SKYLINE LANDFILL

ATTACHMENT C1

APPENDIX C1-F

INTERMEDIATE COVER
EROSION AND SEDIMENTATION CONTROL PLAN

STATE OF TEXAS
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REGISTERED PROFESSIONAL ENGINEER

4/12/2012

Includes pages C1-F-1 through C1-F-10

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NARRATIVE

This appendix presents temporary erosion and sediment control structures for the intermediate cover phase of landfill development. Temporary means the time between the construction of intermediate cover and the construction of final cover or the placement of additional waste, as the case may be. Intermediate topslope surfaces and external sideslopes, for the purposes of compliance with 30 TAC §330.305(d), are:

a) those above grade slopes that directly drain to the site perimeter stormwater management system (i.e., areas where the stormwater directly flows to a perimeter channel or detention pond)

b) those that have received intermediate or final cover

c) those that have either reached their permitted elevation, or will subsequently remain inactive for longer than 180 days

Slopes that drain to ongoing waste placement, pre-excavated areas, areas that have received only daily cover, or areas under construction that have not received waste are not covered under this appendix.

EXISTING CONDITIONS SUMMARY

Drawing C1-F-1 – Intermediate Cover Erosion Control Features shows the areas where final cover has been constructed. The remaining areas in Phases 1A and 1B have received daily or intermediate cover. Phase 2 is currently being developed. No development has occurred in Phase 3.

Fill operations are ongoing in Phases 1A, 1B, and 2. Areas where fill operations are currently ongoing will receive daily cover. Areas that have been inactive longer than 180 days have received intermediate cover. Temporary erosion control measures may need to be installed on existing intermediate cover areas to control erosion and minimize soil loss if these areas have less than 60 percent vegetative cover. Intermediate cover areas that have existing well established vegetation (at least 60 percent coverage) will not be disturbed to construct temporary erosion control features.

Areas that reach their permitted elevation or plan to remain inactive for longer than 180 days will receive intermediate cover. As areas receive intermediate cover, temporary erosion control measures will be constructed. Temporary erosion and sediment control features will be placed within 180 days from construction of intermediate cover. All intermediate cover areas will be managed to control erosion and achieve predicted soil loss of less than 50 tons per acre per year. Temporary and permanent drainage structures will be constructed as the landfill develops intermediate and final cover slopes.

Stormwater runoff from the external slopes of Phase 1A flows into the east perimeter channel to Pond T. Stormwater runoff from the internal slopes of Phase 1A flows to a temporary channel into Pond K. As the external slopes of Phases 1B and 2 are developed, stormwater runoff will flow into Pond T or the west perimeter channel. Stormwater runoff from the internal slopes of Phases 1B and 2 flows to Pond K. All stormwater from constructed slopes is routed through various temporary and permanent drainage features before being discharged into Ten Mile Creek. These structures provide erosion and sediment control.

The Skyline Landfill has an active stormwater pollution prevention plan (SWPPP), Permit No. TXR05M408, prepared consistent with the TPDES general permit. The SWPPP is up to date and maintained in the Site Operating Record. The SWPPP provides detailed Best Management Practices (BMPs) including training and implementation strategies to reduce the potential of pollutants in stormwater discharge. The plan also includes detailed stormwater and erosion control measures for current landfill construction activities.

EROSION AND SEDIMENT CONTROL LANDFILL COVER PHASES

The purpose of this section is to define the landfill cover phases and where they are addressed throughout the Skyline Landfill permit:

Daily Cover – Daily cover is defined in §330.165(a). Daily cover consists of 6 inches of well compacted earthen material not previously mixed with garbage, rubbish, or other solid waste applied at the end of each operating day. The placement and erosion control practices for daily cover areas are defined in Part IV – Site Operating Plan and in the Best Management Practices Section of this appendix.

Intermediate Cover – Intermediate cover is defined in §330.165(c). Intermediate cover consists of at least 12 inches of suitable earthen material and is graded and maintained to prevent erosion and ponding of water. The placement requirements and erosion control practices for intermediate cover areas are defined in this appendix.

Final Cover – Final cover is defined in Subchapter K. The placement and erosion control practices for final cover areas are defined in Attachment C1, Appendix C1-E. Final cover at the Skyline Landfill will be managed as provided for in the closure and postclosure plan required by 30 TAC 330 Subchapter K, Closure and Post-Closure.

BEST MANAGEMENT PRACTICES

Vegetation and temporary erosion control structures provide the most effective means to reduce the amount of soil loss during operation of the landfill. Best management practices utilized for erosion and sediment control may be broadly categorized as nonstructural and structural controls. Nonstructural controls addressing erosion include the following:

- Minimization of the disruption of the natural features, drainage, topography, or vegetative cover features
- Phased development to minimize the area of bare soil exposed at any given time
- Plans to disturb only the smallest area necessary to perform current activities
- Plans to confine sediment to the construction area during the construction phase
- Scheduling of construction activities during the time of year with the least erosion potential, when applicable
- Specific plans for the stabilization of exposed surfaces in a timely manner

Structural controls are preventative and also mitigative since they control erosion and sediment movement. Structural controls addressing erosion include the following:

- Vegetative and Non-Vegetative Stabilization. A soil stabilization and vegetation schedule is provided in this appendix.
- Check Dams. Check dams may be constructed using gravel, rock, gabions, compost socks, or sand bags to reduce flow velocity and therefore erosion in a perimeter channel or detention pond.
- Filter Berms. Filter berms may be constructed of mulch, woodchips, brush, compost, shredded woodwaste, or synthetic filter materials. Mesh socks may be filled with compost, mulch, woodchips, brush, or shredded woodwaste. Filter berms or filled mesh socks may be installed at the bottom of slopes, throughout the perimeter drainage system, and on sideslopes. The maximum drainage area to the filter berm or filled mesh sock will not exceed 2 acres. Specifications for the filter berms are provided on Drawing C1-F-3, Detail TD11.
- Baled Hay. Hay bales, straw bales, or baled hay shall be approximately 30 inches in length and be composed entirely of vegetable matter. Hay bales shall be embedded in the soil a minimum of 4 inches and where possible one-half the height of the hay bale.
- Sediment Traps. Sediment traps are small excavated areas that function as a sediment basin. Sediment traps allow for the settling of suspended sediment in stormwater runoff. Sediment traps may be constructed in perimeter channels, temporary internal channels, and at entrances to detention ponds. The maximum drainage area contributing to a sediment trap will not exceed 10 acres.

- Temporary Sediment Control Fence or Silt Fence. Silt fences or fabric filter fences may be used where there is sheet flow. The maximum drainage area to the silt fence will not exceed the manufacturer's specification, but in no case be greater than 0.5 acre per 100 feet of fence. To ensure sheet flow, a gravel collar or level spreader may be used upslope of the silt fence.

- Swales. These structures will be constructed of a material with the top 6 inches capable of sustaining native plant growth. Rolled erosion control mats or blankets made from natural materials or synthetic fiber, grass, or compost/mulch/straw may be used as erosion protection along the flowline. These structures direct the flow to the drainage system. These structures decrease downslope velocities of runoff that could cause erosion on the intermediate cover slopes.

- Letdown Chutes. Letdown chutes are bermed conveyance structures constructed on the intermediate cover slopes. Flow will be directed to the letdown chutes via swales, then conveyed to the perimeter drainage system. The letdown chutes will be lined with an FML geomembrane, turf reinforcement mats, riprap, concrete, gabions, crushed concrete, or stone.

Erosion will be controlled by vegetation on topslopes, sideslopes, and in drainage conveyance structures with flow velocities less than or equal to 5 fps. For drainage conveyance structures with flow velocities greater than 5 fps, turf reinforcement, rock riprap, concrete, gabions, or other appropriate materials will be used for surface reinforcement.

Intermediate cover erosion and sediment control structures are shown on Drawings C1-F-1 through C1-F-4. During site development, both structural and non-structural BMPs will be employed to control erosion.

The potential for wind erosion of the intermediate cover surface will be mitigated through the placement of temporary intermediate cover erosion control measures and establishment of vegetative cover. Temporary erosion control measures include surface roughening, surface wetting, application of tackifiers, or hydromulching the intermediate cover surface.

SOIL STABILIZATION AND VEGETATION SCHEDULE

The soil stabilization and vegetation schedule is as follows:

- Areas that will remain inactive for periods greater than 180 days will receive intermediate cover.

- Intermediate cover on slopes will be stabilized by tracking into the slope. Soil stabilization can be enhanced by mulching, the addition of soil tackifiers, soil treatment, or any combination of these measures. The intermediate cover will be graded to provide positive drainage.

- Temporary erosion control structures will be installed within 180 days from when intermediate cover is constructed.

- The intermediate cover area will be seeded or sodded as soon as practical, following placement of intermediate cover and will be documented in the site operating record. All intermediate cover areas will be managed to control erosion and achieve a predicted soil loss of less than 50 tons per acre per year. A 60 percent vegetative cover will be established over the intermediate cover areas within 180 days from intermediate cover construction unless prevented by climatic events (e.g., drought, rainfall, etc.). Additional temporary erosion control measures will be implemented during these events to facilitate the establishment of vegetative cover.

- Mulch, woodchips, or compost may be used as a layer placed over the intermediate cover to protect the exposed soil surface from erosive forces and conserve soil moisture until vegetation can be established. The mulch, woodchips, or compost will be used to stabilize recently graded or seeded areas. The mulch, woodchips, or compost will be spread evenly over a recently seeded area and tracked into the surface to protect the soil from erosion and moisture loss, if required to promote the establishment of vegetation. These materials are not required for the establishment of vegetation on the intermediate cover; however, they may be used if the Skyline Landfill determines they are needed to promote vegetative growth or to provide additional erosional stability to the intermediate cover surface. These materials will vary in thickness but will not be placed to a thickness to inhibit vegetative growth.

- The intermediate cover and temporary erosion control structures will be maintained as detailed in the Stormwater System Maintenance Plan.

- Final cover will be constructed as the site develops. Temporary erosion control features will be removed as permanent erosion control structures are constructed.

STORMWATER SYSTEM MAINTENANCE PLAN

The Skyline Landfill will restore and repair temporary stormwater systems such as channels, drainage swales, chutes, and flood control structures in the event of wash-out or failure. In addition, the BMPs discussed in this appendix will also be replaced or repaired in the event of failure. Excessive sediment will be removed, as needed, so that the drainage structures function as designed. Site inspections by landfill personnel will be performed weekly or within 48 hours of a rainfall event of 0.5 inches or more.

The following items will be evaluated during the inspections:

- Erosion of intermediate cover areas, perimeter ditches, temporary chutes, swales, detention ponds, berms, and other drainage features

- Settlement of intermediate cover areas, final cover areas, perimeter ditches, chutes, swales, and other drainage features

- Silt and sediment build-up in perimeter ditches, chutes, swales, and detention ponds

- Presence of ponded water on intermediate cover or behind temporary erosion control structures

- Obstructions in drainage features

- Presence of erosion or sediment discharge at offsite stormwater discharge locations

- Temporary erosion and sediment control features

Maintenance activities will be performed to correct damaged or deficient items noted during the site inspections. These activities will be performed as soon as possible after the inspection. The time frame for correction of damaged or deficient items will vary based on weather, ground conditions, and other site-specific conditions.

Maintenance activities will consist of the following, as needed:

- Placement of additional temporary or permanent vegetation

- Placement, grading, and stabilization of additional soils in eroded areas or in areas which have settled

- Replacement of riprap or other structural lining

- Removal of obstructions from drainage features

- Removal of silt and sediment build-up from the temporary erosion control structures

- Removal of ponded water on the intermediate cover or behind temporary erosion control structures

- Repairs to erosion and sedimentation controls

- Installation of additional erosion and sedimentation controls

Documentation and training requirements are discussed below:

- Site inspections by landfill personnel will be performed weekly or within 48 hours of a rainfall event of 0.5 inches or more.

- Documentation of the inspection will be included in the site operating record.

- Documentation of maintenance activities that were performed to correct damaged or deficient items noted during the site inspections will be included in the site operating record.

- Landfill personnel will be trained to perform inspections, install and maintain temporary erosion control structures.

BENCH AND BERM/SWALE SPACING

SLOPE (%)	MAXIMUM SURFACE FLOW LENGTH (FT)	MAXIMUM DRAINAGE AREA (ACRES)
6	550	21.8
25	250	6.8

LEGEND

- PERMIT BOUNDARY
- LANDFILL FOOTPRINT
- EXISTING GROUND CONTOUR (550)
- STATE PLANE GRID (NAD 27) (N 323000)
- PROPOSED CONTOUR (600)
- PHASE BOUNDARY

NOTE:

1. EXISTING CONTOURS COMPILED BY AEROMETRIC FROM AERIAL PHOTOGRAPHY. FLOWN MARCH 6, 2011. COORDINATE SYSTEM IS BASED ON TEXAS STATE PLANE NAD 27, TEXAS NORTH CENTRAL ZONE, US FEET.
2. THIS PLAN IS FOR GENERAL CONDITIONS AND MAY NOT REFLECT THE EXACT CONFIGURATION OF THE LANDFILL. THE ACTUAL SIZE OF THE INCREMENTS FOR EXCAVATION, LINING, OR FINAL COVER MAY VARY WITH SITE OPERATIONS.
3. THE LANDFILL ACCESS AND HAUL ROADS WILL BE SURFACED TO PROVIDE ALL WEATHER ACCESS. ROAD LOCATIONS TO BE DETERMINED DURING SITE OPERATIONS AND LOCATIONS WILL VARY.
4. THE STORMWATER RUN-OFF CONTROL SYSTEM WILL CONSIST OF THE PERIMETER DRAINAGE CHANNEL, AND STORMWATER DETENTION PONDS.
5. REFER TO PART III, ATTACHMENT C-DRAINAGE DESIGN REPORT FOR STORMWATER SYSTEMS AND EROSION AND SEDIMENT CONTROL PLAN. REFER TO PART III, ATTACHMENT D6-LEACHATE AND CONTAMINATED WATER MANAGEMENT PLAN FOR CONTAINMENT AND DIVERSION BERM CALCULATIONS.
6. UNCONTAMINATED STORMWATER COLLECTED IN SUMPS WILL BE PERIODICALLY REMOVED FROM EXCAVATED AREAS BY PUMPING TO PERIMETER DRAINAGE CHANNELS OR USED IN SITE OPERATIONS (DUST CONTROL, IRRIGATIONS, ROAD AND LINER CONSTRUCTION).
7. PHASE 1 AND 2 DEVELOPMENT DEPICTS ONGOING WASTE DISPOSAL OPERATIONS IN PHASES 1 THROUGH 3 TO MAXIMUM WASTE FILL ELEVATION EQUAL TO TOP OF PERIMETER BERMS. EXCAVATION AND LINER CONSTRUCTION ONGOING IN PHASE 3.
8. WASTE FILL GENERALLY NORTH TO SOUTH IN DIRECTION.

C1-F-7

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INTERMEDIATE COVER EROSION FEATURES

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
MAJOR PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

REVISIONS

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

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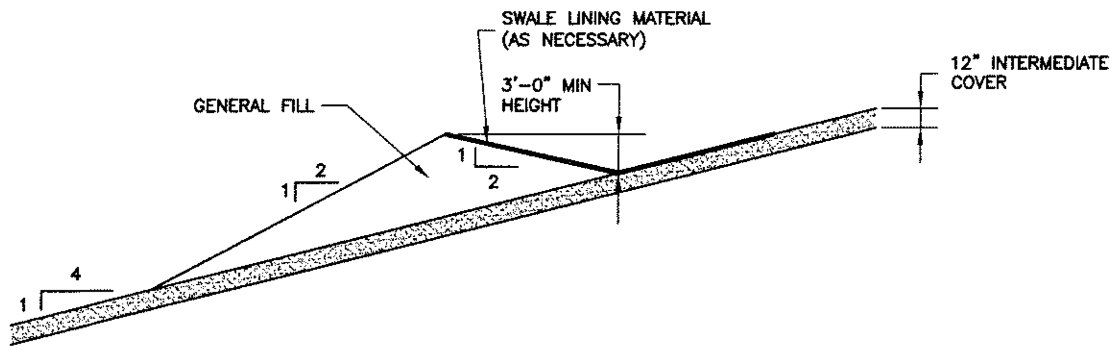

TEMPORARY SIDESLOPE SWALE (TD1 / C1-F-2)

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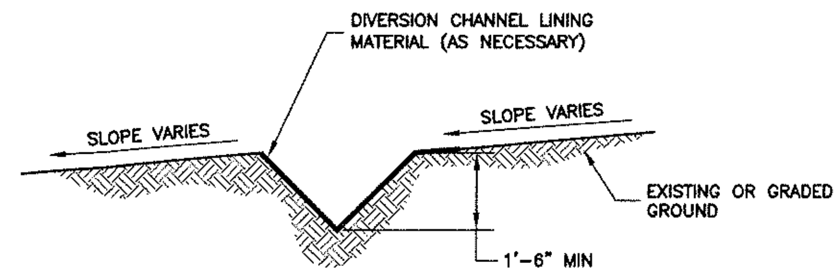

TEMPORARY DIVERSION CHANNEL (TD3 / C1-F-2)

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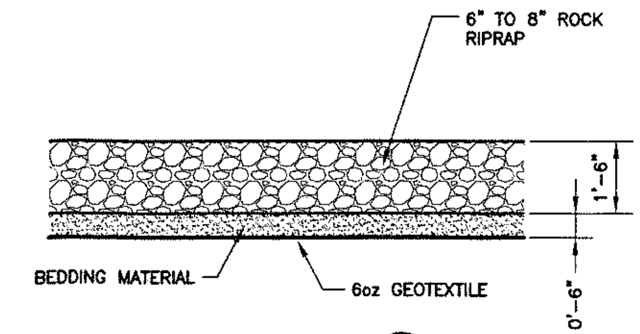

ROCK RIPRAP (TD5 / C1-F-2)

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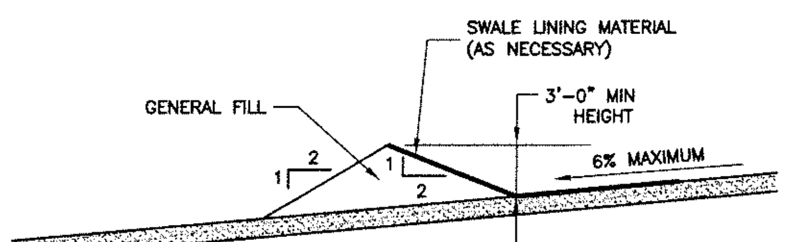

TEMPORARY TOPSLOPE SWALE (TD2 / C1-F-2)

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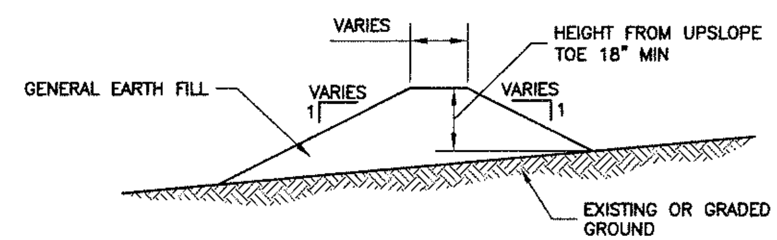

TEMPORARY DIVERSION BERM (TD4 / C1-F-2)

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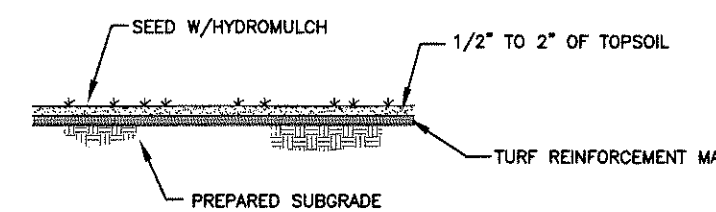

TEMPORARY TURF REINFORCEMENT MATTING (TD6 / C1-F-2)

NTS

NOTE:

1. LINING MATERIAL, IF NECESSARY, FOR THE TEMPORARY DRAINAGE SWALES OR THE TEMPORARY DIVERSION CHANNEL WILL BE TURF REINFORCEMENT MATTING OR OTHER SUITABLE MATERIALS.

TEMPORARY EROSION CONTROL STRUCTURES

1. TEMPORARY EROSION CONTROL STRUCTURE DETAILS DEPICT VARIOUS TYPES OF EROSION CONTROL FEATURES FOR CURRENT AND FUTURE DEVELOPMENT.
2. ALL TEMPORARY EROSION CONTROL STRUCTURES SHOWN MAY NOT BE CONSTRUCTED DEPENDING ON SITE CONDITIONS.
3. LANDFILL WILL SELECT EROSION CONTROL DETAILS TO BE USED FOR SITE SPECIFIC CONDITIONS.
4. ACTUAL DIMENSIONS OF TEMPORARY EROSION CONTROL STRUCTURES MAY VARY BASED ON SITE CONDITIONS.

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TEMPORARY EROSION CONTROL STRUCTURES

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
MAJOR PERMIT AMENDMENT

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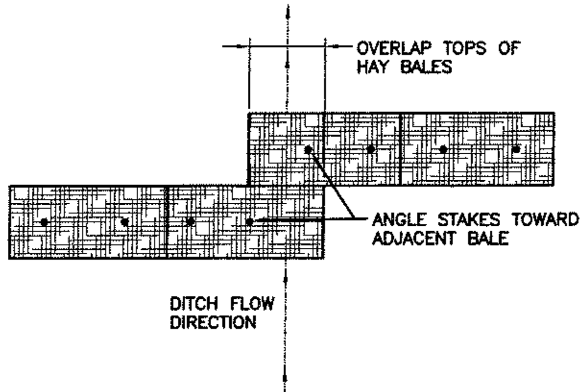
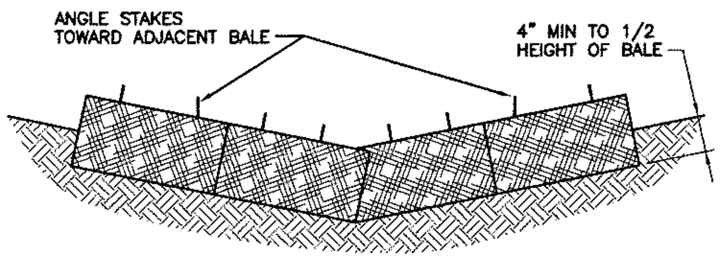


PLAN VIEW

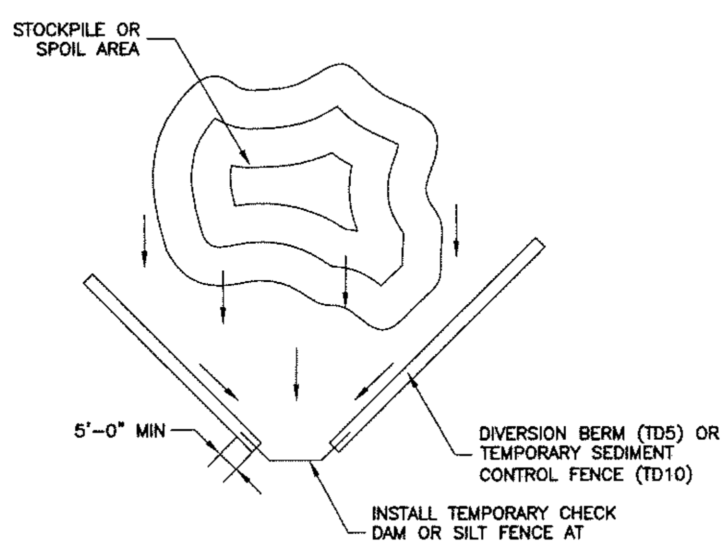


PROFILE VIEW

BALED HAY FOR EROSION CONTROL (TD7)

NTS C1-F-3

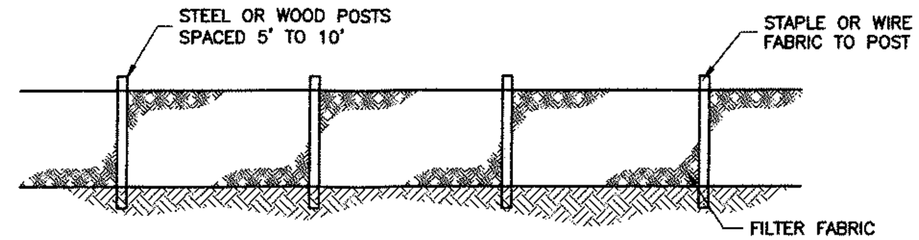
HAY BALE NOTE:
1. HAY BALES SHALL BE EMBEDDED IN THE SOIL A MINIMUM OF 4" AND WHERE POSSIBLE 1/2 THE HEIGHT OF THE BALE.



STOCKPILE EROSION CONTROL (TD8)

NTS C1-F-3

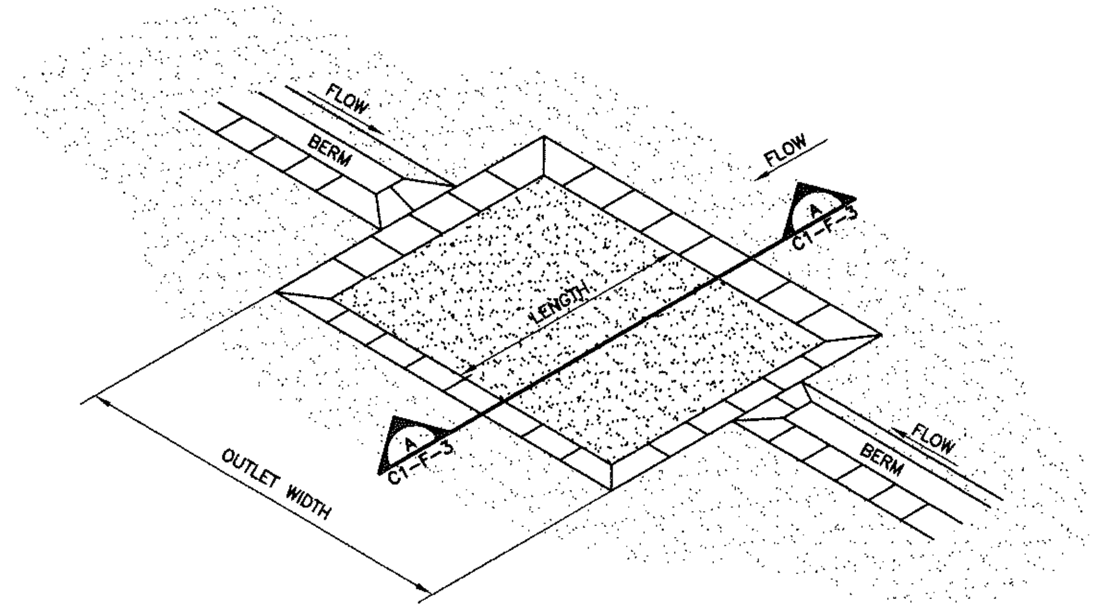
NOTE:
1. CONSTRUCT DIVERSION DIKE TO DIVERT STORMWATER RUN-OFF FROM STOCKPILE OR SPOIL AREA THROUGH CHECK DAM, HAY BALES, OR SILT FENCE.



TEMPORARY SEDIMENT CONTROL (SILT) FENCE (TD9)

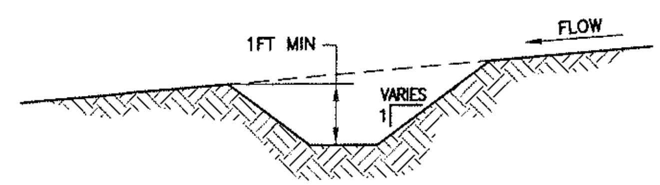
NTS C1-F-3

SILT FENCE NOTES:
1. MAXIMUM DRAINAGE AREA TO THE FENCE SHOULD NOT EXCEED THE MANUFACTURER'S SPECIFICATION BUT IN NO CASE BE GREATER THAN 0.5 ACRE PER 100 FEET OF FENCE.
2. TO ENSURE SHEET FLOW, A GRAVEL COLLAR OR LEVEL SPREADER MAY BE USED UPSLOPE OF THE SILT FENCE.



SEDIMENT TRAP PLAN

NTS



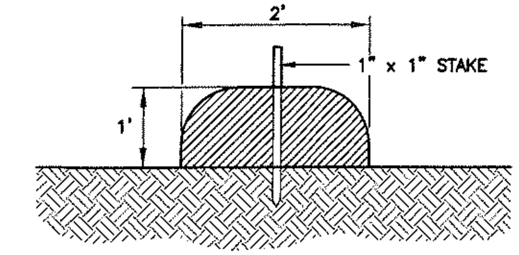
SEDIMENT TRAP SECTION (A-A)

NTS C1-F-3

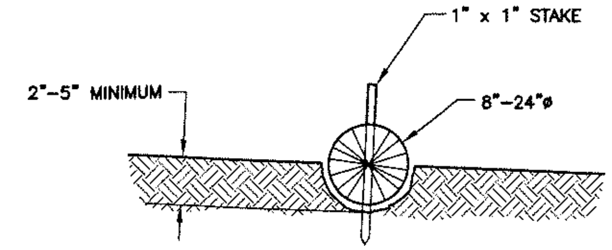
SEDIMENT TRAP (TD10)

NTS C1-F-3

NOTE:
1. OUTLET INTO STABILIZED AREA (VEGETATION, ROCK, ETC.)
2. THE MAXIMUM AREA CONTRIBUTING TO A SEDIMENT TRAP SHOULD BE LESS THAN 10 ACRES.



OPTION 1



OPTION 2

FILTER BERM (TD11)

NTS C1-F-3

FILTER BERM NOTES:
1. FILTER BERMS MAY BE CONSTRUCTED OF MULCH, WOODCHIPS, BRUSH, COMPOST, SHREDDED WOODWASTE, OR SIMILAR MATERIALS.
2. FILTER BERMS MAY ALSO CONSIST OF MESH SOCKS FILLED WITH MULCH, WOOHCHIPS, BRUSH, COMPOST, SHREDDED WOODWASTE, OR SIMILAR MATERIALS.
3. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND THE COMPOST FILTER BERM.
4. STAKES WILL BE PLACED 2-5" DEEP.
5. MAXIMUM DRAINAGE AREA TO THE FILTER BERM SHOULD NOT EXCEED 2 ACRES.

TEMPORARY EROSION CONTROL STRUCTURES

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2. ALL TEMPORARY EROSION CONTROL STRUCTURES SHOWN MAY NOT BE CONSTRUCTED DEPENDING ON SITE CONDITIONS.
3. LANDFILL WILL SELECT EROSION CONTROL DETAILS TO BE USED FOR SITE SPECIFIC CONDITIONS.
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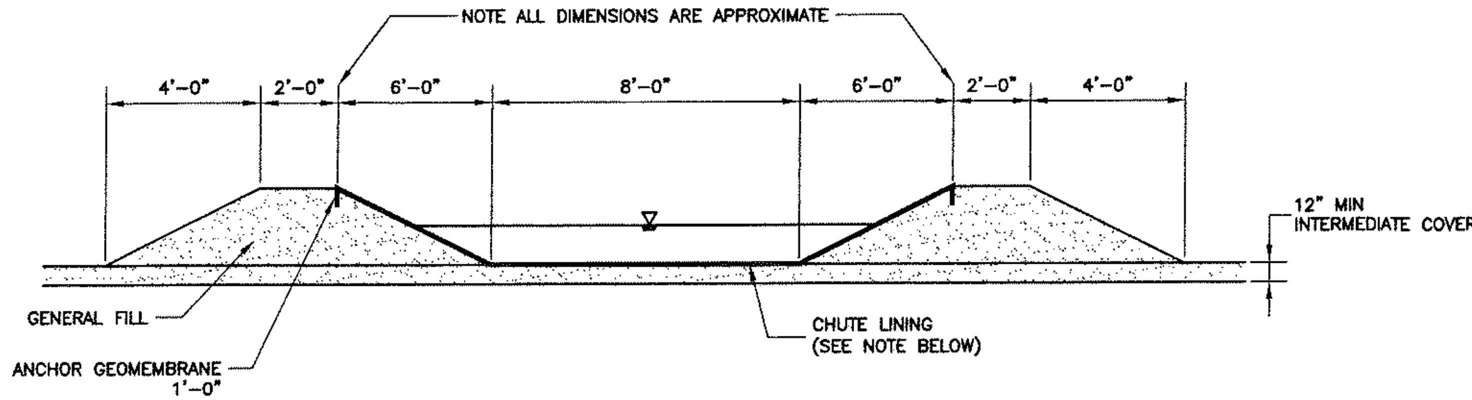
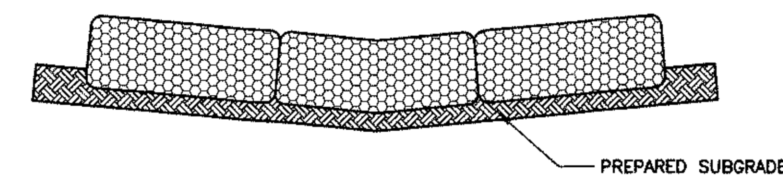


TEMPORARY CHUTE LETDOWN (TD12 / C1-F-4)

NTS

NOTE: CHUTE LINING WILL CONSIST OF ONE OF THE FOLLOWING: TURF REINFORCEMENT, SACRIFICIAL GEOMEMBRANE, GABIONS, ROCK RIPRAP, CONCRETE, CRUSHED CONCRETE, OR STONE.

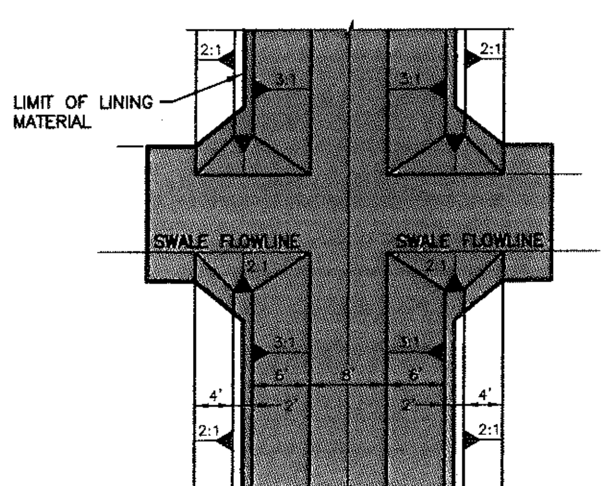


CHECK DAM (TD14 / C1-F-4)

NTS

CHECK DAM NOTES:

1. MAY BE CONSTRUCTED USING GRAVEL, ROCK, GABIONS, COMPOST SOCKS, OR SAND BAGS.
2. PLACED ON PREPARED SUBGRADE OR BEDDING MATERIAL ALONG THE CONTOUR AT 0% GRADE OR AS NEAR AS POSSIBLE.
3. TOP WIDTH OF TWO FEET MINIMUM.
4. SIDESLOPES 2H:1V OR FLATTER.
5. MAY BE USED WHEN CONTRIBUTING DRAINAGE AREAS ARE LESS THAN 10 ACRES. MULTIPLE CHECK DAMS MAY BE INSTALLED IF DRAINAGE AREAS ARE GREATER THAN 10 ACRES.
6. CHECK DAMS SHOULD BE USED WHEN THE VOLUME OF RUNOFF IS TOO GREAT FOR OTHER EROSION CONTROL FEATURES (i.e. SILT FENCES, HAY BALES).



SWALE/CHUTE CONFLUENCE (TD13 / C1-F-4)

NTS

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TEMPORARY EROSION CONTROL STRUCTURES

1. TEMPORARY EROSION CONTROL STRUCTURE DETAILS DEPICT VARIOUS TYPES OF EROSION CONTROL FEATURES FOR CURRENT AND FUTURE DEVELOPMENT.
2. ALL TEMPORARY EROSION CONTROL STRUCTURES SHOWN MAY NOT BE CONSTRUCTED DEPENDING ON SITE CONDITIONS.
3. LANDFILL WILL SELECT EROSION CONTROL DETAILS TO BE USED FOR SITE SPECIFIC CONDITIONS.
4. ACTUAL DIMENSIONS OF TEMPORARY EROSION CONTROL STRUCTURES MAY VARY BASED ON SITE CONDITIONS.

STATE OF TEXAS
KENNETH J. WELCH
60773
REGISTERED PROFESSIONAL ENGINEER
4/12/2012

ISSUED FOR PERMITTING PURPOSES

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

C1-F-10

TEMPORARY EROSION CONTROL STRUCTURES

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
MAJOR PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD
DALLAS • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 — TBPG FIRM NO. 50222

DSN. FAW	DATE : 04/12	ATTACHMENT
DWN. BBB	SCALE : GRAPHIC	C1-F-4
CHK. KJW	DWG : C1_F_2-4.dwg	

SKYLINE LANDFILL

ATTACHMENT C1

APPENDIX C1-G

INTERMEDIATE COVER
EROSION CONTROL STRUCTURE DESIGN

STATE OF TEXAS
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REGISTERED
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4/12/2012

Includes pages C1-G-1 through C1-G-27

CONTENTS

STATE OF TEXAS
KENNETH J. WELCH
60773
REGISTERED
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4/12/2012

NARRATIVE

This appendix presents the supporting documentation to evaluate and design temporary erosion and sediment control structures for the intermediate cover phase of landfill development.

INTERMEDIATE COVER PLAN

As intermediate cover is constructed, temporary chutes and swales will be constructed to prevent erosion and sedimentation. Erosion control features (i.e., filter berms, rock check dams, hay bales, or equivalent) may be constructed at the toe of filled areas to minimize erosion and prevent disturbance of the existing grassed slopes. Otherwise, temporary erosion and sediment control features will be installed within 180 days from when the intermediate cover is constructed. An existing conditions summary and Best Management Practices are included in Appendix C1-F. Example intermediate cover drainage calculations are included in this appendix for use in site operations.

INTERMEDIATE COVER EVALUATION

The intermediate cover evaluation is based on the Universal Soil Loss Equation (USLE) following Soil Conservation Service (SCS) procedures. The evaluation is based on a 12-inch thick intermediate cover layer with 60 percent vegetated cover. Calculations for the soil loss for intermediate cover on external 6 percent and 25 percent slopes have been provided on pages C1-G-6 through C1-G-7.

SHEET FLOW DESIGN

The sheet flow calculations are presented for external 6 percent and 25 percent slope configurations. The permissible non-erodible velocities should be less than 5 ft/sec (clayey soil) or 4 ft/sec (sandy soil) on vegetated intermediate cover. The Manning's Equation and Rational Method were used to calculate sheet flow velocity.

TEMPORARY DRAINAGE SWALE DESIGN

The temporary drainage swales are designed for typical drainage areas and flowline slopes. The procedures in the TxDOT Hydraulic Design Manual, October 2011, were used to determine peak flow, flow depth, flow velocity, and swale capacity. The Rational Method and the Manning's Equation were used to calculate the design parameters.

TEMPORARY DIVERSION CHANNEL DESIGN

The temporary diversion channels are designed for typical drainage areas and flowline slopes. The procedures in the TxDOT Hydraulic Design Manual, October 2011, were used to determine peak flow, flow depth, flow velocity, and diversion channel capacity. The Rational Method and the Manning's Equation were used to calculate the design parameters.

TEMPORARY DRAINAGE LETDOWN DESIGN

The temporary drainage letdowns are designed for typical drainage areas on a 25 percent external side slope. The procedures in the TxDOT Hydraulic Design Manual, October 2011, were used to determine peak flow, flow depth, flow velocity, and letdown capacity. The Rational Method and the Manning's Equation were used to calculate the design parameters.

INTERMEDIATE COVER EVALUATION

INTERMEDIATE COVER EVALUATION

SOIL LOSS

This section presents the supporting documentation for evaluation of the potential for intermediate cover soil erosion loss at the Skyline Landfill. The evaluation is based on the premise of adding excess soil to increase the time required before maintenance is needed as recommended in the EPA Solid Waste Disposal Facility Criteria Technical Manual (EPA 530-R-93-017, November 1993).

The design procedure is as follows:

1. Minimum thickness of the intermediate cover is evaluated based on the maximum soil loss of 50 tons per acre per year.

	6% slope	**25% slope**
Maximum Sheet Flow Length	550 ft	250 ft
Soil Loss	2.36 tons/acre/year	25.10 tons/acre/year

2. Soil loss is calculated using the Universal Soil Loss Equation (USLE) by following SCS procedures. The soil loss is based on 60 percent vegetative cover as recommended in the TNRCC, "Use of the Universal Soil Loss Equation in Final Cover/Configuration Design Procedural Handbook" (October 1993). These calculations are provided on pages C1-G-6 and C1-G-7.

3. Sheet flow velocities for a 25-year storm event are calculated to be less than permissible non-erodible velocities. The supporting calculations are presented on page C1-G-13.

4. Temporary vegetation for the intermediate cover areas will be native and introduced grasses with root depths of 6 inches to 8 inches.

5. Native and introduced grasses will be hydroseeded, drill seeded, or broadcast seeded with fertilizer on the disked (parallel to contours) intermediate cover layer as soon as practical following placement of intermediate cover and will be documented in the site operating record. All intermediate cover areas will be managed to control erosion and achieve a predicted soil loss of less than 50 tons per acre per year. Temporary erosion and sediment control features (including at least 60 percent vegetative cover) will be installed within 180 days from when the intermediate cover is constructed. Areas that experience erosion or do not readily vegetate will be reseeded until vegetation is established or the soil will be replaced with soil that will support the grasses.

SOIL LOSS FOR EXISTING INTERMEDIATE COVER AREAS

This section presents the supporting documentation for evaluation of the potential for intermediate cover soil erosion loss on the existing intermediate cover slopes at the Skyline Landfill. These areas have existing well established vegetation (at least 60 percent coverage), and will not be disturbed to construct temporary erosion control features.

	6% slope	25% slope
Maximum Sheet Flow Length	550 ft	250 ft
Soil Loss	2.36 tons/acre/year	25.10 tons/acre/year

SHEET FLOW VELOCITY

The sheet flow velocity calculations are presented for external 6 percent and 25 percent slope configurations. The procedures outlined in the TxDOT Hydraulic Manual were used to determine velocities. Maximum sheet flow lengths for all three conditions were evaluated. Calculations are provided on page C1-G-13.

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Intermediate Cover Erosion Loss Evaluation

Required: 1. Determine the erosion loss for the intermediate cover design based on a maximum soil loss of 50 tons/acre/year.

Method: Expected soil loss is calculated using the Universal Soil Loss Equation.

References: 1. TNRCC, *Use of the Universal Soil Loss Equation in Final Cover/Configuration Design Procedural Handbook,* October 1993.

Solution: Annual Soil Loss in tons/acre/year (A) = RKLSCP

Design Parameters	External Top Slope (6%)	External Side Slope (25%)	
Rainfall Factor (R) =	310	310	Dallas/Ellis Counties[1]
Soil Erodibility Factor (K) =	0.23	0.23	(Clay)
Longest Run =	550	250	ft
Slope =	6	25	%
Topographic Factor (LS) =	1.58	9.31	
Crop Management Factor (C) =	0.042	0.042	(60% vegetative cover)
Erosion Control Practice Factor (P) =	0.50	0.90	
Soil Loss (A) =	2.36	25.10	tons/acre/year

Summary: As noted in the permit drawings, the intermediate cover will be a minimum of 12 inches thick. As shown above, the maximum soil loss is 25.10 tons/acre/year, which is less than the maximum allowable soil loss of 50 tons/acre/year.

Note: [1]The Dallas/Ellis county line crosses the landfill footprint.

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Intermediate Cover LS Factor Calculations

Required: 1. Determine the Length/Slope Factor based on slope length and slope gradient.

References: 1. TNRCC, *Use of the Universal Soil Loss Equation in Final Cover/Configuration Design Procedural Handbook,* October 1993.

Solution: Length/Slope Factor (LS) = $(L / 72.6)^m * (65.41*\sin 2\upsilon + 4.56 * \sin \upsilon + 0.065)$

LS = Length/Slope Factor
L = Slope Length (ft)
υ = radians
m = exponent dependent on the slope gradient

m = 0.2 for S <= 1.0%
0.3 for 1.0% < S <= 3.5%
0.4 for 3.5% < S < 5.0%
0.5 for S => 5.0%

Length, L (ft)	Slope, S %	Slope, S (ft/ft)	υ (radians)	υ (degrees)	m	LS
550	6	16.67	0.060	3.434	0.5	1.58
250	25	4	0.245	14.036	0.5	9.31

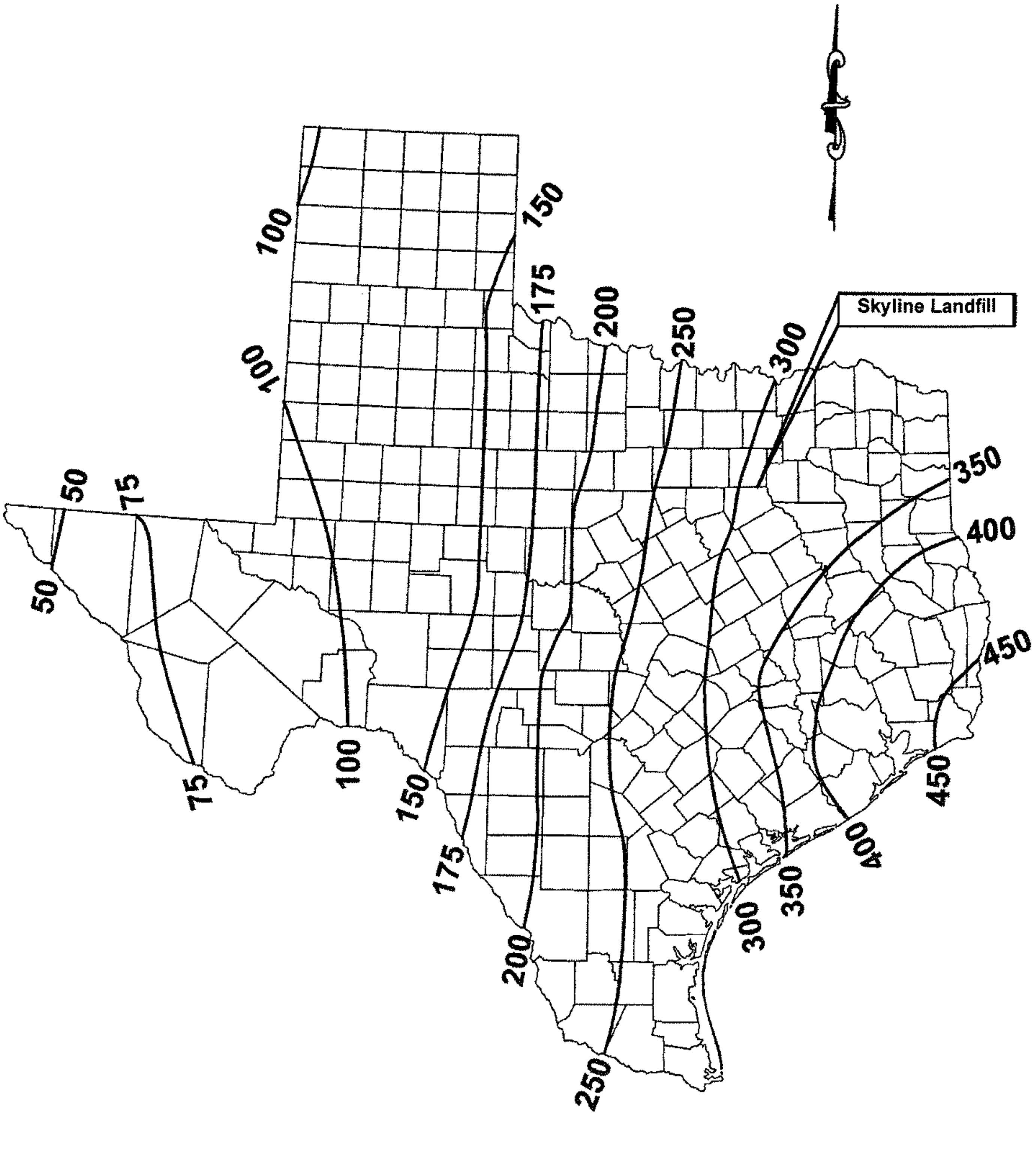


FIGURE 1 - AVERAGE ANNUAL VALUES OF THE RAINFALL EROSION INDEX

Table 1: Approximate Values of Factor K for USDA Textural Classes

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Texture Class	Organic Matter Content		
	<0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine Sand	0.16	0.14	0.10
Very Fine Sand	0.42	0.36	0.28
Loamy Sand	0.12	0.10	0.08
Loamy Fine Sand	0.24	0.20	0.16
Loamy Very Fine Sand	0.44	0.38	0.30
Sandy Loam	0.27	0.24	0.19
Fine Sandy Loam	0.35	0.30	0.24
Very Fine Sandy Loam	0.47	0.41	0.33
Loam	0.38	0.32	0.29
Silt Loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy Clay Loam	0.27	0.25	0.21
Clay Loam	0.28	0.25	0.21
Silty Clay Loam	0.37	0.32	0.26
Sandy Clay	0.14	0.13	0.12
Silty Clay	0.25	0.23	0.19
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.

Table 2: Factor C for Permanent Pasture, Range, and Idle Land[1]

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Vegetative Canopy		Cover that Contacts the Soil Surface					
Type and Height[2]	Percent Cover[3]	Percent Ground Cover					
		0	20	40	60	80	95+
No Appreciable Canopy		0.45	0.20	0.10	0.042	0.013	0.003
Tall weeds or short brush with average drop fall height of 20 in.	25	0.36	0.17	0.09	0.038	0.013	0.011
	50	0.26	0.13	0.07	0.035	0.012	0.003
	75	0.17	0.10	0.06	0.032	0.011	0.003

Extracted from: United States Department of Agriculture, AGRICULTURE HANDBOOK NUMBER 537

[1] The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 feet.

[3] Portions of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's eye view).

Table 3: P Factors for Contouring, Contour Stripcropping and Terracing

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Land Slope	P Values		
%	Contouring†	Contour Stripcropping	Terracing†
2.0 to 7	0.50	0.25	0.50
8.0 to 12	0.60	0.30	0.60
13.0 to 18	0.80	0.40	0.80
19.0 to 24	0.90	0.45	0.90

(This table appeared in SCS (5), p.9)

† Contouring and terracing columns are suitable for MSWLF cover. Contour stripcropping is not suitable for the type of vegetative cover normally practiced at municpal landfills.

Table 4: Guide for Assigning Soil Loss Tolerance Values (T) to Solid Having Different Rooting Depths

Rooting Depth	Soil Loss Tolerance Values Annual Soil Loss (Tons/Acre)	
Inches	Renewable Soil a/	Renewable Soil b/
0 - 10	1	1
10 - 20	2	1
20 - 40	3	2
40 - 60	4	3
60	5	4

(This table appeared in SCS (6), p.4)

a/ Soil with favorable substrata that can be renewed by tillage, fertilizer, organic matter, and other management practices. This column does not represent MSWLF final covers under normal conditions.

b/ Soil with unfavorable substrata such as rock or soft rock that cannot be renewed by economical means. Most of the MSWLF covers with constructed clay cap and/or flexible membrane should use this performance criteria.

SHEET FLOW

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Intermediate Cover Sheet Flow Velocity

Required: Determine the sheet flow velocity for the intermediate cover design and compare to the permissible non-erodible flow velocity.

Method:
1. Determine the 25-year peak flow rate using the Rational Method.
2. Calculate flow depth using Manning's Equation.
3. Calculate sheet flow velocity and compare to permissible non-erodible velocity.

References:
1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution:
1. Determine the 25-year peak flow rate (Q) using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.42	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	8.5 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(typical value for intermediate cover)
25-Year Peak Flow Rate (Q) =	CIA cfs	

	External Top Slope (6%)	External Side Slope (25%)		
Longest Run =	550	250	ft	(longest sheet flow distance to swale)
Width =	1	1	ft	(unit width of flow)
Area =	0.0126	0.0057	acre	
Q	0.075	0.034	cfs	

2. Calculate the flow depth using Manning's Equation.
   - Rearrange Manning's Equation for wide and shallow flow to calculate flow depth:

$$y = (Qn/1.49S^{0.5})^{0.6}$$

Manning's Roughness (n) =		0.03		(typical value for intermediate cover)
Slope =	0.06	0.25	ft/ft	
Depth (y) =	0.047	0.019	ft	

3. Calculate sheet flow velocity and compare to permissible non-erodible velocity.
   - A permissible non-erodible velocity of 5 ft/sec (clayey soil) or 4 ft/sec (sandy soil) is typical for vegetated intermediate covers. Refer to page C1-G-6 for soil loss calculations.

$$V = Q / (y * \text{width})$$

Sheet flow velocity	**1.59**	**1.78**	**ft/sec**

Summary: The permissible non-erodible velocity should be less than 5.0 ft/sec (clayey soil) or 4.0 ft/sec (sandy soil) on vegetated intermediate cover. Therefore, the expected sheet flow velocity is acceptable on the external intermediate cover slopes with 60% vegetative cover.

TEMPORARY DRAINAGE SWALE DESIGN

TEMPORARY DRAINAGE SWALE DESIGN

The temporary drainage swale design for intermediate cover areas is presented for the typical swale flowline of 0.5 percent. The procedures in the TxDOT Hydraulic Design Manual were used to determine peak flow, flow depth, flow velocity, and swale capacity. The temporary swales will be located on the intermediate cover to prevent erosion as follows:

Slope (%)	Maximum Sheet Flow Length (ft)	Maximum Drainage Area (acres)	Maximum Swale Length (ft)
6	550	21.8	1,725
25	250	6.8	1,184

All temporary swales shall be designed to minimize erosion and provide a maximum flow depth of 2 feet. The total height of the swales at the flowline is a minimum of 3 feet, as depicted in Appendix C1-F on page C1-F-2. As noted in the calculations, the velocities in the swales are less than permissible non-erodible velocities. If sustained erosion is observed, facility management will evaluate and construct additional temporary drainage swales. Example drainage swale calculations for a grassed intermediate cover are provided on pages C1-G-16 and C1-G-17.

TEMPORARY DIVERSION CHANNEL DESIGN

The temporary diversion channel design for diverting surface water runon around excavations is presented for three typical slopes of 0.5 percent, 1 percent and 2 percent and three typical drainage areas of 1, 5, and 10 acres. The procedures in the TxDOT Hydraulic Design Manual were used to determine peak flow, flow depth, flow velocity, and diversion channel capacity. Temporary diversion channels will be designed to minimize erosion and sedimentation.

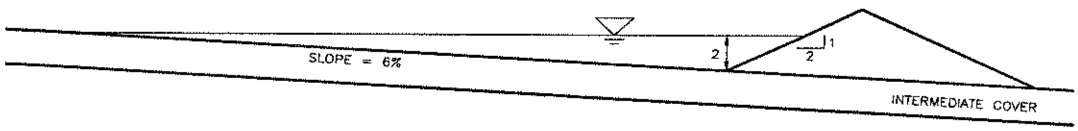
WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Drainage Swale Analysis - External Intermediate Cover Topslopes

Required: Determine the intermediate cover topslope drainage swale capacity.

Method:
1. Calculate the intermediate cover topslope swale's flow capacity using Manning's Equation.
2. Determine the maximum allowable topslope drainage area using the Rational Method.
3. Determine the maximum swale length based on the maximum sheet flow length.

References:
1. Texas Department of Transporation, *Hydraulic Design Manual*, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution:
1. Calculate flow capacity using Manning's Equation.
 - Swale Characteristics:



Max swale flow depth = 2.00 ft
Running swale slope = 0.5 %
Manning's Roughness = 0.03
Left slope = 16.67 :1
Right slope = 2 :1
Flow Area (A) = ((LS+RS)*D^2)/2
Wetted Perimeter (WP) = ((LS*D)^2+D^2)^(0.5) + ((RS*D)^2+D^2)^(0.5)
Hydraulic Radius (R) = A/WP

Flow Area (A) = 37.333
Wetted Perimeter (WP) = 37.865
Hydraulic Radius (R) = 0.986

- Use Manning's Equation to determine the flow velocity in the swale.
 Velocity (V) = 1.49*R^(2/3)*S^(1/2)/n
 Velocity (V) = 3.479 ft/sec

- Calculate the swale's flow capacity.
 Swale capacity (Q) = V * A
 Q = 129.9 cfs

2. Determine the maximum allowable drainage area using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.42	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	8.5 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(typical value for intermediate cover)
25-Year Peak Flow Rate (Q) =	CIA cfs	

Rearrange the Rational Formula to calculate allowable drainage area:
 Drainage Area = Q / (CI)

Maximum Swale Drainage Area = 21.8 acres

3. Determine the maximum swale length based on the maximum sheet flow length.

Maximum Sheet Flow Length = 550 ft

$$\text{Maximum Swale Length} = \frac{\text{Maximum Swale Drainage Area} * 43560}{\text{Maximum Sheet Flow Length}}$$

Maximum Swale Length = 1725 ft

Summary: The maximum sheet flow length will be 550 feet and maximum drainage area is 21.8 acres. The calculated velocity is less than the permissible non-erodible velocity.

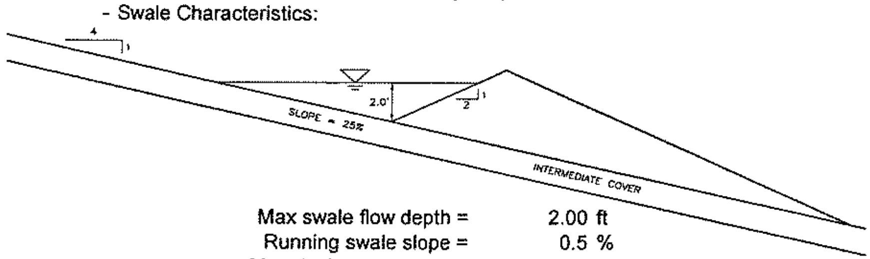
WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Drainage Swale Analysis - External Intermediate Cover Sideslopes

Required: Determine the intermediate cover sideslope drainage swale capacity.

Method:
1. Calculate the intermediate cover sideslope swale's flow capacity using Manning's Equation.
2. Determine the maximum allowable sideslope drainage area using the Rational Method.
3. Determine the maximum swale length based on the maximum sheet flow length.

References:
1. Texas Department of Transporation, *Hydraulic Design Manual*, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Maxima for Texas*, 2004.

Solution:
1. Calculate flow capacity using Manning's Equation.
 - Swale Characteristics:



Max swale flow depth = 2.00 ft
Running swale slope = 0.5 %
Manning's Roughness = 0.03
Left slope = 4.00 :1
Right slope = 2 :1
Flow Area (A) = ((LS+RS)*D^2)/2
Wetted Perimeter (WP) = ((LS*D)^2+D^2)^(0.5) + ((RS*D)^2+D^2)^(0.5)
Hydraulic Radius (R) = A/WP

Flow Area (A) = 12.000
Wetted Perimeter (WP) = 12.718
Hydraulic Radius (R) = 0.944

- Use Manning's Equation to determine the flow velocity in the swale.
Velocity (V) = 1.49*R^(2/3)*S^(1/2)/n
Velocity (V) = 3.378 ft/sec

- Calculate the swale's flow capacity.
Swale capacity (Q) = V * A
Q = 40.5 cfs

2. Determine the maximum allowable drainage area using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.42	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	8.5 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(typical value for intermediate cover)
25-Year Peak Flow Rate (Q) =	CIA cfs	

- Rearrange the Rational Formula to calculate allowable drainage area:
Drainage Area = Q / (CI)

Maximum Swale Drainage Area = 6.8 acres

3. Determine the maximum swale length based on the maximum sheet flow length.

Maximum Sheet Flow Length = 250 ft

$$\text{Maximum Swale Length} = \frac{\text{Maximum Swale Drainage Area} * 43560}{\text{Maximum Sheet Flow Length}}$$

Maximum Swale Length = 1184 ft

Summary: The maximum sheet flow length will be 250 feet and maximum drainage area is 6.8 acres. The calculated velocity is less than the permissible non-erodible velocity.

TEMPORARY DIVERSION CHANNEL DESIGN

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Temporary Diversion Channel

Diversion channel drainage areas were based on the typical size that may occur during the development of the site. The diversion channels are intended to prevent surface water from entering the active or excavated areas. 1-, 5-, and 10-acre drainage areas were considered:

Diversion Channel Slope	Diversion Channel Area (Acres)	Flow (cfs)	Bottom Width (ft)	Side Slopes (H:V)	Manning's number (n)	Normal Depth (ft)	Flow Area (ft^2)	Velocity (ft/s)	Energy Head (ft)
0.5	1	6.0	0	3	0.03	0.98	2.86	2.10	1.05
0.5	5	29.8	0	3	0.03	1.78	9.52	3.13	1.93
0.5	10	59.6	0	3	0.03	2.31	16.01	3.72	2.52
1	1	6.0	0	3	0.03	0.86	2.21	2.72	0.97
1	5	29.8	0	3	0.03	1.56	7.34	4.06	1.82
1	10	59.6	0	3	0.03	2.03	12.35	4.83	2.39
2	1	6.0	0	3	0.03	0.75	1.70	3.53	0.95
2	5	29.8	0	3	0.03	1.37	5.66	5.26	1.80
2	10	59.6	0	3	0.03	1.78	9.52	6.26	2.39

Notes:

1. The calculations shown in the table above are normal depths from a 25-year rainfall event.
2. The required diversion channel depth will have 0.5 foot of freeboard.
3. Diversion channels shall be grassed. Erosion control features will be provided for velocities exceeding 5 fps.
4. During operation of the site different configurations of diversion channels may be used to minimize erosion and erosive velocities. The landfill operator will determine the sizing of diversion channels if different lining materials is used.
5. The shading represents sample calculation presented on pages C1-G-20 and C1-G-21.

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Temporary Diversion Channel
Example Calculations

Required: Determine the necessary dimensions of the temporary diversion channel for routing surface water around excavations.

Methods:
1. Calculate the 25-year peak flow rate (Q) for a 1-acre drainage area using the Rational Method.
2. Calculate the normal depth for the temporary diversion channel for a drainage area of 1 acre with a slope of 2%.

References:
1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution:
1. Calculate the 25-year peak flow rate (Q) for a 1-acre drainage area using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.42	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	8.5 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(ref 1, Table 4-11)
Area (A) =	1 acre	
25-Year Peak Flow Rate (Q) =	CIA cfs	
Q =	(0.7)(8.5)(1)	
Q =	6.0 cfs	

2. Calculate the normal depth for the temporary diversion channel for a drainage area of 1 acre with a slope of 2%.

List of Symbols:
- Q_d = design flow rate for channel, cfs
- R = hydraulic radius, ft
- n = Manning's roughness coefficient
- S = channel slope, ft/ft
- b = bottom width of channel, ft
- z_r = ratio of run to rise for channel sideslope for right sideslope of diversion channel
- z_l = ratio of run to rise for channel sideslope for left sideslope of diversion channel
- A_f = flow area, sf
- g = gravitational acceleration = 32.2 ft/s^2
- T = top width of flow, ft
- d = normal depth of diversion channel, ft

Design Inputs:

Q_d =	6.0	cfs
S =	0.02	ft/ft
b =	0	ft
z_r =	3	(H) : 1 (V)
z_l =	3	(H) : 1 (V)
n =	0.03	

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Temporary Diversion Channel
Example Calculations

Step A - Based on the geometry of the swale cross section, solve for R and A_f.

$$R = \frac{bd + 1/2d^2(z_r + z_l)}{b + d((z_l^2 + 1)^{0.5} + (z_r^2 + 1)^{0.5})}$$

$$A_f = bd + 1/2d^2(z_r + z_l)$$

Assume: d = 0.75 ft

R = 0.357 ft

A_f = 1.70 sf

Solve for Q: Q = 6.0

If Q is not equal to Q_d, select a new d and repeat calculations.

The program uses an iterative process to calculate the normal depth of the diversion channel to satisfy Manning's Equation.

$$Q = \frac{1.486}{n} A R^{0.67} S^{0.5}$$

Step B - solve for velocity, T, Froude number, velocity head, and energy head.

Q = VA => V = Q/A

V = 3.53 ft/s

$$T = b + d(z_l + z_r)$$

T = 4.52 ft

$$F_r = \frac{V}{(gA/T)^{0.5}}$$

F_r = 1.01

$$\text{Velocity Head} = \frac{V^2}{2g}$$

Velocity Head = 0.19 ft

Energy Head = depth + velocity head

Energy Head = 0.95 ft

TEMPORARY DRAINAGE LETDOWN DESIGN

TEMPORARY DRAINAGE LETDOWN DESIGN

The temporary letdowns design is applicable for external sideslopes of the landfill with intermediate cover. Temporary letdown chutes will typically consist of channels lined with erosion control material. The flow capacity of the letdown structures was determined based on the Manning's Equation. The maximum flow calculated from the Manning's Equation is used to determine the maximum drainage area based on the Rational Method. The design calculations presented on pages C1-G-25 through C1-G-27 represent typical calculations for letdown chutes lined with different materials on a 25 percent slope. If sustained erosion is observed, facility management will evaluate the use and construction of temporary letdowns.

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Temporary Letdown/Chute Flow Evaluation

Required: 1. Determine the capacity of a variety of letdown chutes with different lining materials.

Method: 1. Use Manning's Equation to calculate the temporary chute capacity for a variety of lining materials.
2. Use the Rational Method to determine the maximum drainage area for a variety of temporary chute lining materials and temporary chute bottom widths.

References: 1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution: 1. Chutes will be designed to function during the 25-year storm event.

Where: Q = Chute Capacity (cfs)
n = Manning's Coefficient (unitless)[1]
A = Cross-Sectional Area (ft^2)
WP = Wetted Perimeter (ft)
R = Hydraulic Radius (ft)
S = Letdown Slope (ft/ft)
d = Normal Depth (ft)
b = Bottom Width of Chute (ft)
z = Chute Side Slope (ft/ft)

$$A = bd + zd^2$$

$$WP = b + 2\,[(zd)^2 + d^2]^{0.5}$$

$$R = A / WP$$

$$Q = \frac{1.486(A)(R^{2/3})(S^{1/2})}{n}$$

[1] The Manning's Coefficient was selected from the references for the applicable lining material.

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SKYLINE LANDFILL
Temporary Letdown/Chute Flow Evaluation

HDPE Geomembrane Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.25	8	0.25	3	0.013	2.19	9.58	0.228	21.35	46.7
0.25	30	0.25	3	0.013	7.69	31.58	0.243	22.28	171.3

* Manning's coefficient selected for a temporary HDPE geomembrane lined chute.

Concrete Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.25	8	0.25	3	0.015	2.19	9.58	0.228	18.50	40.5
0.25	30	0.25	3	0.015	7.69	31.58	0.243	19.31	148.5

* Manning's coefficient selected for a temporary concrete lined chute.

Turf Reinforcement Mat Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.4	8	0.25	3	0.030	3.68	10.53	0.349	12.29	45.2
0.4	30	0.25	3	0.030	12.48	32.53	0.384	13.08	163.2

* Manning's coefficient selected for a temporary turf reinforcement mat lined chute.

Gabion, Riprap, Crushed Stone, or Crushed Concrete Lined Chute

Depth d (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope z (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter WP (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.4	8	0.25	3	0.035	3.68	10.53	0.349	10.53	38.8
0.4	30	0.25	3	0.035	12.48	32.53	0.384	11.21	139.9

* Manning's coefficient selected for a temporary gabion, riprap, crushed stone, or crushed concrete lined chute.

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
Temporary Letdown/Chute Flow Evaluation

2. Use the Rational Method to determine the maximum drainage area for a variety of temporary chute lining materials and temporary chute bottom widths.

25-Year Rainfall Depth (Pd) =	1.42	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	8.5 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(ref 1, Table 4-11)

- Rearranging the rational formula, the maximum drainage area is determined as follows:

Q = Flow Rate
A = Maximum Drainage Area
A = Q/(CI)
A = 46.7/(0.7*8.5)
A = 7.8 acres

HDPE Geomembrane Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	46.7	7.8
30	171.3	28.7

Concrete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	40.5	6.8
30	148.5	24.9

Turf Reinforcement Mat Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	45.2	7.6
30	163.2	27.4

Gabion, Riprap, Crushed Stone, or Crushed Concete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	38.8	6.5
30	139.9	23.5

DESIGN SUMMARY

The Skyline Landfill will implement the erosion and sediment control features on the intermediate cover as the landfill develops. The following items will be implemented as filling operations are ongoing:

- Intermediate cover will be established on all areas that have received waste but will remain inactive for periods greater than 180 days.
- Sufficient permanent and temporary erosion and sediment control features shall be constructed to redirect surface water and prevent erosion.
- Temporary erosion and sediment control features shall be constructed within 180 days of placement of intermediate cover.
- Temporary erosion control structures (e.g., rock check dams, filter berms) may be established along the toe of existing vegetated intermediate cover areas with approximately 70-90 percent coverage.
- Final cover will be constructed as the site develops. Temporary erosion control features will be removed as permanent erosion controls are constructed.