590 of these Specifications.

1.05 QUALIFICATIONS

A. The CONTRACTOR responsible for the construction of the passive landfill gas vents shall be properly licensed to conduct drilling activity and employ only competent workmen for the execution of this Work. All such Work shall be performed under the direct supervision of an experienced driller favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

B. The driller shall be capable of identifying geologic formations, maintaining complete and current well logs and daily notes for the vent completion report.

C. The CONTRACTOR shall provide satisfactory evidence that all materials to be furnished in performing the Work are new and all equipment to be used is in good working order.

1.06 HANDLING OF MATERIALS

A. All parts and materials shall be properly protected so that no damage, deterioration, or contamination will occur from the time of shipment until the Work described in this Section is complete.

B. If in the opinion of the QUALITY ASSURANCE OFFICIAL, parts and materials are damaged, deteriorated, or contaminated, the materials will be rejected and immediately removed from the Site. The CONTRACTOR shall replace the parts and materials at the CONTRACTOR's expense.

1.07 QUALITY ASSURANCE

A. The CONTRACTOR shall perform all testing required and supply any labor and equipment necessary for the testing of the geomembrane cap penetrations. Coordinate testing with the work of Section 02590 of these Specifications, as required.

PART 2 - PRODUCTS

2.01 HDPE PIPE BOOTS/SLEEVES AND SKIRTS

A. The pipe boot/sleeve and skirt shall be constructed from geomembrane with the same material properties as the geomembrane for the landfill cap as specified in Section 02590 of these Specifications.

B. The HDPE geomembrane boots/sleeves and skirts shall be made by the same manufacturer as the geomembrane for the landfill caps.

2.02 GAS VENT MATERIALS

A. As described in Part 3 of this Section and as shown on the Contract Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Inspect all materials upon delivery and before placement to document that they are in the original packaging as supplied by the manufacturer or supplier and free of any material that may alter the chemical quality of the vent.

3.02 PREPARATION

A. Protect existing structures from damage.

B. Prepare the area for staging of drill cuttings prior to relocation to designated areas on the landfills in accordance with Section 02221 of these Specifications.

C. The CONTRACTOR shall provide access to all passive gas vent locations. Proposed access locations shall be reviewed with the CBS REPRESENTATIVE.

3.03 DRILLING

A. The anticipated range of depth for the passive landfill gas vents varies based on the bottom of waste material and final cap elevation. The actual depth will be determined in the field by the QUALITY ASSURANCE OFFICIAL. The end of boring shall be determined based upon actual conditions. For each gas vent, drill a stable 18-inch diameter borehole to the required depth. Measure and record the final depth of the borehole. Passive gas vent locations are shown on the Contract Drawings.

B. Prior to attempting to install the vents, ensure that the borehole does not tend to cave, blow-in, or both, is not obstructed, and is aligned plumb. Any borehole that must be abandoned shall be done so in accordance with applicable State requirements or guidelines.

C. Spoils generated during drilling shall be tested for PCB content and shall be handled and disposed of in accordance with criteria established in the RD/RA Work Plan.

D. The CONTRACTOR shall follow the CONTRACTOR's Site-specific Health and Safety Plan and adhere to all applicable local, municipal, State, and Federal regulations during drilling procedures.

3.04 WELL CONSTRUCTION

A. Passive gas vent construction details are shown on the Contract Drawings.

B. Assembly of the passive gas vents:

1. Inspect PVC pipe prior to placement and use only clean water to clean well materials.
2. Take precautions to assure that grease, oil, or other contaminants do not contact the vent and probe construction materials.
3. Personnel shall wear clean gloves while handling the vent assemblies.
4. Passive gas vents shall be assembled with 6-inch diameter Schedule 80 PVC pipe as shown on the Contract Drawings. PVC pipe shall be Type 1, Grade 1 conforming to ASTM D1784 and ASTM 1785. Passive gas vents shall be slotted to the dimensions and lengths as shown on the Contract Drawings. All drill cuttings shall be removed from the pipe prior to installation or forming sections.
5. Vents shall be placed to within 24 inches of the bottom of the boring.
6. Vents shall be aligned plumb prior to backfilling the borehole. Backfill material shall be as specified on the Contract Documents.

C. Installation of backfill:

1. Calculate the theoretical volumes of backfill required to fill the annular space between the screen and the wall of the borehole prior to placement and measure and record the actual volume used during installation.
2. Backfill shall extend around the well screen as shown on the Contract Documents. Take precautions not to bridge material. AASHTO No. 57 stone for the vents shall comply with Section 02233 of these Specifications. Sand pack shall prevent intrusion of overlying grout.
3. Backfill shall be non-carbonate.

D. Installation of bentonite seals:

1. Bentonite seal shall be Volclay Grout or PureGold Grout, both manufactured by American Colloid Company, or Benseal as manufactured by Baroid Drilling Fluids, or favorably reviewed alternate. Mix in accordance with the manufacturer's instructions. If needed, water for bentonite slurry mixing shall be provided by the CONTRACTOR. Mixing of the bentonite slurry shall continue until all lumps are removed. If used, bentonite slurry shall be tremied. Bentonite seals shall be completed in a manner that provides a complete seal without voids.

2. A bentonite seal mix shall set for at least 24 hours after sealing to assure complete set-up prior to vent or probe assembly.

E. All vents shall be as-built surveyed in accordance with Section 01050 of these Specifications.

3.05 DECONTAMINATION

A. The drill rig and all drilling equipment shall be steam-cleaned upon arrival on-Site and prior to leaving the Site. Steam cleaning shall also be conducted following installation of vents. Potable water for steam cleaning shall be supplied by the CONTRACTOR. Between boreholes, all soil and wastes shall be removed from the drill rig and drilling equipment at the borehole location. Drill cuttings and other solid materials shall be disposed of in accordance with Section 02221 of these Specifications.

3.06 LIQUIDS HANDLING

A. All aqueous and non-aqueous liquids used, collected or encountered during the performance of this Work and including decontamination water shall be handled in accordance with Section 02402 of these Specifications.

3.07 PIPE BOOT CONSTRUCTION METHODS

A. An HDPE pipe boot/sleeve and skirt shall be installed in areas where the geomembrane caps must be penetrated by the passive landfill gas vents and cleanout ports, as shown on the Contract Drawings.

B. Prior to constructing the boot/sleeve, the CONTRACTOR shall assure that the material in the area of the penetration is properly compacted and that the area is clean. Take care to assure the geomembrane and geocomposite are not damaged.

C. Pipe boots/sleeves shall be fabricated to fit tightly around the outside diameter of the penetrating feature. If boots/sleeves are prefabricated, the Shop Drawings shall show dimensions or callouts indicating the fit. If the boots/sleeves are field constructed, the fit shall be made to the satisfaction of the QUALITY ASSURANCE OFFICIAL.

D. The size of the skirt which flares away from the penetrating feature shall be adequate to provide 12-inch minimum overlap over the geomembrane or as satisfactory to the QUALITY ASSURANCE OFFICIAL.

E. Extrusion welding shall be as shown on the Contract Drawings and performed in accordance with the requirements of Section 02590 of these Specifications.

F. Cushion material underneath band clamps shall extend 2 inches beyond each band's edges.

G. Do not allow cushion material to gather or wrinkle around boot when clamp is tightened.

3.08 PIPE BOOT INSPECTION AND TESTING

A. Test all welds to the geomembrane utilizing a non-destructive test method in accordance with Section 02590 of these Specifications.

B. The CONTRACTOR is responsible for providing all necessary non-destructive test equipment. Conduct all weld testing in the presence of the QUALITY ASSURANCE OFFICIAL.

*****END OF SECTION*****

SECTION 02831

CHAIN-LINK FENCE AND GATES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

The CONTRACTOR shall furnish all labor, materials, equipment and appurtenances required for the installation of a complete chain-link fence system. Fencing and gates shall be installed in the locations shown on the Contract Drawings and as otherwise required by the CONTRACTOR and favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

1.02 SUBMITTALS

A. Shop Drawings

1. The CONTRACTOR shall submit to the QUALITY ASSURANCE OFFICIAL, at least ten (10) days prior to construction, catalog cuts, manufacturer's installation instructions, and dimensioned drawings for fencing, gates, and associated details for installation.
2. Submit detailed layout drawing showing the location of each fence post.

B. Submit in accordance with Section 01300 of these Specifications.

1.03 DELIVERY AND HANDLING

A. Deliver materials with the manufacturer's tags and labels intact.

B. Handle and store materials in such a manner that will avoid damage.

1.04 QUALITY ASSURANCE

A. Comply with the standards of the Chain-Link Manufacturers Institute and these Specifications.

B. Provide fencing as a complete unit produced by a single manufacturer including the required erection accessories, fittings, and fasteners.

1.05 CODES AND STANDARDS

The latest edition of the publications listed below are included as a part of these Specifications.

A. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A53	Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
A123/A123M	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

A153/A153M	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A392	Zinc-Coated Steel Chain-Link Fence Fabric
A641/A641M,	Zinc-Coated (Galvanized) Carbon Steel Wire

PART 2 - PRODUCTS

2.01 GENERAL

A. Height for new fencing shall be six (6) feet as shown on the Contract Drawings. Posts shall be set at no more than 10-foot centers, in concrete footings, poured the full size of the excavated holes. Corner posts shall have the necessary strut and tie bracing. Gates shall be provided as specified in Article 2.02G herein and at the locations indicated on the Contract Drawings.

B. Where fencing crosses ditches, steep grades, and other unusual conditions, make special provisions to insure that the security, appearance, maintainability and permanence of the standard fencing are maintained.

2.02 MATERIALS AND CONSTRUCTION

A. Fence Mesh and General Note: 9 gauge wire, woven to 2-inch squares, zinc-coated (hot-dip galvanized), galvanized after weaving, 6-foot wide roll. Continuous tension wire shall be provided at the lower and upper edges of the mesh. Fence mesh shall be of one continuous piece from top to bottom and between posts. Zinc-coated fabric shall conform to ASTM A392, Class 2.

B. Line Post: 2-1/2-inch O.D. ASTM A53 standard weight Galvanized Pipe (3.65#/ft.)

C. Corner Post: 3-inch O.D. ASTM A53 standard weight Galvanized Pipe (5.79#/ft.)

D. Gate Post: 4-inch O.D. ASTM A53 standard weight Galvanized Pipe (9.11#/ft.)

E. Top Rail: 1-5/8-inch O.D. ASTM A53 standard weight Galvanized Pipe (2.27#/ft.) with extra long pressed steel sleeves.

F. Tension Wire: No. 7 gauge steel spring coil tension wire, zinc-coated (hot-dip galvanized). Zinc-coated wire shall conform to ASTM A641, Class 3.

G. Swing Gates:

1. Frame shall be 2-inch O.D. ASTM A53 standard weight galvanized pipe with galvanized pressed steel or galvanized malleable iron corner ells riveted or bolted at corners.
2. Internal bracing shall be NPS 1 ASTM A53 standard weight galvanized pipe with 3/8-diameter galvanized adjustable truss rods and truss fasteners.
3. Bottom hinge shall be galvanized malleable iron pivot type.

4. Top hinge shall allow gate to swing 90° to 180°.
5. Gate shall be complete with padlocking device, center rest, and semi-automatic catch to secure gate in open position.
6. Gates shall be provided to match fence height and with the following minimum widths:
   a. Vehicular Gates: Provide dual gates of equal width to provide an overall clear width of 16 feet.

H. Hardware, fasteners, and accessories: galvanized and compatible with other fence system components.

I. Brace rail: ASTM A53 standard weight galvanized pipe with 3/8-inch diameter galvanized steel truss rods and truss tighteners.

J. Lifting Eyes: Provide at each end of removable panels of adequate strength and attachment to allow fence panel removal. Provide galvanized steel or stainless steel. Repair damage to galvanized surfaces with Galv-Alloy or other means.

K. Extension Arms:

1. Line Post arms shall be fabricated of pressed steel or malleable iron base with pressed steel extension riveted on.
2. Corner Posts arms shall be fabricated of 11-gauge (minimum) pressed steel or heavy malleable iron base with 11-gauge (minimum) pressed steel extension riveted on.
3. Arms shall be galvanized in accordance with ASTM A123.
4. Arms shall be able to withstand a minimum pull down weight of 300 pounds and of the barbed wire stretched to proper tension.
5. Arms shall be securely fastened to post.

L. Tension Bars and Bands: Tension bars for pulling fence fabric to terminal posts shall be 3/4-inch steel bars, hot-dip galvanized in accordance with ASTM A123. Bands for fastening tension bars to terminal posts shall be 11 gauge by 1-inch wide steel; hot-dip galvanized in accordance with ASTM A123.

M. Barbed Wire: Shall be 12½ gauge, zinc coated (hot dip galvanized), four point barbs, maximum barb spacing of 5 inches, attached to posts with 1-foot-long 45-degree galvanized extension arms. Zinc coated barbed wire will conform to ASTM A-121, Class 3.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Excavation: Augering holes for post footings.

1. Auger holes to the depths indicated on the Contract Drawings. If solid rock is encountered near the surface, drill into rock at least 12-inches for line posts and at least 18-inches for end, pull corner, and gate posts. Drill hole at least 1-inch greater diameter than the largest dimension for

the post to be placed. If solid rock is below soil overburden, drill to full depth required. Penetration into rock need not exceed the minimum depths specified above.

2. All post hole soil cuttings shall be cleaned up, spread, and covered with seeded topsoil.
3. All health and safety precautions shall be followed during posthole excavation, fence post placement, and posthole backfilling.

B. Setting Posts: Remove loose and foreign materials from sides and bottoms of holes and moisten soil prior to placing concrete.

1. Center and align posts in holes 12 inches above bottom of excavation.
2. Place concrete around posts in a continuous pour and vibrate or tamp for consolidation. Check each post for horizontal alignment and plumb and hold in position during placement and finishing operations.
3. Trowel finish tops of footings and slope or dome to direct water away from posts. Concrete top to be a minimum of 1-inch above the finished grade. Extend footings for gateposts to the underside of bottom hinge. Set keeps, stops, sleeves and other accessories into concrete as required.
4. Keep exposed concrete surfaces moist for at least seven (7) days after placement or cure with membrane curing materials or other acceptable curing methods.

C. Concrete Strength: Concrete for setting of fence posts shall have a minimum 28-day compressive strength of 3000 psi. Allow concrete to attain at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than seven days after placement, before rails, tension wires, barbed wire or fabric is installed. The CONTRACTOR may propose use of high early strength concrete (Type III) for approval by the QUALITY ASSURANCE OFFICIAL. Do not stretch and tension fabric and wires and do not hang gates until the concrete has attained its full design strength.

D. Top and Bottom Rails: Run top rail continuously through post caps or extension arms, bending to radius for curved runs. Provide one expansion coupling in every five with 6-inch sleeve to take up expansion and contraction. Top and bottom rails required for removable fence sections, and only top rails required for non-removable fencing.

E. Brace Assemblies: Install braces so posts are plumb when diagonal rod is under proper tension. Bracing shall be installed midway between top rail and ground from each corner post to first line post. Braces shall be securely fastened to posts by heavy galvanized pressed steel connections. Braces shall be trussed from line post back to corner post with 3/8-inch diameter galvanized steel rods.

F. Tension Wire: Install tension wires by weaving through the fabric and tying to securing the wire to the fabric with No. 1 gauge galvanized hog rings on 24-inch centers.

G. Fabric: Pull fabric taut and tie to posts, rails and tension wires. Install fabric on security side of fence and anchor to framework so that fabric remains in tension after pulling force is released. Fabric shall be fastened to top rail with No. 9 gauge aluminum tie wires on 24-inch centers. Fabric shall be fastened to line posts with No. 6 gauge galvanized clips on 14-inch centers or No. 9 gauge galvanized wire on 12-inch centers. Bottom of fabric shall be set at top of concrete.

H. Tension Bars: Tension bars shall be fastened to corner posts with No. 11 gauge by 1-inch wide galvanized tension bands and 3/8-inch diameter galvanized carriage bolts on approximately 14-inch centers.

I. Damaged Coatings: Damaged coating in the shop or during field erection by recoating with Manufacturer's recommended repair compound, applied per Manufacturer's directions.

J. Stretcher Bars: Thread through or clamp to fabric 4-inches on center and secure to posts with metal bands spaced 15-inches on center.

K. Tie Wires: Use U-shaped wire appropriate for the diameter of pipe. Attach pipe and fabric firmly with tie wire ends twisted at least two full turns. Bend ends of wire to minimize hazard to persons or clothing.

L. Fasteners: Install nuts for tension band and hardware bolts on side of fence opposite fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

M. Fencing: Fencing shall essentially follow the contour of the natural grade or concrete slab, as appropriate. Fences in which contour of the natural grade results in a space of 6 inches or more between bottom of chain link fabric and ground surface shall be handled as follows:

1. Intermediate posts shall be set at low point.
2. Sufficient strands of barbed wire shall be provided to limit clear opening above ground and between strands to 3 inches.

N. Barbed Wire: Install barbed/razor wire taunt and in three (3) paralleling rows along the extension arms.

3.03 CLEANING

A. Perform cleaning during installation of the Work and upon completion of the Work. Remove from the Site all fence debris and equipment. Repair all damage resulting from the installation of the chain-link fence system as directed by the CBS REPRESENTATIVE, at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02933

SEEDING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the seeding of all areas disturbed, regraded or receiving a cover during the course of construction. CONTRACTOR shall provide a person experienced and skilled in this type of work to implement, supervise, and inspect all Work.

1.02 SUBMITTALS

A. A manufacturer's Certificate of Compliance for the seed mixture from the Manufacturer shall be submitted to the QUALITY ASSURANCE OFFICIAL with each shipment of each type of seed. These certificates shall include the guaranteed percentages of purity, weed content and germination of the seed, and also the net weight and date of shipment. No seed may be sown until the CONTRACTOR has submitted the certificates and they have been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

B. Submit type and application rate for fertilizer, lime, and other additives.

1.03 QUALITY ASSURANCE

A. Seed to provide a satisfactory stand of grass. To be acceptable, bare spots shall be scattered and there shall be no bare spots larger than 1 square yard and the stand of grass shall consist of a uniform stand of at least 75 percent established permanent (i.e., perennial) grass species by the end of the first growing season.

B. Maintain Erosion and Sedimentation Controls in accordance with Section 02125.

1.04 DEFINITIONS

Weeds include, but are not limited to, Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Broome Grass.

PART 2 - PRODUCTS

2.01 SEED MIXTURE

The seed to be applied shall be in accordance with Subsection 3.1, Surface Stabilization, of the Indiana Handbook for Erosion Control in Developing Areas (October 1992) and approved by the CBS REPRESENTATIVE. Alternative seed mixtures or sod may be applied if favorably reviewed by the QUALITY ASSURANCE OFFICIAL and CBS REPRESENTATIVE.

2.02 FERTILIZER

Commercial balanced N-P-K fertilizer shall be applied in accordance with manufacturer's or USDA Soil Conservation Service local extension office instructions to promote new vegetative growth.

2.03 MULCH

A. Straw mulch shall be oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.

B. Wood fiber mulch shall consist of wood fiber produced from clean, whole uncooked wood, formed into resilient bundles having a high degree of internal friction and shall be dry when delivered on the project.

2.04 WATER

Water shall be clean, fresh, potable and free of substances or matter which could inhibit vigorous growth of grass.

2.05 LIME

Agricultural grade lime shall be applied as necessary to promote new vegetative growth in accordance with manufacturer's or USDA Soil Conservation Service local extension office instructions.

PART 3 - EXECUTION

3.01 SEED BED PREPARATION

A. The areas shall be made friable and receptive to seeding by approved methods which will not disrupt the line and grade of the slope surface. In no event will seeding be permitted on hard or crusted soil surface.

B. Fine grade areas to a firm even surface, free from lumps or stones 2 inch or more in any dimension. Installation of grass may be done immediately after finish grading provided the seeding bed is in a good condition and not muddy or hard. If it is hard, till to a friable condition again.

3.02 INSPECTION

A. CONTRACTOR shall verify that prepared soil base is ready to receive the work of this Section.

B. CONTRACTOR shall inspect seedbed just prior to seeding. If traffic has left the soil compacted, the area must be retilled.

3.03 DELIVERY, STORAGE, AND HANDLING

A. CONTRACTOR shall deliver grass seed mixture in sealed containers showing weight, seed mix, year of production, date of packaging, and location of packaging. Seed in damaged packaging is not acceptable.

B. CONTRACTOR shall deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer. Fertilizer in damaged packaging is not acceptable.

3.04 LIMING

When required, ground limestone which has been protected from moisture and is dry and free flowing, shall be evenly spread over the area to be seeded, as necessary, to promote new vegetative growth.

3.05 FERTILIZING

CONTRACTOR shall apply fertilizer in accordance with manufacturer's instructions.

3.06 HYDROSEEDING

A. CONTRACTOR shall apply seed mixture at rates shown in Part 2 of this Section. Seed evenly in two intersecting directions. If seeding is done by hydromulching, then the seeding mixture in Part 2 shall be increased by 10 percent.

B. Planting season shall be as indicated in Part 2 of this Section.

C. Do not hydroseed immediately following rain, when ground is too dry or frozen, or during windy periods.

D. When applying materials with the hydroseeder, do not use more than 100 to 150 pounds of solids per 100 gallons of water. If inoculate is in a seed, fertilizer, and lime slurry, it should be used within three to four hours, or a fresh supply of inoculate should be added. It is preferable to hydroseed when the soil is moist.

3.07 MULCHING

A. Straw mulch or chipped mulch shall be applied at a rate of 2 tons per acre.

B. Wood fiber mulch shall be applied to seeded area at a rate of 1,400 pounds per acre. Immediately before spraying, the mulching material shall be mixed with water in the sprayer and kept uniformly suspended in the water by agitation during the spraying operation.

3.08 RESEEDING

Where, in the opinion of CBS, vegetative coverage is less than 75% after the first growing season, and any bare spots greater than one square yard. CONTRACTOR shall place additional seed in accordance with Paragraph 3.06 at the CONTRACTOR's expense.

****END OF SECTION****

DRAWINGS FOR :

FINAL CAP DESIGN REPORT

LEMON LANE LANDFILL
BLOOMINGTON, INDIANA

Volume 2 of 2

PREPARED FOR :

CBS CORPORATION

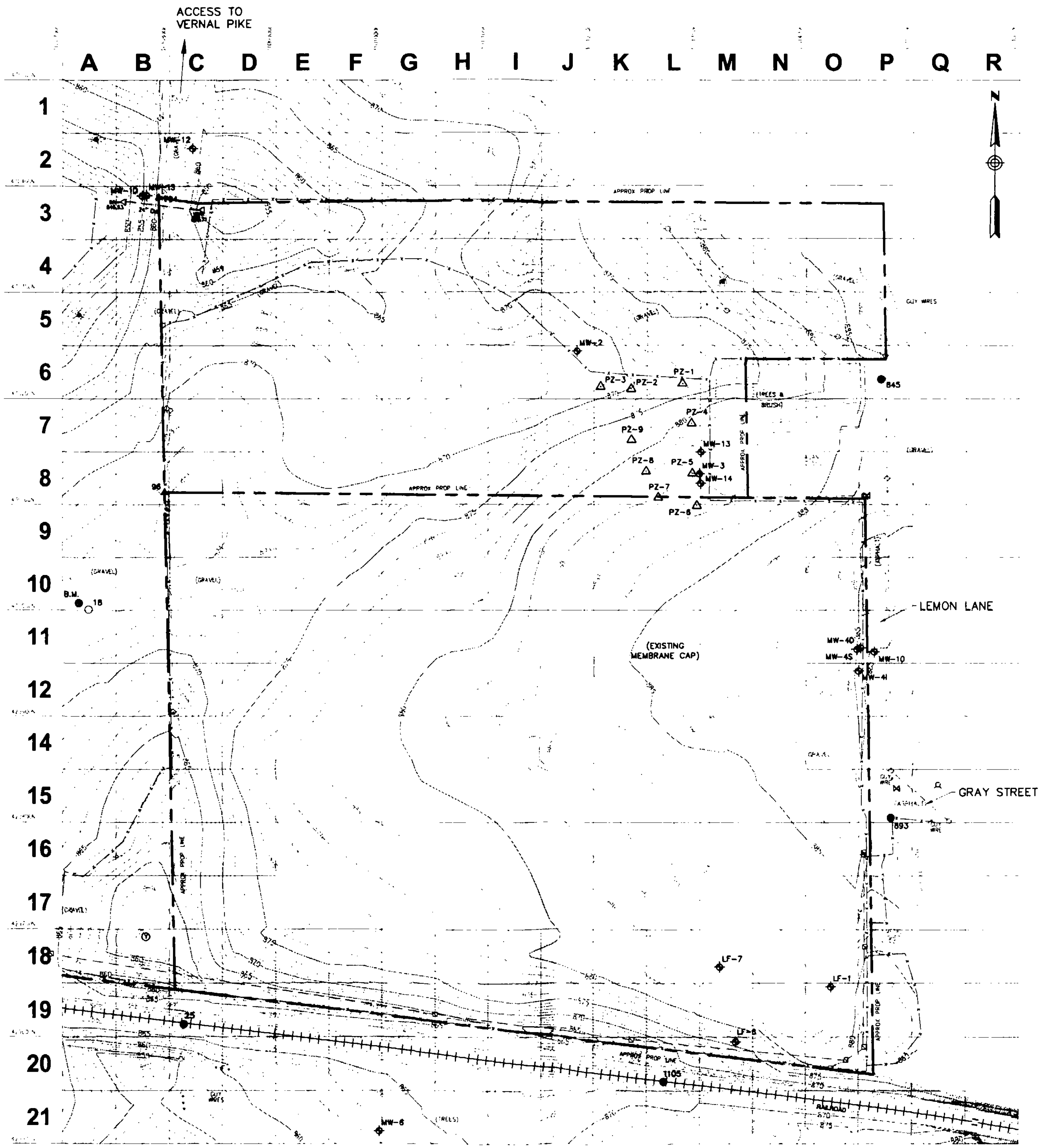
Prepared by :

Golder Associates
Philadelphia USA

OCTOBER 18, 2000

DRAWING LIST

Drawing No.	Drawing Title
-	COVER SHEET
1	SITE MAP AND SURVEY CONTROL POINTS
2	LIMITS OF WASTE CONSOLIDATION
3	CAP SUBGRADE PLAN
4	FINAL CAP GRADING PLAN
5	LANDFILL CROSS SECTIONS
6	CAP SECTION AND TRANSITION DETAILS
7	STORMWATER MANAGEMENT PLAN
8	BASIN DETAILS
9	STORMWATER DETAILS (SHEET 1 OF 2)
10	STORMWATER DETAILS (SHEET 2 OF 2)
11	MISCELLANEOUS DETAILS



EXISTING MONUMENT LEGEND

P.K. NAIL	●	BENCHMARK (B.M.)	⊕
CONCRETE MONUMENT	▲	5/8 REBAR W/PLASTIC CAP SET	○

● BENCHMARK ●

BM REBAR 17.55' WEST OF NORTHWEST FENCELINE
ELEV. = 873.72

CONTROL TABLE

NUMBER	NORTHING	EASTING	ELEVATION	DESCRIPTION
18	1430000.83	3100724.74	873.72	IRON REBAR W/ PLASTIC CAP
25	1429811.70	3100813.66	868.59	PK NAIL
704	1430389.58	3100789.55	860.54	CONCRETE MONUMENT
845	1430218.16	3101470.05	885.55	PK NAIL
893	1429804.55	3101479.68	887.38	PK NAIL
1105	1429558.51	3101268.41	869.38	PK NAIL
96	1430111.74	3100795.30	873.84	CONCRETE MONUMENT (SEE NOTE 5)

LEGEND

- GROUND SURFACE CONTOUR (5 FT)
- PROPERTY LINE
- BRUSHLINE
- EXISTING FENCELINE
- BUILDING FOOTPRINT
- POWER LINE
- GAS LINE (SEE NOTE 7)
- ROAD
- RAILROAD
- INDIVIDUAL TREE
- LF-1 MONITORING WELL LOCATION AND DESIGNATION
- PZ-1 PIEZOMETER LOCATION AND DESIGNATION
- SUMP
- UTILITY POLE
- A:6 SAMPLING GRID SYSTEM (SEE NOTE 4)

NOTES

1.) LOCATION INFORMATION FOR PIEZOMETERS PZ-1 THROUGH PZ-9 AND MONITORING WELLS LF-1, LF-6 AND LF-7 WERE PROVIDED BY PSARA TECHNOLOGIES INC.

2.) SURVEY CONTROL TABLE OBTAINED FROM SITE TOPOGRAPHIC MAP PREPARED BY SMITH NEUBECKER AND ASSOCIATES (SEE REFERENCE 1).

3.) THIS MAP REFERENCES THE NEW INDIANA STATE PLANE COORDINATE SYSTEM, AND AS SUCH UTILIZES NAD83 AND NGVD 1929.

4.) GRID SYSTEM OBTAINED FROM FIGURE 5 OF PSARA TECHNOLOGIES INC. REPORT ENTITLED, "FIELD SAMPLING PLAN FOR THE DELINEATION OF PERIMETER SOILS AT THE LEMON LANE LANDFILL". DATED FEBRUARY 2000.

5.) LOCATION OF CONCRETE MONUMENT (HUB #96) PROVIDED BY PSARA TECHNOLOGIES INC.

6.) MONITORING WELL LOCATIONS OBTAINED FROM SITE TOPOGRAPHIC MAP PREPARED BY SMITH NEUBECKER AND ASSOCIATES (SEE REFERENCE 1). MONITORING WELL DESIGNATION OBTAINED FROM PSARA TECHNOLOGIES INC.

7.) PRIOR TO CONSTRUCTION, THE GAS LINE WITHIN THE SITE BOUNDARY SHALL BE ABANDONED BY THE UTILITY. DURING CONSTRUCTION, THE CONTRACTOR SHALL REMOVE THIS ABANDONED LINE. AFTER EXCAVATION AND CONSOLIDATION OF WASTE, A NEW GAS LINE SHALL BE INSTALLED. THE LOCATION AND DEPTH OF THE NEW GAS LINE SHALL BE SURVEYED AND PROVIDED TO CBS ON AN AS BUILT MAP.

REFERENCE

1.) BASE MAP TAKEN FROM CADD FILE PROVIDED BY SMITH, NEUBECKER AND ASSOCIATES INC., TITLED "TOPOGRAPHIC SURVEY", DATED DECEMBER 9, 1999.

40 0 40 80
scale feet

REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY

PROJECT:

CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

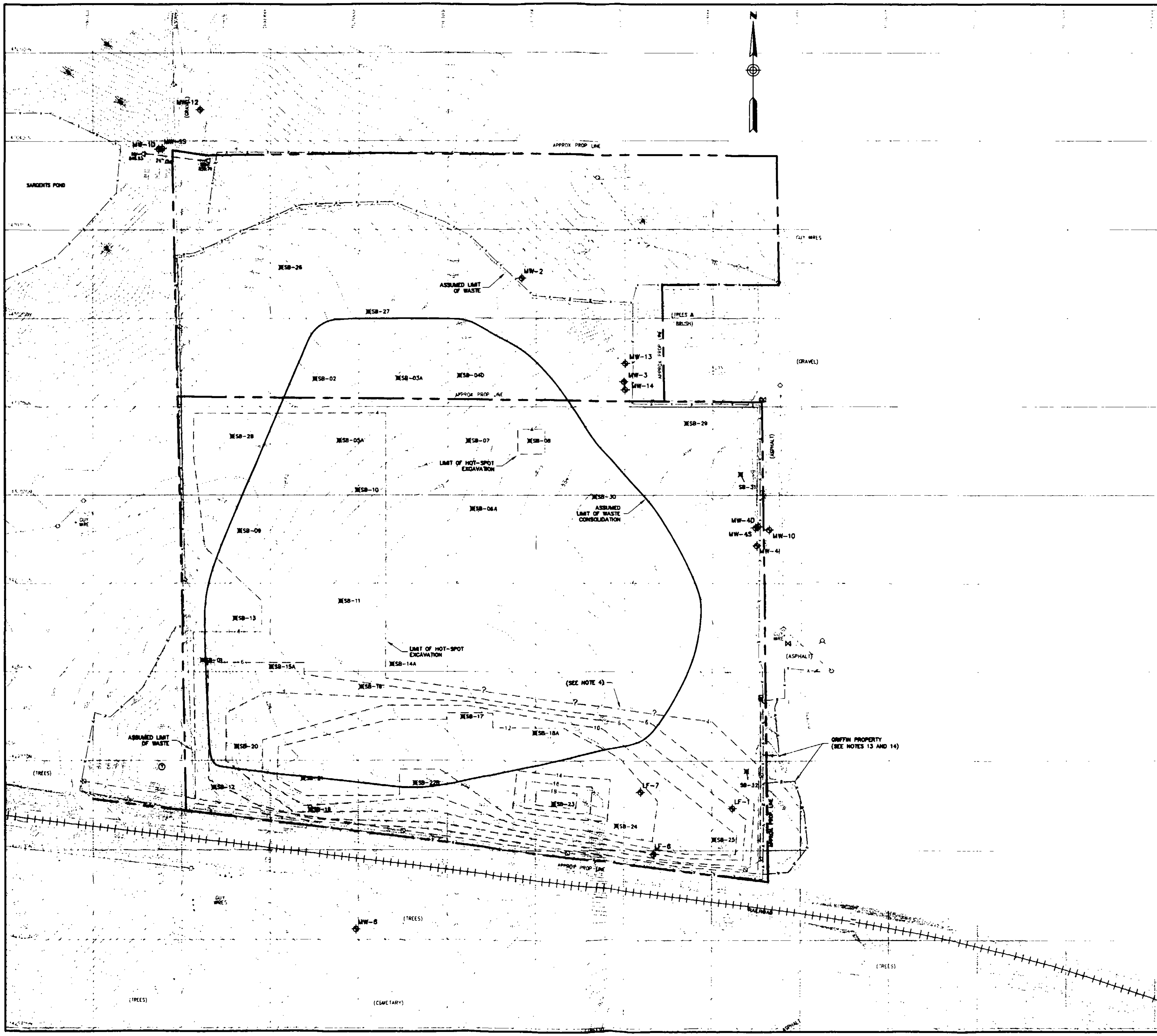
SHEET TITLE:

SITE MAP AND SURVEY CONTROL POINTS

Golder Associates
Philadelphia USA

PROJECT No.	993-6573		FILE No.:	IN01-077
CLIENT PROJ. No.			DRAFTING SUBTITLE:	04
DES BY	VEF	06/02/00	SCALE:	AS SHOWN
CAD BY	MJS	09/08/00		
CHK BY	DBW	09/08/00		
RVW BY	RES	09/08/00		

DRAWING 1



LEGEND

	ASSUMED LIMIT OF WASTE (SEE NOTE 3)
	ASSUMED LIMIT OF WASTE CONSOLIDATION (SEE NOTE 1)
— — — 10 — — —	DEPTH OF EXCAVATION CONTOUR (SEE NOTE 5)
— —?— —?— —	ANTICIPATED LIMIT OF EXCAVATION (SEE NOTE 4)
	EXISTING GROUND SURFACE CONTOUR (1 FT)
	EXISTING GROUND SURFACE CONTOUR (5 FT)
	PROPERTY LINE
	BRUSHLINE
	EXISTING FENCELINE
	BUILDING FOOTPRINT
	POWER LINE
	GAS LINE (SEE NOTE 11)
	ROAD
	RAILROAD
	INDIVIDUAL TREE
	SUMP
	UTILITY POLE
	WATER VALVE
	FIRE HYDRANT
SB-01	BORING LOCATION
MW-1	MONITORING WELL LOCATION

NOTES

1.) ASSUMED LIMIT OF WASTE CONSOLIDATION REPRESENTS EXTENT OF WASTE MATERIAL FOLLOWING EXCAVATION. THE MAXIMUM ALLOWABLE PCB CONCENTRATION OF THE SOIL SURFACE OUTSIDE THE LIMIT OF CONSOLIDATION IS PRESENTED IN THE RD/RA WORKPLAN. ACTUAL LIMIT OF WASTE CONSOLIDATION MAY VARY BASED ON FINAL EXCAVATION DEPTHS AS DETERMINED BY POST EXCAVATION SAMPLING AND SURFACE WATER DRAINAGE REQUIREMENTS. RCRA CAP SHALL COVER AREA WITHIN LIMIT OF WASTE CONSOLIDATION.

2.) WASTE MATERIAL BETWEEN THE EXISTING FENCELINE AND THE LIMIT OF WASTE CONSOLIDATION THAT MEETS THE CRITERIA OF CONSOLIDATION IN THE RD/RA WORK PLAN WILL BE EXCAVATED AND PLACED WITHIN THE LIMIT OF WASTE CONSOLIDATION. THE RCRA CAP WILL EXTEND AT A MINIMUM TO THE LIMIT OF WASTE CONSOLIDATION.

3.) ASSUMED LIMIT OF WASTE IS BASED ON BOREHOLE DATA AND CURRENT EXTENT OF CAP MEMBRANE.

4.) LIMIT OF HOT-SPOT EXCAVATION CORRESPONDS TO A FOUR FOOT VERTICAL CUT AT LOCATION SHOWN, OTHER THAN EAST OF 3101100 EASTING. SIDEWALL SAMPLES WILL BE TAKEN EAST OF THE 3101100 EASTING LINE ALONG NORTH FACE OF THE 4 FT CONTOUR.

5.) EXCAVATION DEPTHS AND LIMIT ARE BASED ON LIMIT TAKEN FROM CADD FILE PROVIDED BY EARTHTECH, TITLED "DEPTH OF >50ppm WASTE TO BE REMOVED", DATED 2/25/98, AND MODIFIED PER FAX SENT BY CBS TO TOM ALCAMO (EPA). DEPTHS OF EXCAVATION CONTOURS SHOWN REFLECT ANTICIPATED CONSTRUCTION METHODS AND SURVEY LAYOUT TO BE USED DURING CONSTRUCTION AS SHOWN ON FIGURE 9 OF THE RD/RA WORKPLAN. CONFIGURATION OF ACTUAL WASTE EXCAVATION DEPTHS MAY VARY BASED UPON FIELD SURVEY LAYOUT AND CONSTRUCTION SEQUENCING.

6.) FINAL DEPTH AND LIMIT OF HOT-SPOT EXCAVATIONS MAY VARY FROM THOSE SHOWN, BASED UPON POST EXCAVATION SAMPLING RESULTS, ADDITIONAL BORING DATA AND VISUAL OBSERVATIONS MADE DURING CONSTRUCTION.

7) DEPTHS OF EXCAVATION ARE TAKEN FROM THE EXISTING GROUND SURFACE.

8.) BORINGS SB-1 THROUGH SB-25: LOCATIONS AND BORING LOGS OBTAINED FROM PSARA TECHNOLOGIES, INC. SUMMARY REPORT FOR LEMON LANE LANDFILL, DATED MARCH 7, 1997, AS SHOWN ON FIGURE 3 FROM THE RD/RA WORK PLAN.

9.) SB-26 THROUGH 32: PERFORMED BY TETRA TECH ON BEHALF OF EPA IN JANUARY, 2000. LOCATION AND ELEVATION INFORMATION WAS PROVIDED BY TETRA TECH AS SHOWN ON FIGURE 3 FROM THE RD/RA WORK PLAN.

10) BORINGS THAT CONTAIN A LETTER FOLLOWING THE NUMERICAL DESIGNATION, I.E. SB-03A, REPRESENT BORINGS THAT WERE OFFSET AND REDRILLED FROM THE ORIGINAL LOCATION DUE TO OBSTRUCTIONS ENCOUNTERED DURING INITIAL DRILLING ATTEMPT.

11.) PRIOR TO CONSTRUCTION, THE GAS LINE WITHIN THE SITE BOUNDARY SHALL BE ABANDONED BY THE UTILITY. DURING CONSTRUCTION, THE CONTRACTOR SHALL REMOVE THIS ABANDONED LINE. AFTER EXCAVATION AND CONSOLIDATION OF WASTE, A NEW GAS LINE SHALL BE INSTALLED. THE LOCATION AND DEPTH OF THE NEW GAS LINE SHALL BE SURVEYED AND PROVIDED TO CBS ON AN AS BUILT MAP.

12) COORDINATE SYSTEM SHOWN ON THIS FIGURE REFERENCES THE NEW INDIANA STATE PLANE COORDINATE SYSTEM.

13) SEE FIGURE 4 OF RD/RA WORK PLAN FOR PCB DATA FOR GRIFFIN PROPERTY.

14) REFER TO FIGURES 6 AND 7 OF THE SAMPLE AND ANALYSIS PLAN (APPENDIX D OF RD/RA WORK PLAN) FOR EXCAVATION INFORMATION PERTAINING TO THE GRIFFIN PROPERTY.

15.) LOCATION INFORMATION FOR MONITORING WELLS LF-1, LF-6 AND LF-7 WERE PROVIDED BY PSARA TECHNOLOGIES INC.

16.) MONITORING WELL LOCATIONS OBTAINED FROM SITE TOPOGRAPHIC MAP PREPARED BY SMITH NEUBECKER AND ASSOCIATES (SEE REFERENCE 1). MONITORING WELL DESIGNATION OBTAINED FROM PSARA TECHNOLOGIES INC.

REFERENCE

1.) BASE MAP AND PROPERTY LINE TAKEN FROM CADD FILE PROVIDED BY SMITH, NEUBECKER AND ASSOCIATES INC., TITLED "TOPOGRAPHIC SURVEY", DATED DECEMBER 9, 1999.

40 0 40 80
scale feet

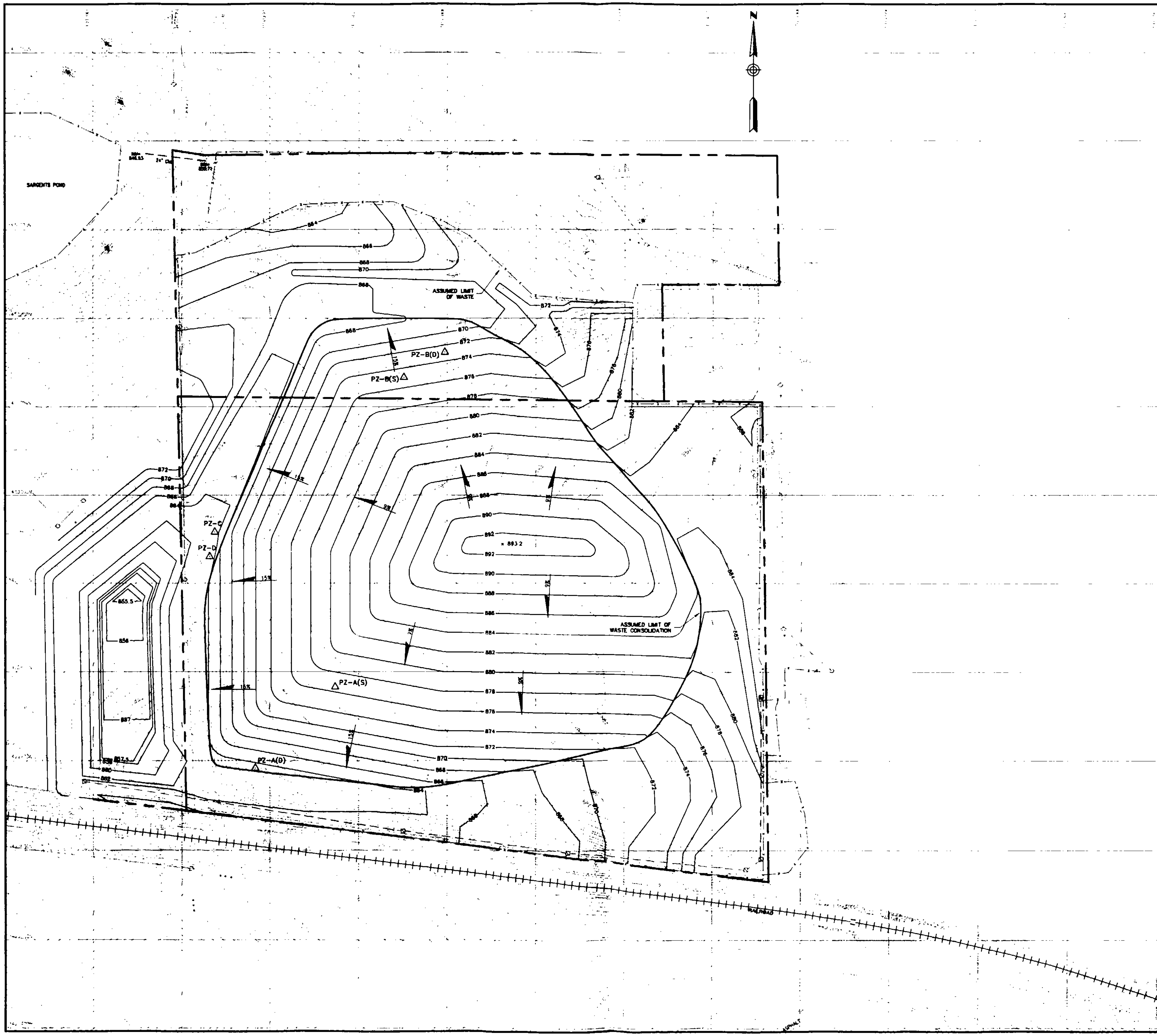
REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY

PROJECT:
CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE:
LIMIT OF WASTE CONSOLIDATION

Golder Associates
Philadelphia USA

PROJECT No.	993-6573		FILE No.	IN01-078
CLIENT PROJ. No.			DRAFTING SUBTITLE:	04
DES BY	VEF	06/01/00	SCALE:	AS SHOWN
CAD BY	MJS	09/08/00	DRAWING 2	
CHK BY	DBW	09/08/00		
RVW BY	RES	09/08/00		



PIEZOMETERS TO BE INSTALLED		
DESIGNATION	NORTHING	EASTING
PZ-A(S)	1429782.87	3100873.36
PZ-A(D)	1429691.57	3100883.12
PZ-B(S)	1430133.35	3101050.83
PZ-B(D)	1430161.80	3101097.26
PZ-C	1429958.20	3100837.70
PZ-D	1429930.30	3100831.90

LEGEND

ASSUMED LIMIT OF WASTE (SEE NOTE 3)

ASSUMED LIMIT OF WASTE CONSOLIDATION (SEE NOTE 1)

884 — ANTICIPATED TOP OF SUBGRADE CONTOUR (SEE NOTES 4 AND 9)

EXISTING GROUND SURFACE CONTOUR (1 FT)

EXISTING GROUND SURFACE CONTOUR (5 FT)

PROPERTY LINE

BRUSHLINE

FENCELINE

BUILDING FOOTPRINT

POWER LINE

GAS LINE

ROAD

RAILROAD

INDIVIDUAL TREE

SUMP

UTILITY POLE

PZ-A(S) — PROPOSED PIEZOMETER, (SEE NOTE 5) SEE DETAILS 1/11 & 2/11

× 893.2 — PROPOSED HIGH POINT ELEVATION

NOTES

1.) ASSUMED LIMIT OF WASTE CONSOLIDATION REPRESENTS EXTENT OF WASTE MATERIAL FOLLOWING EXCAVATION. THE MAXIMUM ALLOWABLE PCB CONCENTRATION OF THE SOIL SURFACE OUTSIDE THE LIMIT OF CONSOLIDATION IS PRESENTED IN THE RD/RA WORK PLAN. CAP SHALL COVER AREA WITHIN THE LIMIT OF WASTE CONSOLIDATION. ACTUAL LIMIT OF WASTE CONSOLIDATION MAY VARY BASED ON FINAL EXCAVATION DEPTHS AS DETERMINED BY POST EXCAVATION SAMPLING AND SURFACE WATER DRAINAGE REQUIREMENTS.

2.) WASTE MATERIAL BETWEEN THE EXISTING FENCE LINE AND THE ASSUMED LIMIT OF WASTE CONSOLIDATION THAT MEETS THE CRITERIA FOR CONSOLIDATION IN RD/RA WORK PLAN WILL BE EXCAVATED AND PLACED WITHIN THE LIMIT OF WASTE CONSOLIDATION. THE RCRA CAP WILL EXTEND TO THE LIMIT OF WASTE CONSOLIDATION.

3.) ASSUMED LIMIT OF WASTE IS BASED ON BOREHOLE DATA AND EXTENT OF CURRENT CAP MEMBRANE.

4.) UPPER SIX INCHES OF FILL PLACED OUTSIDE THE LIMIT OF WASTE CONSOLIDATION SHALL BE TOPSOIL AND SHALL BE VEGETATED, UNLESS SHOWN OTHERWISE ON THE DRAWINGS.

5.) ACTUAL PIEZOMETER LOCATIONS WILL BE DETERMINED IN THE FIELD FOLLOWING THE COMPLETION OF WASTE CONSOLIDATION. PIEZOMETERS PZ-A(D) AND PZ-B(D) SHALL BE BEDROCK PIEZOMETERS, AS SHOWN IN DETAIL 1 ON FIGURE 11. PIEZOMETERS PZ-A(S), PZ-B(S), PZ-C AND PZ-D SHALL BE FILL PIEZOMETERS, AS SHOWN IN DETAIL 1 ON FIGURE 11. PZ-C AND PZ-D WILL BE INSTALLED AT THE LOCATION OF THE INFILTRATION GALLERIES THAT WERE ESTABLISHED DURING WASTE EXCAVATION.

6.) REFER TO FIGURE 4 FOR FINAL CAP GRADING PLAN.

7.) BLEND CONSTRUCTED GRADES AT THE LIMIT OF DISTURBANCE TO SMOOTHLY TIE-IN TO ADJACENT PROPERTIES TO IMPROVE DRAINAGE AND MINIMIZE LOCAL PONDING AND EROSION.

8.) GRADES SHOWN WITHIN THE LIMITS OF WASTE CONSOLIDATION HAVE BEEN DEVELOPED TO ACCOMMODATE THE VOLUME OF WASTE CURRENTLY ESTIMATED TO BE CONSOLIDATED ONSITE. THESE GRADES MAY BE ADJUSTED DURING CONSTRUCTION TO ACCOMMODATE THE ACTUAL VOLUME OF WASTE TO BE CONSOLIDATED ONSITE. MAXIMUM GRADES SHALL NOT EXCEED 25% AND MINIMUM GRADES SHALL NOT BE LESS THAN 5%.

9.) GRADES SHOWN WITHIN THE ASSUMED LIMIT OF WASTE CONSOLIDATION REFLECT A MINIMUM 12-INCH THICK SOIL CUSHION LAYER PLACED ABOVE THE TOP OF CONSOLIDATED WASTE MATERIAL.

10.) GRADES SHOWN OUTSIDE OF THE ASSUMED LIMIT OF WASTE CONSOLIDATION DO NOT TAKE INTO ACCOUNT ANY REQUIREMENT FOR PLACEMENT OF CLEAN COVER SOIL BASED ON ANALYTICAL RESULTS.

11.) ALL WORK IN THE VICINITY OF RAILROAD SHALL BE COORDINATED BY CBS.

12.) ALL WORK IN THE VICINITY OF THE EXISTING GAS LINE SHALL BE COORDINATED BY CBS.

13.) CONTRACTOR IS RESPONSIBLE FOR INSTALLATION AND MAINTENANCE OF EROSION AND SEDIMENT CONTROLS IN ACCORDANCE WITH SPECIFICATION SECTION 02125 AND THE EROSION AND SEDIMENT CONTROL PLAN.

REFERENCE

1.) BASE MAP AND PROPERTY LINE TAKEN FROM CADD FILE PROVIDED BY SMITH, NEUBECKER AND ASSOCIATES INC., TITLED "TOPOGRAPHIC SURVEY", DATED DECEMBER 9, 1998.

40 0 40 80
scale feet

REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY
1	10/17/00	REVISED PIEZOMETER LOCATIONS	MJS		

PROJECT:
CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

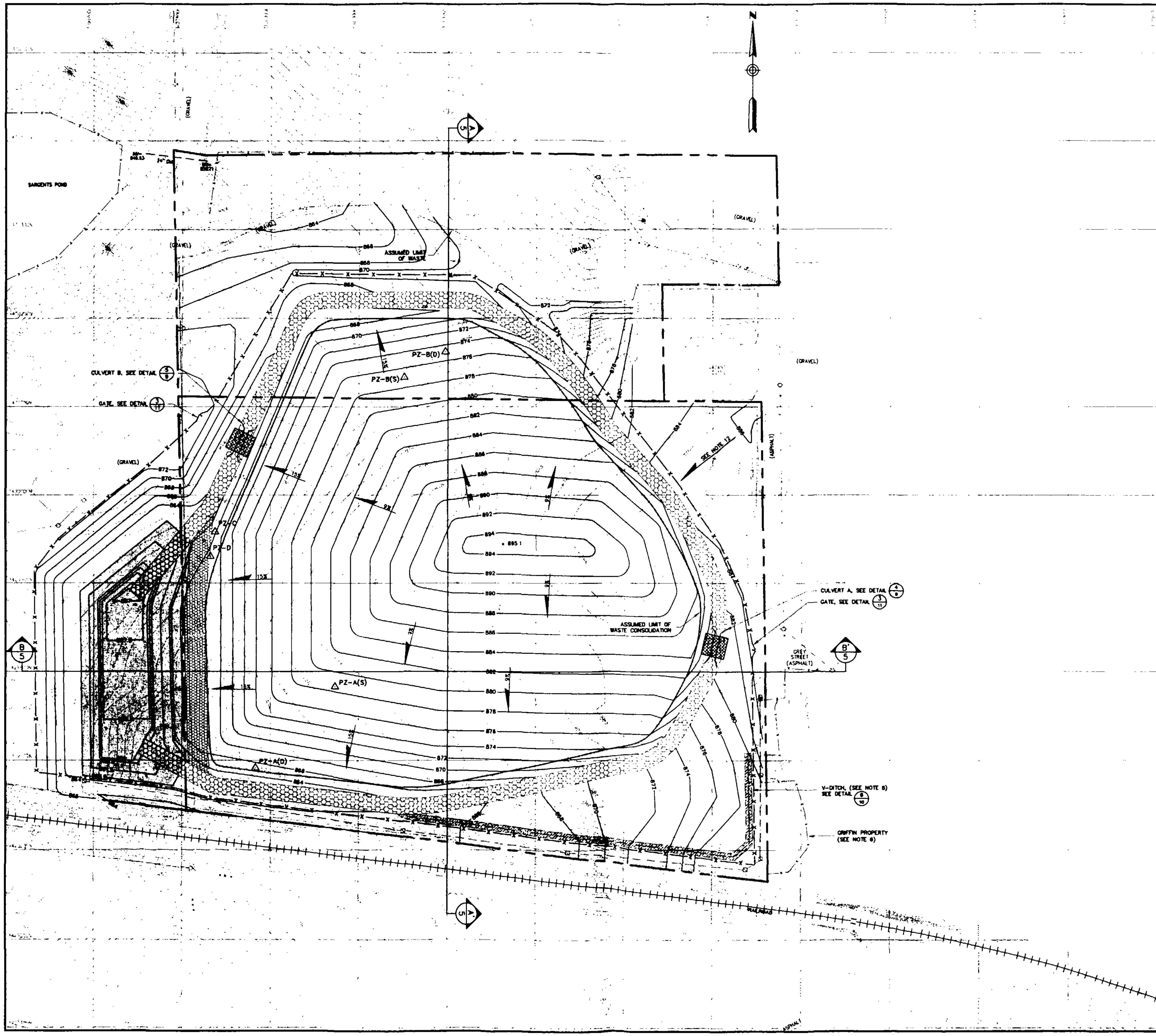
SHEET TITLE:
CAP SUBGRADE PLAN

Golder Associates
Philadelphia USA

PROJECT No.	993-6573	
CLIENT PROJ. No.		
DES BY	VEF	06/01/00
CAD BY	MJS	09/08/00
CHK BY	DBW	09/08/00
RVW BY	RES	09/08/00

FILE No.: 1IN01-079
DRAFTING SUBTITLE: 04
SCALE: AS SHOWN

DRAWING 3



LEGEND

- ASSUMED LIMIT OF WASTE
- ASSUMED LIMIT OF WASTE CONSOLIDATION (SEE NOTE 1)
- 886 — ANTICIPATED TOP OF CAP CONTOUR (SEE NOTES 3 & 4)
- EXISTING GROUND SURFACE CONTOUR (1 FT)
- EXISTING GROUND SURFACE CONTOUR (5 FT)
- PROPERTY LINE
- BRUSHLINE
- EXISTING FENCELINE
- BUILDING FOOTPRINT
- POWER LINE
- GAS LINE (SEE NOTE 5)
- ROAD
- RAILROAD
- INDIVIDUAL TREE
- SUMP
- UTILITY POLE
- PROPOSED FENCELINE, SEE DETAIL 3/11
- BASIN CAP SECTION, SEE DETAIL 4/6
- PERIMETER CHANNEL, SEE DETAILS 2/6 & 1/10
- CAP TO BASIN TRANSITION, SEE DETAIL 3/6
- V DITCH, SEE DETAIL 6/10
- CHANNEL CROSSING, SEE DETAILS 4/9 & 5/9
- PZ-A(S) — PROPOSED PIEZOMETER, SEE DETAILS 1/11 & 2/11
- x 895.1 — PROPOSED HIGH POINT ELEVATION

NOTES

1.) ASSUMED LIMIT OF WASTE CONSOLIDATION REPRESENTS EXTENT OF WASTE MATERIAL FOLLOWING EXCAVATION. THE MAXIMUM ALLOWABLE PCB CONCENTRATION OF THE SOIL SURFACE OUTSIDE THE LIMIT OF CONSOLIDATION IS PRESENTED IN THE RD/RA WORKPLAN. CAP SHALL COVER AREA WITHIN THE LIMIT OF WASTE CONSOLIDATION. ACTUAL LIMIT OF WASTE CONSOLIDATION MAY VARY BASED ON FINAL EXCAVATION DEPTHS AS DETERMINED BY POST EXCAVATION SAMPLING AND SURFACE WATER DRAINAGE REQUIREMENTS.

2.) BLEND CONSTRUCTED GRADES AT THE LIMIT OF DISTURBANCE TO SMOOTHLY TIE-IN TO ADJACENT PROPERTIES TO IMPROVE DRAINAGE AND MINIMIZE LOCAL PONDING AND EROSION.

3.) PROPOSED GRADES WITHIN THE LIMITS OF WASTE CONSOLIDATION HAVE BEEN DEVELOPED TO ACCOMMODATE THE VOLUME OF WASTE CURRENTLY ESTIMATED TO BE CONSOLIDATED ONSITE. THESE GRADES MAY BE ADJUSTED DURING CONSTRUCTION TO ACCOMMODATE THE ACTUAL VOLUME OF WASTE TO BE CONSOLIDATED ONSITE. MAXIMUM GRADES SHALL NOT EXCEED 25% AND MINIMUM GRADES SHALL NOT BE LESS THAN 5%.

4.) UPPER SIX INCHES OF FILL PLACED OUTSIDE THE ASSUMED LIMIT OF WASTE CONSOLIDATION SHALL BE TOPSOIL AND SHALL BE VEGETATED, UNLESS SHOWN OTHERWISE ON THE DRAWINGS.

5.) PRIOR TO CONSTRUCTION, THE GAS LINE WITHIN THE SITE BOUNDARY SHALL BE ABANDONED BY THE UTILITY. DURING CONSTRUCTION, THE CONTRACTOR SHALL REMOVE THIS ABANDONED LINE. AFTER EXCAVATION AND CONSOLIDATION OF WASTE, A NEW GAS LINE SHALL BE INSTALLED. THE LOCATION AND DEPTH OF THE NEW GAS LINE SHALL BE SURVEYED AND PROVIDED TO CBS ON AN AS BUILT MAP.

6.) FOLLOWING EXCAVATION, GRIFFIN PROPERTY GRADES SHALL BE BLENDED INTO ADJACENT GRADES IN ORDER TO ACHIEVE DRAINAGE IN A WESTERLY DIRECTION.

7.) GRADES SHOWN OUTSIDE OF THE CAP AREA DO NOT TAKE INTO ACCOUNT ANY REQUIREMENT FOR PLACEMENT OF CLEAN COVER SOIL BASED ON ANALYTICAL RESULTS.

8.) V-DITCH SHALL SMOOTHLY TRANSITION INTO PERIMETER CHANNEL. ACTUAL DETAILS OF TRANSITION AREA SHALL BE DETERMINED IN THE FIELD DURING CONSTRUCTION.

9.) WITHIN THE AREA BOUNDED BY THE PERIMETER CHANNEL, THE CONTOURS SHOWN REPRESENT THE TOP OF FINAL CAP GRADES. WITHIN THE BASIN, THE CONTOURS SHOWN REPRESENT THE TOP OF BASIN FINAL GRADES. IN ALL OTHER AREAS, THE CONTOURS SHOWN REPRESENT THE TOP OF BACKFILL/FINISHED GRADES.

10.) ALL WORK IN THE VICINITY OF THE EXISTING GAS LINE SHALL BE COORDINATED BY CBS.

11.) CONTRACTOR IS RESPONSIBLE FOR INSTALLATION AND MAINTENANCE OF EROSION AND SEDIMENT CONTROLS IN ACCORDANCE WITH SPECIFICATION SECTION 02125 AND THE EROSION AND SEDIMENT CONTROL PLAN.

12.) GRADE FROM LEMON LANE ROAD TO DRAIN TO PERIMETER CHANNEL.

REFERENCE

1.) BASE MAP AND PROPERTY LINE TAKEN FROM CADD FILE PROVIDED BY SMITH, NEUBECKER AND ASSOCIATES INC., TITLED "TOPOGRAPHIC SURVEY", DATED DECEMBER 9, 1999.

40 0 40 80
scale feet

REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY
1	10/17/00	REVISED PIEZOMETER LOCATIONS	MJS		

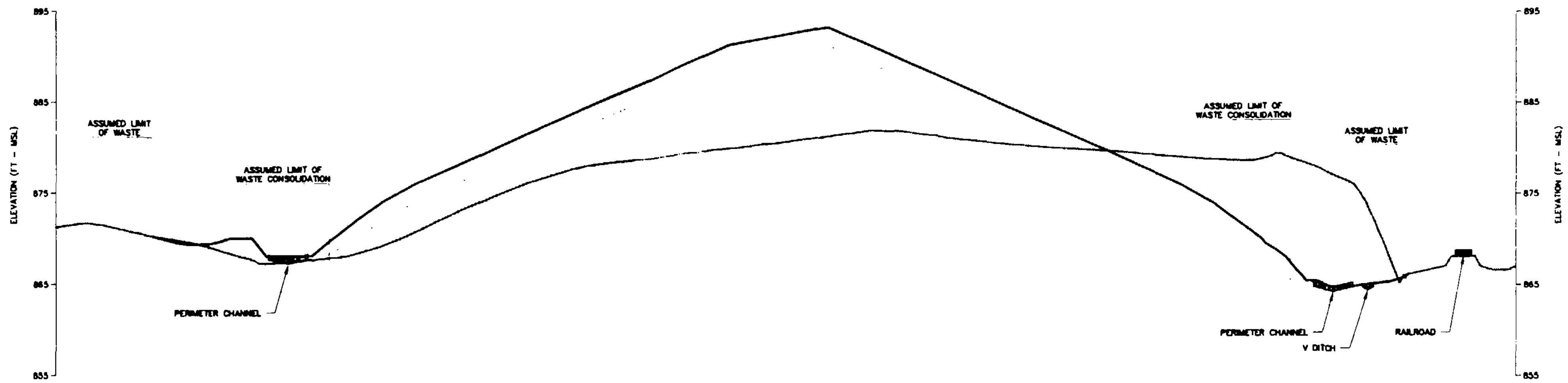
PROJECT:
CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE:
FINAL CAP GRADING PLAN

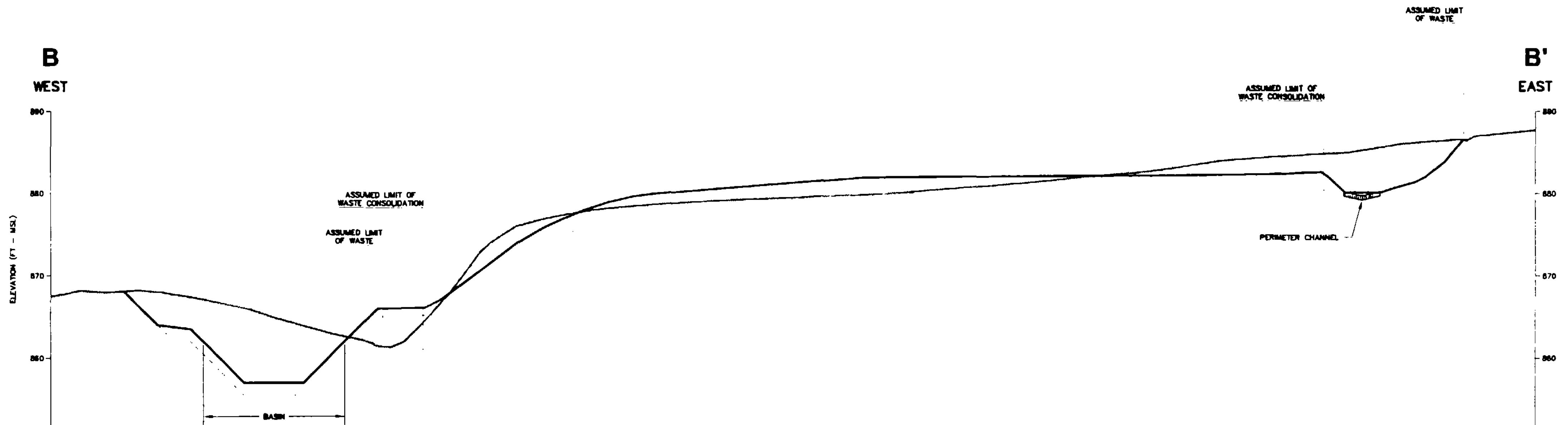
Golder Associates
Philadelphia USA

PROJECT No.	993-6573	FILE No.:	1IN01-080
CLIENT PROJ. No.		DRAFTING SUBTITLE:	04
DES BY VEF	06/01/00	SCALE:	AS SHOWN
CAD BY MJS	09/08/00		
CHK BY DBW	09/08/00		
RVW BY RES	09/08/00		

DRAWING 4



A/5 **CROSS SECTION A-A'**
AS SHOWN



B/5 **CROSS SECTION B-B'**
AS SHOWN

30 0 30 60
horizontal scale feet

6 0 6 12
vetical scale feet

LEGEND

PROPOSED FINAL GRADE
PROPOSED SUBGRADE
PROPOSED EXCAVATION GRADE
EXISTING GROUND SURFACE

NOTES

1) ASSUMED LIMIT OF WASTE CONSOLIDATION DEFINES THE BOUNDARY BETWEEN WASTE MATERIAL AND A SOIL SURFACE WITH MAXIMUM PCB CONCENTRATION AS PRESENTED IN THE RD/RA WORKPLAN. CAP SHALL COVER AREA WITHIN LIMIT OF WASTE CONSOLIDATION. ACTUAL LIMIT OF WASTE CONSOLIDATION MAY VARY BASED ON FINAL EXCAVATION DEPTHS AS DETERMINED BY POST EXCAVATION SAMPLING AND SURFACE WATER DRAINAGE REQUIREMENTS.

2) ASSUMED LIMIT OF WASTE IS BASED ON BOREHOLE DATA AND CURRENT EXTENT OF CAP MEMBRANE.

3.) PROPOSED EXCAVATION GRADES SHOWN REPRESENT THE CURRENTLY ANTICIPATED DEPTHS OF WASTE EXCAVATION BASED UPON THE EPA DEFINED HOT-SPOT EXCAVATION DEPTHS AND THE NON HOT-SPOT EXCAVATION CORRESPONDING TO THE LIMIT OF WASTE CONSOLIDATION AS SHOWN ON FIGURE 2. ADDITIONAL WASTE EXCAVATION SHALL BE REQUIRED IN ISOLATED AREAS TO CREATE PROPOSED GRADES.

4) THE CRITERIA FOR DEPTHS OF EXCAVATION IN NON HOT-SPOT AREAS IS PRESENTED IN THE RD/RA WORK PLAN.

5.) SEE DETAILS ON DRAWING 6 FOR TRANSITION OF CAP TO PERIMETER CHANNEL AND BASIN.

6.) FINAL GRADES FOR PROPOSED PERIMETER CHANNEL ARE NOT PRESENTED ON THESE CROSS SECTIONS.

7.) BLEND CONSTRUCTED GRADES AT THE LIMIT OF DISTURBANCE TO SMOOTHLY TIE-IN TO ADJACENT PROPERTIES TO IMPROVE DRAINAGE AND MINIMIZE LOCAL PONDING AND EROSION.

8.) FINAL CONTOURS OUTSIDE OF THE CAP AREA DO NOT TAKE INTO ACCOUNT ANY REQUIREMENT FOR PLACEMENT OF CLEAN COVER SOIL BASED ON ANALYTICAL RESULTS.

9) WASTE MATERIAL BETWEEN THE EXISTING FENCE LINE AND THE LIMIT OF WASTE CONSOLIDATION THAT MEETS THE CRITERIA FOR CONSOLIDATION IN RD/RA WORK PLAN WILL BE EXCAVATED AND PLACED WITHIN THE LIMIT OF WASTE CONSOLIDATION. THE RCRA CAP WILL EXTEND TO THE LIMIT OF WASTE CONSOLIDATION.

10.) THE HIGHEST GROUNDWATER ELEVATION OBSERVED IN THE VICINITY OF THE SITE IN THE LAST FIVE YEARS REACHED A MAXIMUM LEVEL OF 835.15 ABOVE MEAN SEA LEVEL, AND WAS RECORDED AT MW-6.

REV	DATE	DESCRIPTION	DR BY	CHK BY	RVW BY

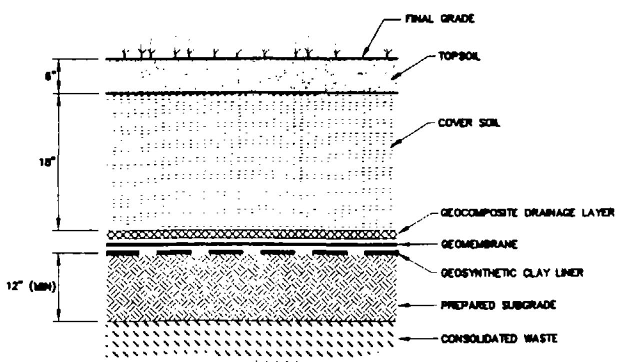
PROJECT:
CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE:
LANDFILL CROSS SECTIONS

Golder Associates
Philadelphia USA

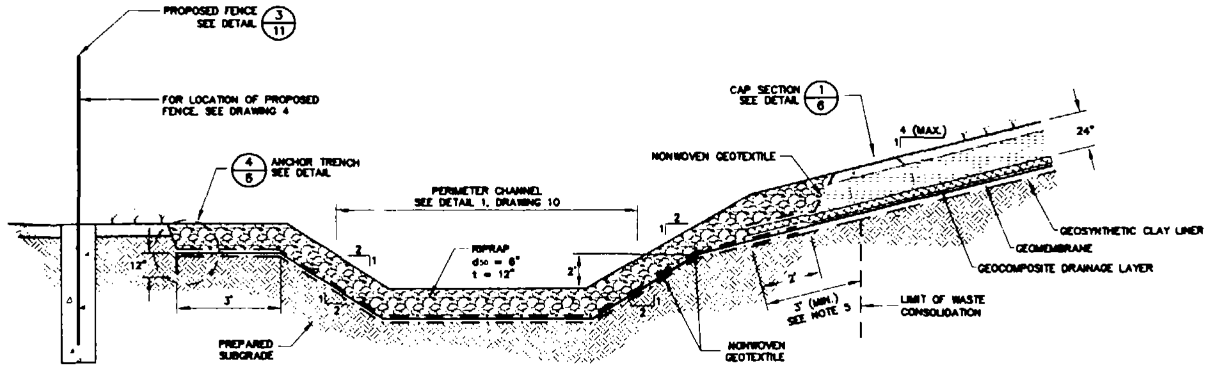
PROJECT No.	983-6573		FILE No.:	IN01-081
CLIENT PROJ. No.			DRAFTING SUBTITLE:	D4
DES BY	VEF	08/02/00	SCALE:	AS SHOWN
DR BY	MJS	09/08/00		
CHK BY	DBW	09/08/00		
RVW BY	RES	09/08/00		

DRAWING 5



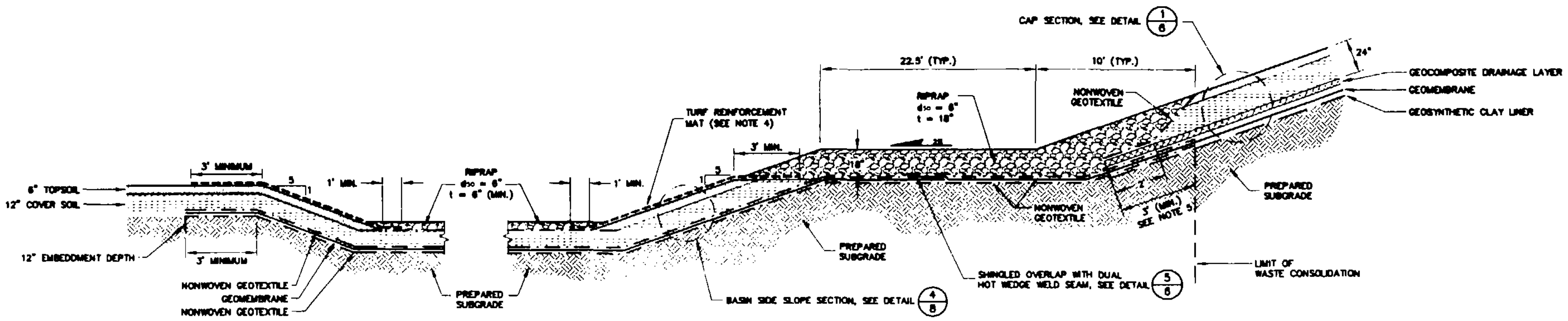
1/6 CAP SECTION

NOT TO SCALE



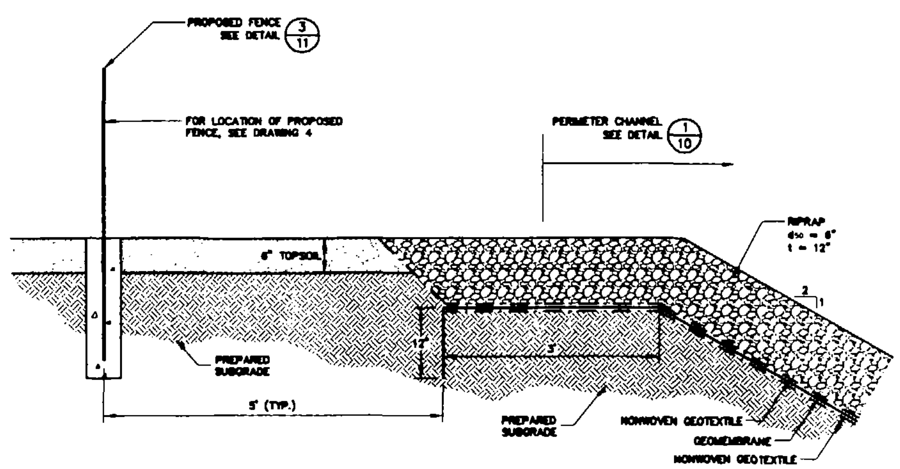
2/6 CAP TO PERIMETER CHANNEL TRANSITION

NOT TO SCALE



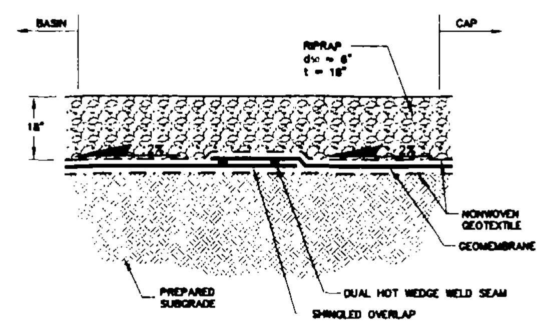
3/6 BASIN AND CAP, WITH TRANSITION

NOT TO SCALE



4/6 CAP ANCHOR TRENCH DETAIL

NOT TO SCALE



5/6 BENCH ANCHOR TRENCH DETAIL

NOT TO SCALE

NOTES

1.) GEOSYNTHETICS SCALE EXAGGERATED FOR CLARITY.

2.) DETAILS 3 AND 5 ON THIS DRAWING REPRESENT CONNECTION OF BASIN AND CAP GEOMEMBRANE.

3.) WITHIN THE LIMITS OF THE RCRA CAP, THE PREPARED SUBGRADE SHALL CONSIST OF A SOIL CUSHION LAYER AS DEFINED IN SPECIFICATION SECTION 02224. OUTSIDE THE LIMITS OF THE RCRA CAP, THE PREPARED SUBGRADE SHALL CONSIST OF BACKFILL MATERIAL SUBSTANTIALLY FREE OF 1 INCH SIZE PARTICLES IN THE UPPER 6 INCHES DIRECTLY BENEATH GEOSYNTHETICS. THE SUBGRADE SHALL BE APPROVED BY THE QUALITY ASSURANCE OFFICER AND THE INSTALLER PRIOR TO GEOSYNTHETIC INSTALLATION.

4.) TURF REINFORCEMENT MAT (TRM) SHALL BE EMBEDDED INTO TOP 1 INCH OF TOPSOIL AND SHALL BE ENKAMAT 7020, LANDLOK ECRM450, ANCHORED PER THE MANUFACTURER'S RECOMMENDATIONS.

5.) THE GCL SHALL EXTEND A MINIMUM OF 3 FEET BEYOND THE LIMIT OF WASTE CONSOLIDATION.

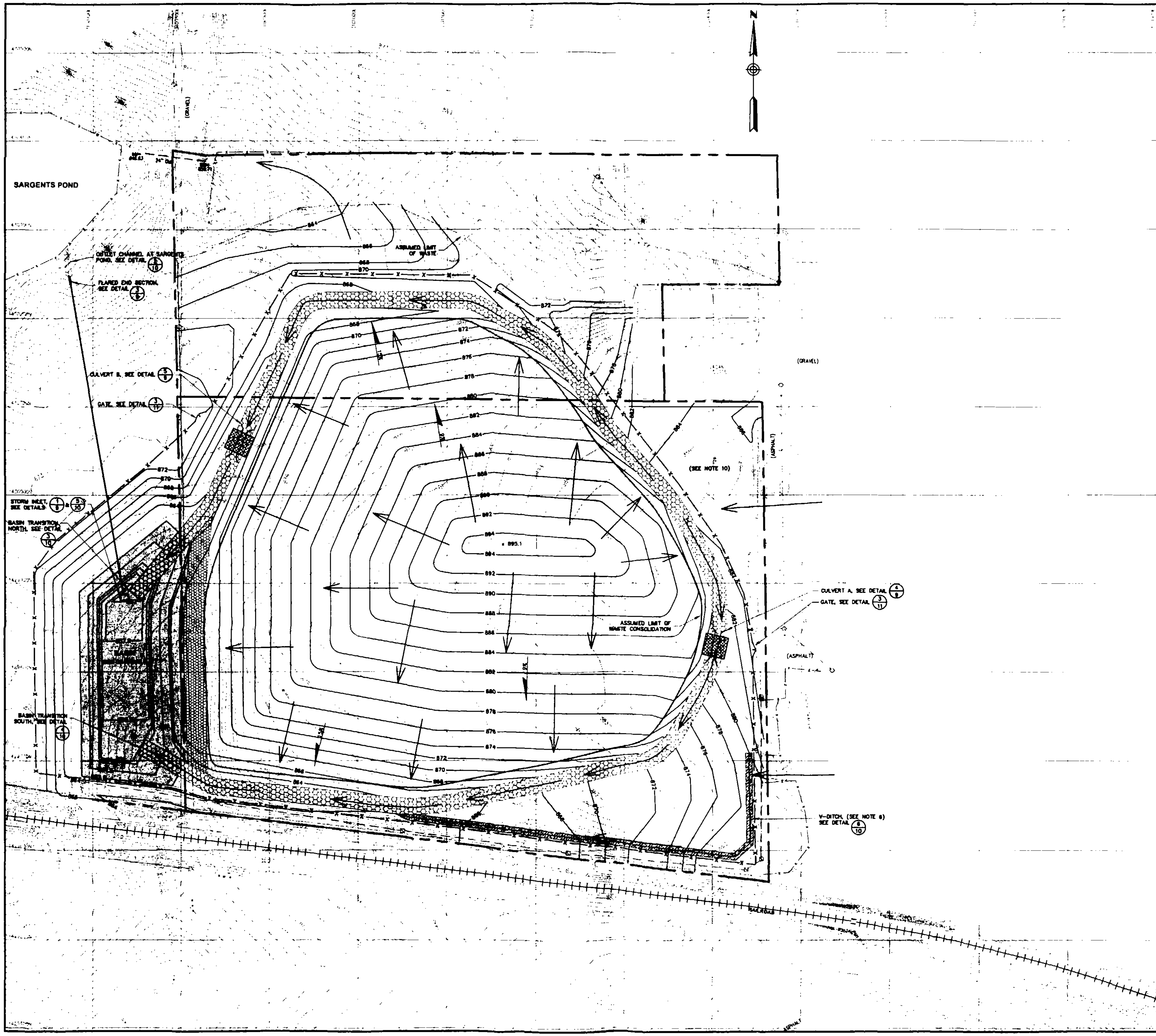
REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY

PROJECT: CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE: CAP SECTION AND TRANSITION DETAILS

Golder Associates
Philadelphia USA

PROJECT No.	993-6573		FILE No.	IN01-082
CLIENT PROJ. No.			DRAFTING SUBTITLE	04
DES BY	VEF	08/05/00	SCALE:	AS SHOWN
CAD BY	MJS	09/08/00	DRAWING 6	
CHK BY	DBW	09/08/00		
RVW BY	RES	09/08/00		



LEGEND

- ASSUMED LIMIT OF WASTE
- ASSUMED LIMIT OF WASTE CONSOLIDATION (SEE NOTE 1)
- 886 — ANTICIPATED TOP OF CAP CONTOUR (SEE NOTE 5)
- EXISTING GROUND SURFACE CONTOUR (1 FT)
- EXISTING GROUND SURFACE CONTOUR (5 FT)
- PROPERTY LINE
- BRUSHLINE
- EXISTING FENCELINE
- BUILDING FOOTPRINT
- POWER LINE
- GAS LINE (SEE NOTE 7)
- ROAD
- RAILROAD
- INDIVIDUAL TREE
- UTILITY POLE
- PROPOSED FENCELINE, SEE DETAIL 3/11
- STORMWATER FLOW DIRECTION
- BASIN SECTION, SEE DETAIL 4/8 & 5/8
- PERIMETER CHANNEL, SEE DETAILS 2/8 & 1/10
- CAP TO BASIN TRANSITION, SEE DETAIL 3/8
- V DITCH, SEE DETAIL 6/10
- CHANNEL CROSSING, SEE DETAILS 4/9 & 5/9

NOTES

1.) ASSUMED LIMIT OF WASTE CONSOLIDATION REPRESENTS EXTENT OF WASTE MATERIAL FOLLOWING EXCAVATION. THE MAXIMUM ALLOWABLE PCB CONCENTRATION OF THE SOIL SURFACE OUTSIDE THE LIMIT OF CONSOLIDATION IS PRESENTED IN THE RD/RA WORKPLAN. CAP SHALL COVER AREA WITHIN LIMIT OF WASTE CONSOLIDATION. ACTUAL LIMIT OF WASTE CONSOLIDATION MAY VARY BASED ON FINAL EXCAVATION DEPTHS AS DETERMINED BY POST EXCAVATION SAMPLING AND SURFACE WATER DRAINAGE REQUIREMENTS.

2.) BLEND CONSTRUCTED GRADES AT THE LIMIT OF DISTURBANCE TO SMOOTHLY TIE-IN TO ADJACENT PROPERTIES TO IMPROVE DRAINAGE AND MINIMIZE LOCAL PONDING AND EROSION.

3.) PROPOSED GRADES HAVE BEEN DEVELOPED TO ACCOMMODATE THE VOLUME OF WASTE CURRENTLY ESTIMATED TO BE CONSOLIDATED ONSITE. THESE GRADES MAY BE ADJUSTED DURING CONSTRUCTION TO ACCOMMODATE THE ACTUAL VOLUME OF WASTE TO BE CONSOLIDATED ONSITE. MAXIMUM GRADES SHALL NOT EXCEED 25% AND MINIMUM GRADES SHALL NOT BE LESS THAN 5%.

4.) WITHIN THE AREA BOUNDED BY THE PERIMETER CHANNEL, THE CONTOURS SHOWN REPRESENT THE TOP OF FINAL CAP GRADES. WITHIN THE BASIN, THE CONTOURS SHOWN REPRESENT THE TOP OF BASIN FINAL GRADES. IN ALL OTHER AREAS, THE CONTOURS SHOWN REPRESENT THE TOP OF BACKFILL/FINISHED GRADES.

5.) CONTOURS OUTSIDE OF THE CAP AREA DO NOT TAKE INTO ACCOUNT ANY *REQUIREMENT FOR PLACEMENT OF CLEAN COVER SOIL BASED ON ANALYTICAL RESULTS.*

6.) V-DITCH SHALL SMOOTHLY TRANSITION INTO PERIMETER CHANNEL. ACTUAL DETAILS OF TRANSITION AREA SHALL BE DETERMINED IN THE FIELD DURING CONSTRUCTION.

7.) PRIOR TO CONSTRUCTION, THE GAS LINE WITHIN THE SITE BOUNDARY SHALL BE ABANDONED BY THE UTILITY. DURING CONSTRUCTION, THE CONTRACTOR SHALL REMOVE THIS ABANDONED LINE. AFTER EXCAVATION AND CONSOLIDATION OF WASTE, A NEW GAS LINE SHALL BE INSTALLED. THE LOCATION AND DEPTH OF THE NEW GAS LINE SHALL BE SURVEYED AND PROVIDED TO CBS ON AN AS BUILT MAP.

8.) PERIMETER CHANNEL SHALL MAINTAIN A MINIMUM SLOPE OF 1% AND A MAXIMUM SLOPE OF 9%.

9.) CONTRACTOR IS RESPONSIBLE FOR INSTALLATION AND MAINTENANCE OF EROSION AND SEDIMENT CONTROLS IN ACCORDANCE WITH SPECIFICATION SECTION 02125 AND THE EROSION AND SEDIMENT CONTROL PLAN.

10.) GRADE FROM LEMON LANE ROAD TO DRAIN TO PERIMETER CHANNEL.

REFERENCE

1.) BASE MAP AND PROPERTY LINE TAKEN FROM CADD FILE PROVIDED BY SMITH, NEUBECKER AND ASSOCIATES INC., TITLED "TOPOGRAPHIC SURVEY", DATED DECEMBER 9, 1999.

40 0 40 80
scale feet

REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY

PROJECT:

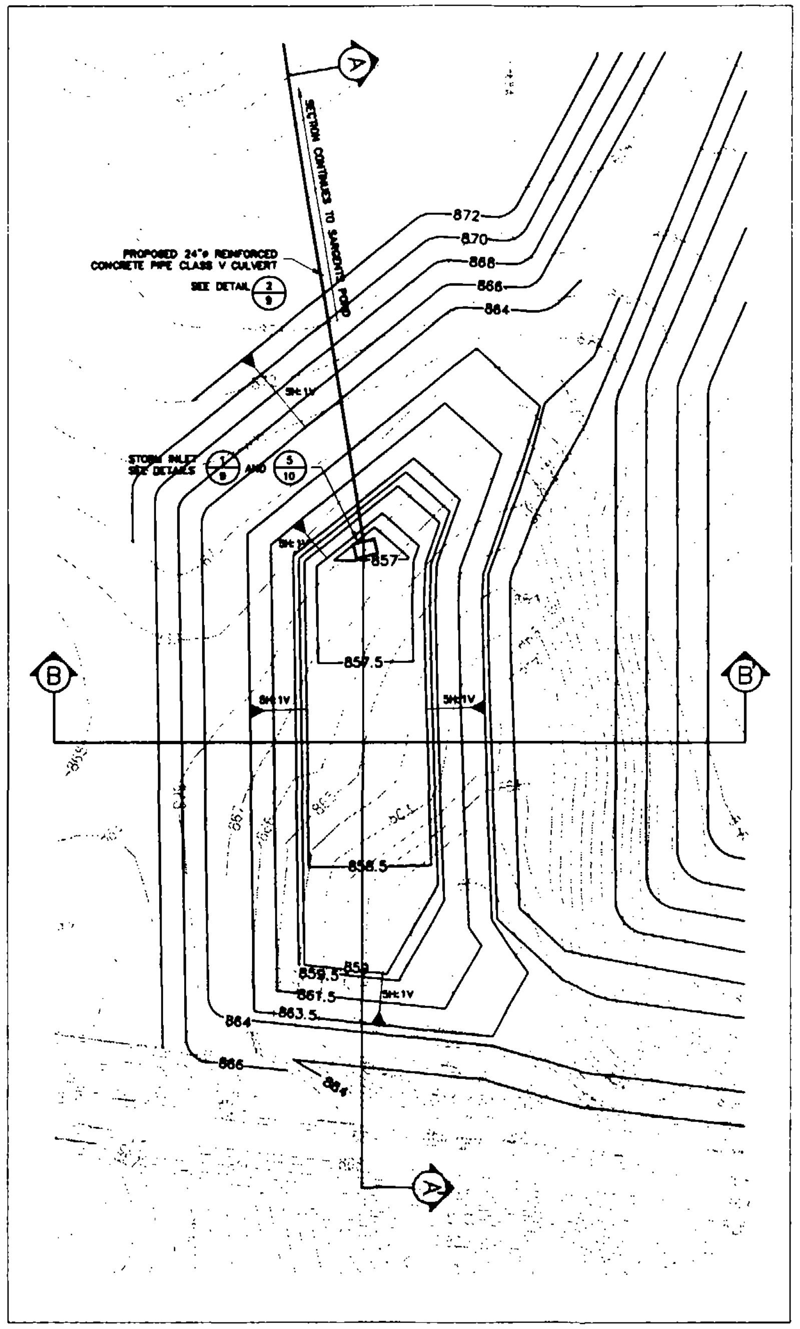
CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE:

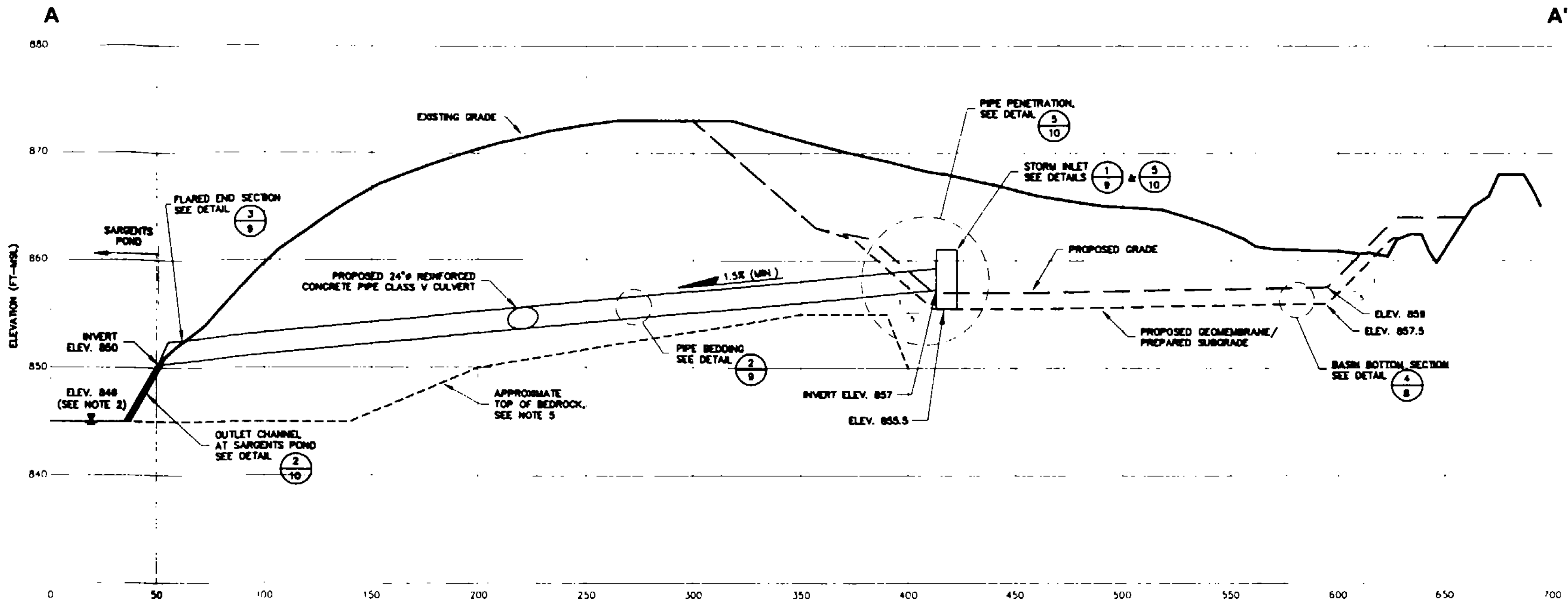
STORMWATER MANAGEMENT PLAN

Golder Associates
Philadelphia USA

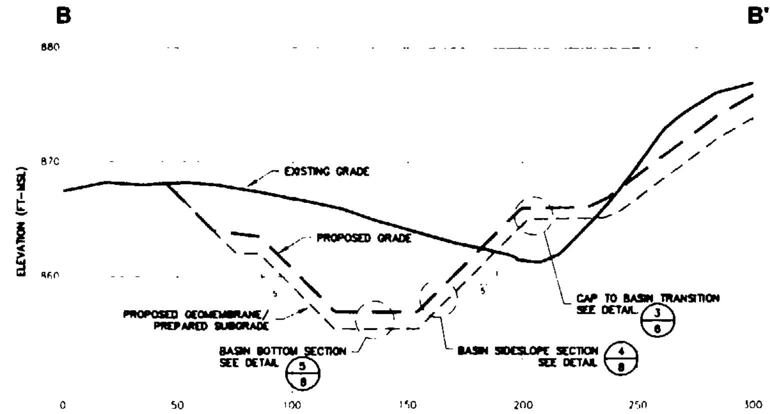
PROJECT No.	993-6573		FILE No.:	IN01-083
CLIENT PROJ. No.			DRAFTING SUBTITLE:	04
DES BY	VEF	06/01/00	SCALE:	AS SHOWN
CAD BY	MJS	09/08/00	DRAWING 7	
CHK BY	DBW	09/08/00		
RVW BY	RES	09/08/00		



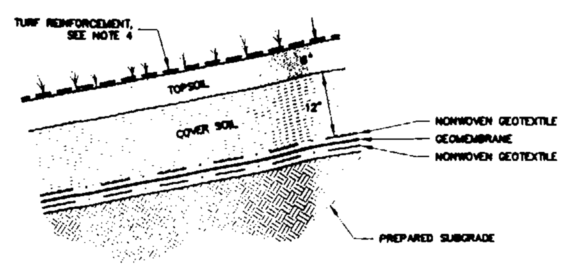
1/8 PLAN VIEW OF BASIN
AS SHOWN



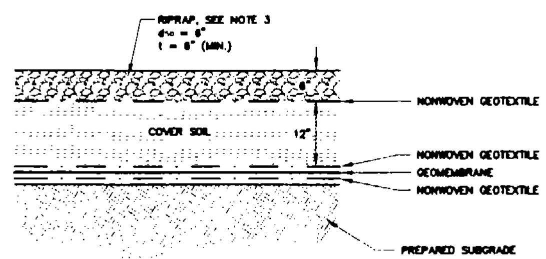
2/8 BASIN CROSS SECTION A-A'
AS SHOWN



3/8 BASIN CROSS SECTION B-B'
AS SHOWN



4/8 BASIN SIDESLOPE SECTION
AS SHOWN



5/8 BASIN BOTTOM SECTION
AS SHOWN

NOTES

1.) GEOSYNTHETICS EXAGGERATED FOR CLARITY.

2.) THE APPROXIMATE MEAN WATER LEVEL IN SARGENTS POND IS ELEVATION 848.

3.) RIPRAP MATERIAL PROPOSED FOR SURFACE OF BASIN MAY BE MODIFIED, AS APPROVED BY THE ENGINEER.

4.) TURF REINFORCEMENT MAT (TRM) SHALL BE EMBEDDED INTO TOP 1 INCH OF TOPSOIL AND SHALL BE ENKAMAT 7020, LANDLOK ECRM450, ANCHORED PER THE MANUFACTURER'S RECOMMENDATIONS.

5.) APPROXIMATE TOP OF BEDROCK SHOWN IS BASED UPON EXTRAPOLATION OF DATA GENERATED FROM SITE BORINGS PROVIDED BY CBS. ACTUAL TOP OF BEDROCK MAY VARY FROM THAT SHOWN.

6 0 6 12
vertical scale feet

30 0 30 60
horizontal scale feet

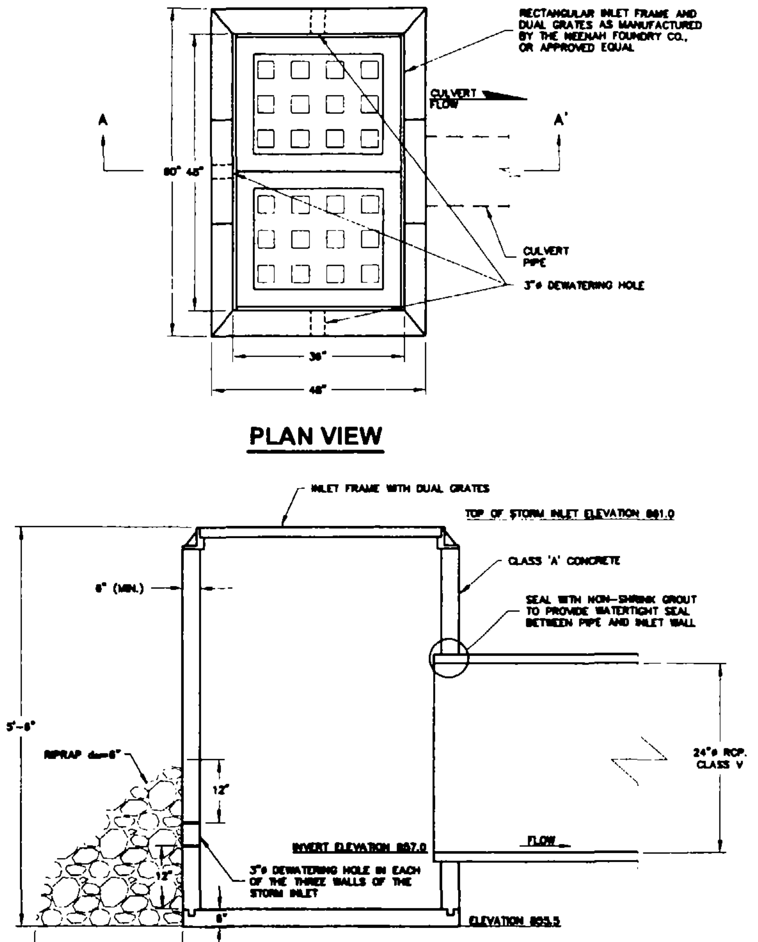
REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY

PROJECT: CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE: BASIN DETAILS

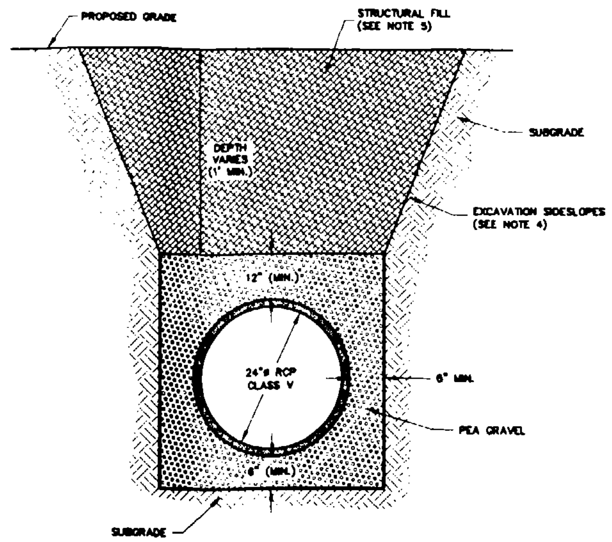
Golder Associates
Philadelphia USA

PROJECT No.	993-6573		FILE No.: IN01-084
CLIENT PROJ. No.			DRAFTING SUBTITLE: D4
DES BY	VEF	08/05/00	SCALE: AS SHOWN
CAD BY	MJS	09/08/00	DRAWING 8
CHK BY	DBW	09/08/00	
RVW BY	RES	09/08/00	



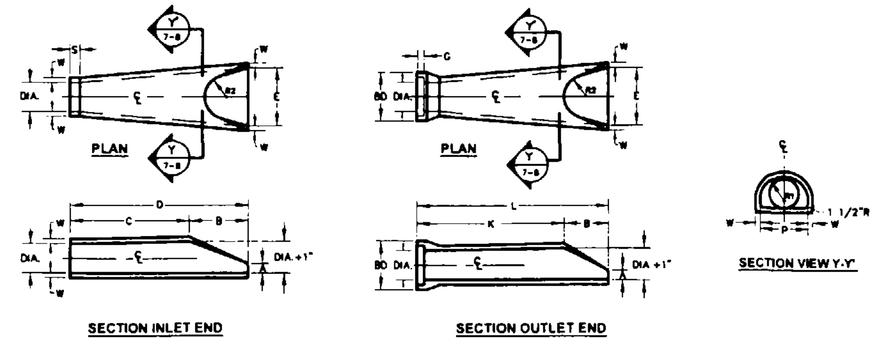
1/9 **STORM INLET**

NOT TO SCALE



2/9 **CULVERT PIPE BEDDING DETAIL**

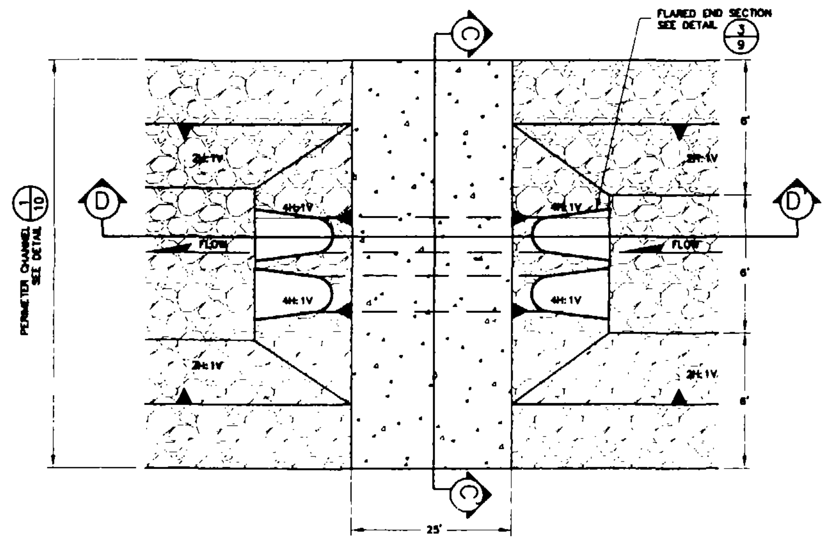
NOT TO SCALE

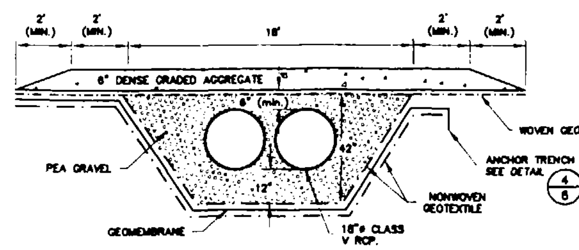


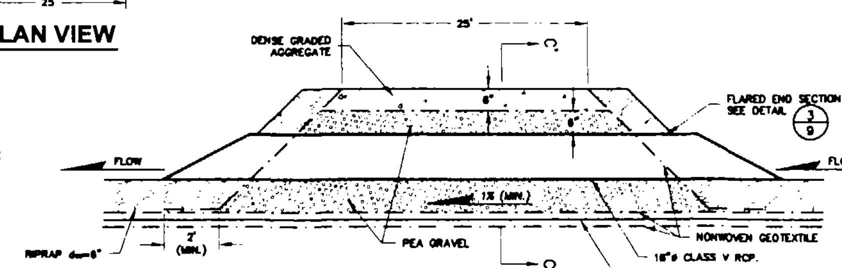
DIA.	W	A	B	C	D	E	BD	K	L	P	DIA.+1"	R1	R2	S	G
18"	2-1/2"	9"	2'-3"	3'-10"	6'-1"	3'-0"	28"	4'-3 7/8	6'-8 7/8"	29"	19"	15-1/2"	12"	4"	2-3/4"
24"	3"	9 1/2"	3'-7 1/2"	2'-6"	6'-1 1/2"	4'-0"	36"	3'-1/2"	6'-6"	33 3/16"	25"	16-13/16"	14"	4"	3"

3/9 **REINFORCED CONCRETE PIPE (RCP) FLARED ENDS**

NOT TO SCALE (SEE NOTE 2)

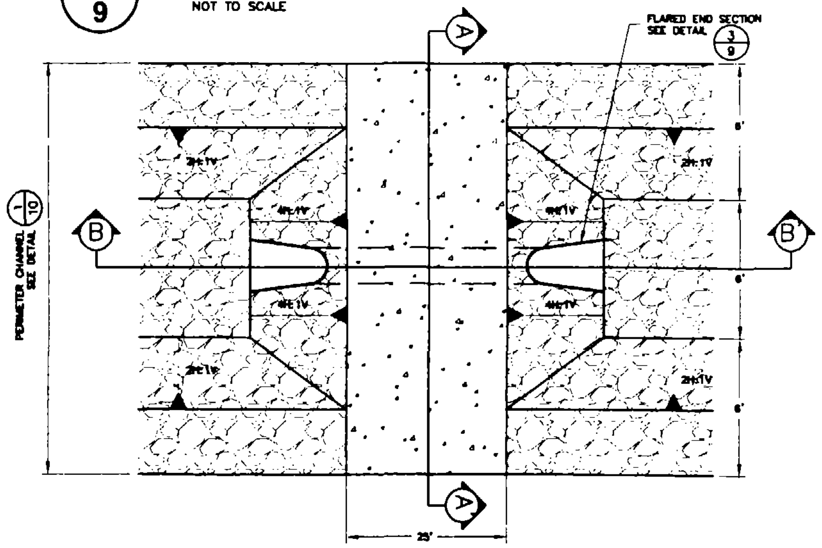


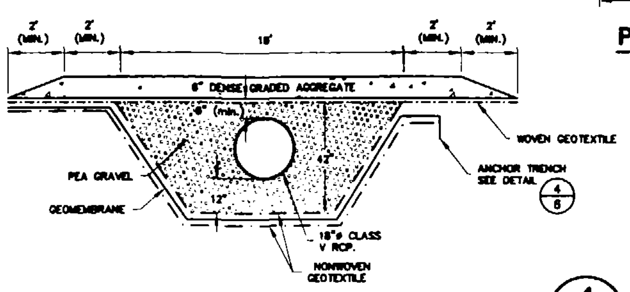


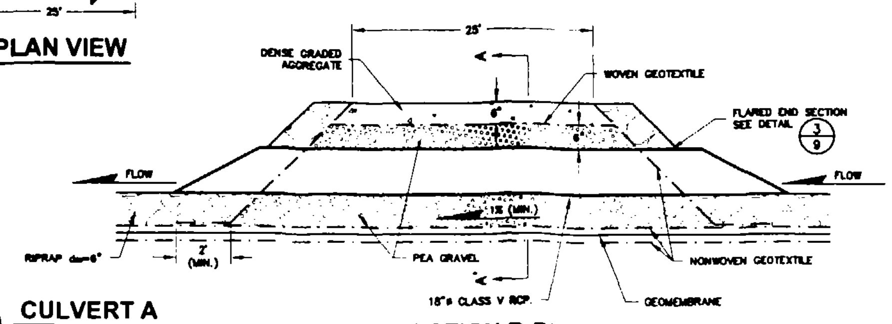


5/9 **CULVERT B**

NOT TO SCALE







4/9 **CULVERT A**

NOT TO SCALE

NOTES

1) GEOSYNTHETICS SCALE EXAGGERATED FOR CLARITY.

2) THE ACTUAL DIMENSIONS OF REINFORCED CONCRETE PIPE FLARED ENDS VARY WITH EACH MANUFACTURER. LENGTH OF CONCRETE PIPE (CULVERTS) MAY REQUIRE ADJUSTING TO ACCOUNT FOR DIFFERING TOTAL LENGTH OF REINFORCED CONCRETE FLARED ENDS.

3.) THE MAXIMUM DISTANCE BETWEEN THE CENTERLINES OF THE 18" PIPES SHALL BE 3 FEET. THE PIPES SHALL BE CENTERED IN THE TRENCH.

4.) EXCAVATION SIDESLOPES SHALL BE IN FULL COMPLIANCE WITH OSHA 29 CFR 1926, SUBPART P, AS WELL AS PROJECT SPECIFICATION SECTION 02150. CONTRACTOR SHALL PERFORM ANY SUBSURFACE INVESTIGATIONS DEEMED NECESSARY FOR THE DESIGN OF SHORING AND BRACING.

5.) ALTERNATIVE MATERIAL MAY BE UTILIZED FOR TRENCH BACKFILL ABOVE PIPE IF APPROVED BY ENGINEER.

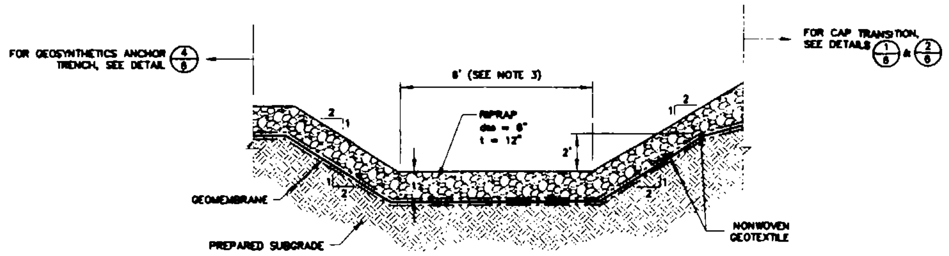
REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY

PROJECT: CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE: STORMWATER DETAILS (SHEET 1 OF 2)

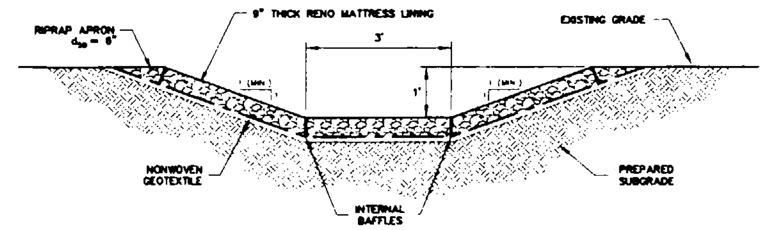
Golder Associates
Philadelphia USA

PROJECT No.	993-6573		FILE No.:	IN01-085
CLIENT PROJ. No.			DRAFTING SUBTITLE:	04
DES BY	VEF	05/01/00	SCALE:	AS SHOWN
CAD BY	MJS	09/08/00		DRAWING 9
CHK BY	DBW	09/08/00		
RVW BY	RES	09/08/00		



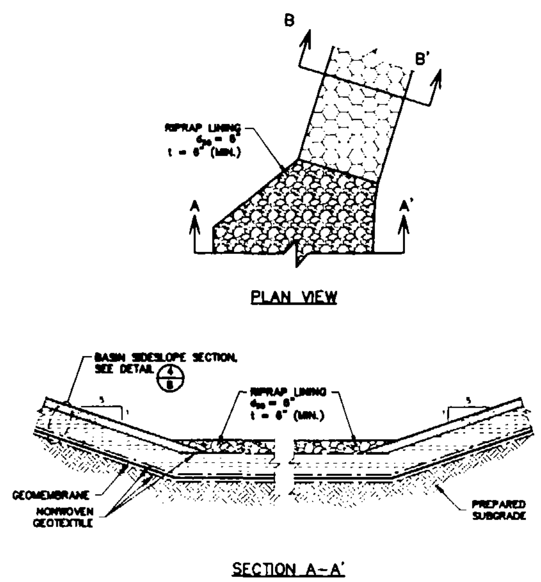
1/10 TYPICAL PERIMETER CHANNEL

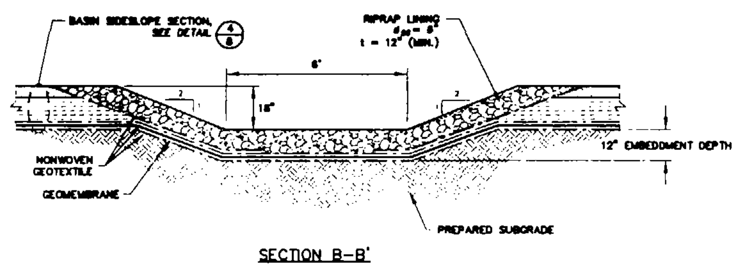
NOT TO SCALE



2/10 OUTLET CHANNEL AT SARGENTS POND

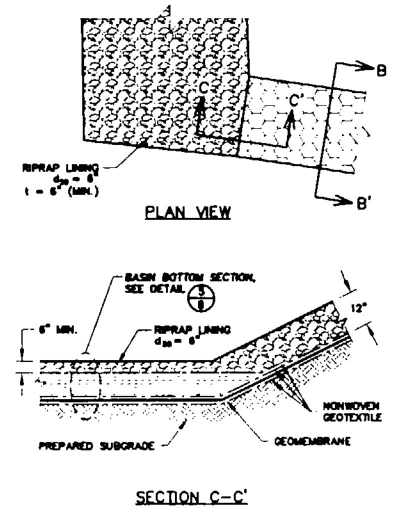
NOT TO SCALE





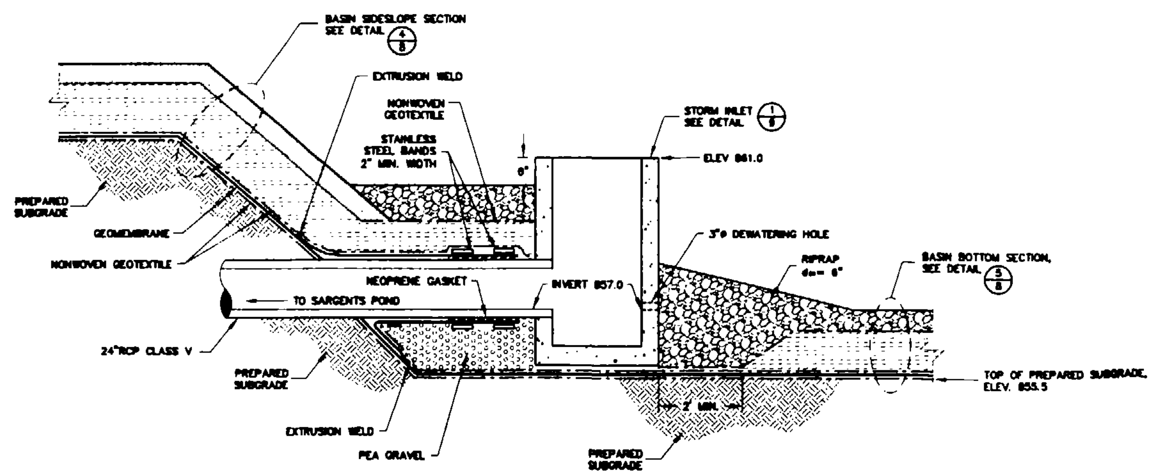
3/10 BASIN TRANSITION NORTH

NOT TO SCALE



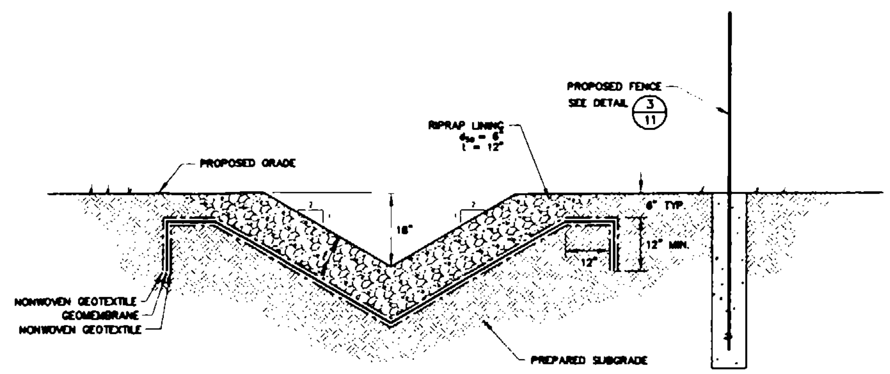
4/10 BASIN TRANSITION SOUTH

NOT TO SCALE



5/10 PIPE PENETRATION DETAIL

SCALE EXAGGERATED FOR EFFECT



6/10 V-DITCH

NOT TO SCALE

NOTES

1.) THE STORM INLET STRUCTURE SHALL BE CONSTRUCTED AS CLOSE AS PRACTICAL TO THE TOE OF THE SLOPE TO ALLOW CONNECTION OF THE GEOMEMBRANE BOOT.

2.) PEA GRAVEL SHALL BE USED TO SUPPORT THE LENGTH OF PIPE BEFORE ENTERING THE BASIN SIDEWALL. PEA GRAVEL SHALL EXTEND TO THE SPRINGLINE OF THE PIPE ACROSS THE WIDTH OF THE STORM INLET STRUCTURE. A LAYER OF RIP RAP SHALL BE PLACED ABOVE THE EXPOSED PEA GRAVEL SURFACE.

3.) PERIMETER CHANNEL BASE WIDTH MAY BE REDUCED TO 4 FEET ON THE EASTERN PERIMETER OF THE SITE, WHERE FLOWS ARE REDUCED. REDUCED WIDTH CHANNEL SHALL TRANSITION SMOOTHLY TO THE 8 FOOT WIDE CHANNEL. FINAL ADJUSTMENTS TO PERIMETER CHANNEL BASE WIDTH SHALL BE MADE DURING CONSTRUCTION, AND SHALL BE RECORDED ON AS-BUILT DRAWINGS.

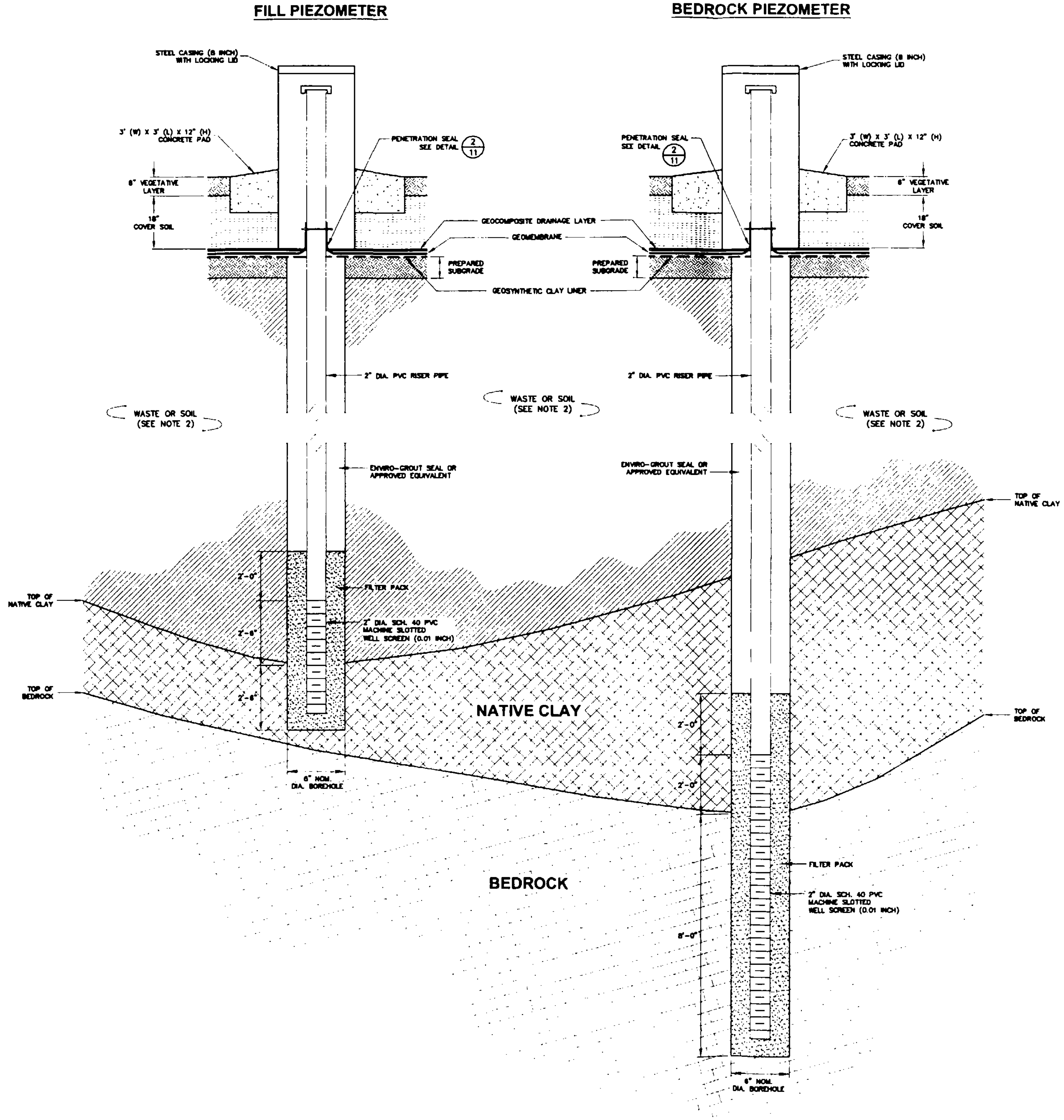
REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY
1	10/17/00	REVISED DETAIL 1 AND ADDED NOTE 3	MJS		

PROJECT:
CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

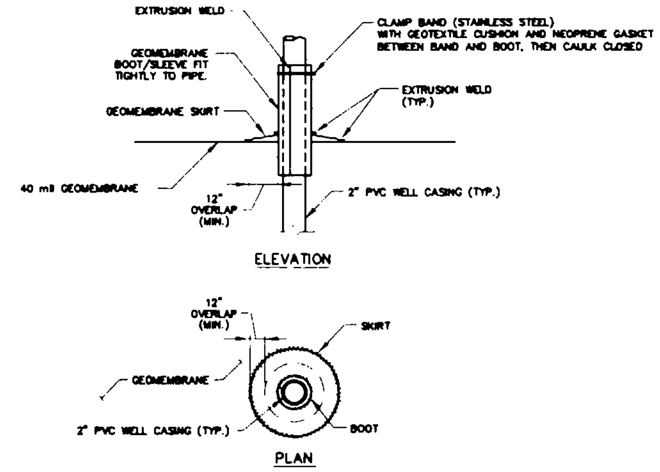
SHEET TITLE:
STORMWATER DETAILS
(SHEET 2 OF 2)

Golder Associates
Philadelphia USA

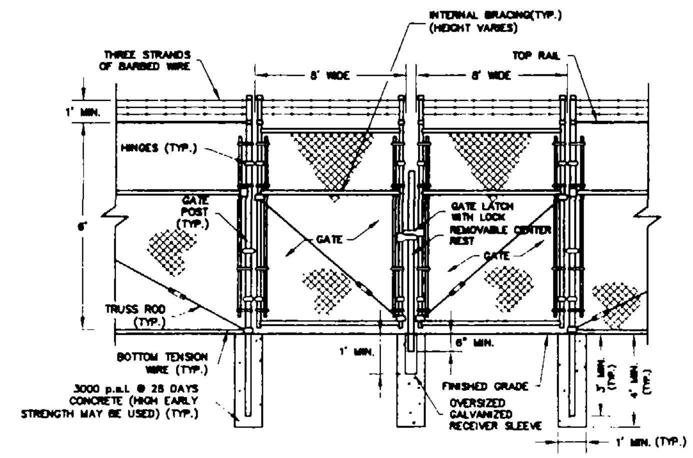
PROJECT No.	993-6573		FILE No. 1IN01-086
CLIENT PROJ. No.			DRAFTING SUBTITLE: 04
DES BY	VEF	08/01/00	SCALE: AS SHOWN
CAD BY	MJS	09/08/00	DRAWING 10
CHK BY	VEF	09/08/00	
RVW BY	DBW	09/08/00	



1/11 TYPICAL PIEZOMETERS
NOT TO SCALE
(SEE NOTES 1-7)



2/11 CAP VERTICAL PENETRATION
NOT TO SCALE
(SEE NOTE 8)



3/11 CHAIN LINK FENCE
NOT TO SCALE

NOTES

1.) DEPTHS OF PIEZOMETERS SHALL BE DETERMINED IN THE FIELD. ELEVATIONS OF THE TOPS OF PROTECTIVE CASINGS SHALL BE DETERMINED IN THE FIELD DURING CONSTRUCTION

2.) PIEZOMETERS PZ-A(S), PZ-A(D), PZ-B(S) AND PZ-B(D) SHALL BE CONSTRUCTED WITHIN THE LIMITS OF WASTE CONSOLIDATION. PIEZOMETERS PZ-C AND PZ-D SHALL BE CONSTRUCTED OUTSIDE THE LIMITS OF WASTE CONSOLIDATION.

3.) PIEZOMETERS PZ-A(S) AND PZ-B(S) SHALL BE CONSTRUCTED AS FILL PIEZOMETERS.

4.) PIEZOMETERS PZ-A(D) AND PZ-B(D) SHALL BE CONSTRUCTED AS BEDROCK PIEZOMETERS.

5.) PIEZOMETERS PZ-C AND PZ-D SHALL BE SCREENED THROUGH THE DEPTH OF PEA GRAVEL WHICH WAS PLACED ABOVE BEDROCK DURING WASTE EXCAVATION AND CONSOLIDATION ACTIVITIES.

6.) FILTER PACK MATERIAL SHALL BE PEA GRAVEL WITH NO MORE THAN 5% PASSING NO. 16 SIEVE OR EQUIVALENT APPROVED BY THE ENGINEER.

7.) BOREHOLE AND RISER DIAMETERS MAY BE INCREASED DURING CONSTRUCTION FOR PZ-C AND PZ-D IF THESE PIEZOMETERS ARE TO BE COMPLETED AS RECOVERY WELLS.

8.) CAP PENETRATION FOR THE UTILITY POLE LOCATED AT (1429904N, 3100803E) WILL BE CONSTRUCTED AS SHOWN ON DETAIL 2, DRAWING 11.

REV	DATE	DESCRIPTION	CAD BY	CHK BY	RVW BY
1	10/18/00	REVISED PIEZOMETER DETAIL AND NOTES	MJS		

PROJECT:
CBS
LEMON LANE LANDFILL FINAL DESIGN
BLOOMINGTON, INDIANA

SHEET TITLE:
MISCELLANEOUS DETAILS

Golder Associates
Philadelphia USA

PROJECT No.	993-6573		FILE No. 1IN01-087
CLIENT PROJ. No.			DRAFTING SUBTITLE 04
DES BY	VEF	08/01/00	SCALE: AS SHOWN
CAD BY	MJS	09/08/00	DRAWING 11
CHK BY	DBW	09/08/00	
RVW BY	RES	09/08/00	