RESPONSE 34

APPENDIX III-2C-1

INTERMEDIATE COVER SOIL EROSION LOSS ANALYSIS

INTERMEDIATE COVER SOIL EROSION LOSS ANALYSIS

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1.0 OBJECTIVE

1) Design the interim erosion and sediment controls for the proposed at the Temple Recycling and Disposal Facility in accordance with 30 TAC §330.305(d).

2) Estimate erosion losses for worst-case intermediate cover slopes for both the top dome surface and external embankment side slopes.

3) Estimate flow velocity and compare to permissible non-erodible velocity.

2.0 DESIGN CRITERIA

In accordance with 30 TAC §330.305(d), the soil erosion and sediment controls are designed according to the following criteria:

-The estimated peak velocity should be less than the permissible erodible velocities under similar conditions.

-The potential soil erosion loss should not exceed the permissible soil loss for comparable soil-slope lengths and soil-cover conditions. The soil erosion loss of 50 ton/acre/year is selected as the permissible soil erosion loss for interim erosion and sediment controls (based on TCEQ guidance - Reference 1).

The permissible non-erodible flow velocity on a grass-covered slope is typically 5.0 ft/sec (Reference 2). The permissible non-erodible flow velocity for bare clay loam soil is 3.75 ft/sec (Reference 3).

Based on TCEQ draft guidance on erosional stability (Reference 1), for the interim condition, the permissible soil loss is not to exceed 50 tons/acre/year and the recommended vegetative cover is 60%. In accordance with the TCEQ draft guidance, the Natural Resources Conservation Services, formerly Soil Conservation Service, of the United States Department of Agriculture's Revised Universal Soil Loss Equation remains to be the most suitable method for calculating soil loss from a landfill.

60% of ground cover is assumed to be achievable during the operational phase of the site (based on TCEQ guidance - Reference 1).

3.0 METHODS

3.1 Flow Velocity

The storm water flow velocity on the slope is calculated following the method provided in the USDA TR-55 (Reference 4). For the slopes less than 300 feet long, sheet flow along the slope is expected. The sheet flow velocities for the 4% and 25% slopes are 0.91 ft-sec and 1.82 ft/sec, respectively (Table 1). Results showed that the sheet flow velocities for all proposed slope gradients are below the permissible non-erodible velocities of 5 ft/sec.

For slopes longer than 300 feet, the flow on the slopes becomes shallow concentrated flow. The flow velocity for shallow concentrated flow is presented in Figure 1.

The proposed top surface is at 4% slope with a maximum slope length of 500 feet, which results in a flow velocity of 3.2 ft/sec (Figure 1). These results indicate that both velocities (sheet flow and shallow concentrated flow) are below the permissible non-erodible velocity of 5 ft/sec, therefore the flow velocity criterion is satisfied on the top surfaces without any slope interrupters.

On the 4H:1V external embankment side slopes, water diversion structures are required and the spacing of the diversion structures is a maximum of 240 feet along the slope. The design will ensure flow velocities less than permissible non-erodible flow velocity.

Table 1: Sheet Flow Velocity Calculation

Flow Type	Roughness Coefficient n^{ote}:	Surface Description	Surface Condition
Sheet/Overland Flow	0.011	Smooth surface (concrete, asphalt, gravel, bare soil)	A
	0.05	Fallow (no residue)	B
	0.06	**Cultivated soils: Residue cover ≤ 20%**	**C**
	0.17	Cultivated soils: Residue cover > 20%	D
	0.15	Grass: Short grass prairie	E
	0.24	Grass: Dense grasses	F
	0.41	Grass Bermuda grass	G
	0.13	Range (natural)	H
	0.4	Woods: Light underbrush	I
	0.8	Woods: Heavy underbrush	J

Notes: The roughness coefficient for sheet flow were from Table 3-1, TR-55 (Reference 4).

Slopes	Sheet/Overland Flow			
	Surface Condition	**Length (ft)**	**Slope (ft/ft)**	**Estimated Flow Velocity (ft/sec)**
Top Surface – 4%	C	300	0.04	0.91
External Embankment Side Slope – 25% slope	C	240	0.25	1.82

3.1.1 Example Sheet/Overland Flow Velocity Calculation

For sheet flow calculated for a distance of up to 300 feet, use:

$$T_t = \frac{0.007(nL)^{0.8}}{P_{25}{}^{0.5}s^{0.4}}$$

$$T_t = \frac{L}{3600V}$$

Where:

T_t = travel time (hr);

n = Manning's roughness coefficient (Table 1);

L = flow length (ft);

P_{25} = 25-year, 24-hour rainfall (in) see Table 2.5 (Reference 5);

s = slope of hydraulic grade line (land slope, ft/ft); and

V = average velocity (ft/s)

Using the 25% slope as an example, the average velocity would be calculated as follows:

$$T_t = \frac{0.007(0.06*240)^{0.8}}{(7.9)^{0.5}(0.25)^{0.4}}$$

T_t= 0.036627 hours

Therefore:

$$V = \frac{L}{3600(T_t)}$$

V= 1.82 ft/sec

3.1.2 Soil Erosion Loss

The soil erosion loss was calculated using the Revised Universal Soil Loss Equation (RUSLE), (USDA, 1997, Reference 6).

A=R*LS*K*C*P

Where:

A = Soil erosion loss, tons/acre/year;

R = Rainfall erosion index = 300 (Reference 5);

K = Soil erodibility factor = 0.21 (4% organic matter for clay loam material form "Table 1, Approximate Values of Factor K for USDA Textural Classes", Reference 7);

LS = Slope length and steepness factor (calculated from Eqs. 8.39-41 and 43 (p. 261) (Haan, 1994) Reference 8);

C = Cover-management factor = 0.042 Table 2 from Reference 7 assuming no appreciable canopy and 60% ground cover;

P = Support Practice Factor = 1.0 (conservation assumption).

4.0 CALCULATIONS/RESULTS

expected soil loss were computed for the top surface slope of 4% and for the external embankment slope of 25%. In accordance with TCEQ guidance (Reference 1), 60% ground cover was assumed for the operational phase of site development, resulting in a cover management factor, C, of 0.042. The longest attainable or allowable slopes were analyzed: 500 feet at 4%; and 240 feet at 25% (the max length between slope interrupters).

Table 2 presents the results of the soil loss calculations. The compound soil loss is significantly less than the permissible soil erosion loss of 50 ton per acre per year recommended by the TCEQ for interim erosion and sediment controls.

Table 2: Soil Erosion Loss Calculation Results – c = 60%

R	K	Slope	Length (l)	Rill susceptibility	LS	C	P	A_i
		(ft/ft)	(ft)	low, mod, high				ton/ac/yr
Top Surface								
300	0.21	0.04	500	mod	0.626	0.042	1	1.7
Example Calculation for External Embankment Side Slope								
300	0.21	0.25	240	mod	7.481	0.042	1	19.8

5.0 CONCLUSION

The proposed 4% top surface can achieve erosional stability during interim conditions of 60% ground cover. Soil loss for the 4% top surface was calculated to be 1.7 tons/acre/year, well below the permissible soil erosion loss of 50 tons/acre/year recommended by the TCEQ for interim erosion and sediment controls.

The external embankment side slopes can achieve erosional stability with a combination of ground cover and storm water diversion structures. To maintain sheet flow runoff (and therefore keep surface water flow velocities below 5 feet per second) and following the typical operation practices, the maximum length of the 25% side slopes is limited to 240 feet. At 60% ground cover, this results in an estimated soil loss of 19.8 tons/acre/year, well below the permissible soil erosion loss of 50 tons/acre/year recommended by the TCEQ for interim erosion and sediment controls.

6.0 REFERENCES

1) Texas Commission of Environmental Quality, "Guidance for Addressing Erosional Stability During All Phases of Landfill Operations (30 TAC §330.305(c), (d), and (e))." February 2007, Draft.

2) TCEQ Regulatory Guidance, "Guidelines for Preparing a Surface Water Drainage Report for a Municipal Solid Waste Facility.", August 2006

3) McCuen Richard. 1998. *Hydrologic Analysis and Design*. New Jersey:Prentice Hall

4) U.S. Department of Agriculture (USDA). 1986. Urban Hydrology for Small Watersheds. TR-55

5) City of Temple, "Drainage Criteria and Design Manual."

6) U.S. Department of Agriculture (USDA). 1997. Predicting soil erosion by water: A guide to conservation planning with the revised universal soil loss equation (RUSLE). (Agricultural Handbook Number 703) US Government Printing Office, Washington, DC.

7) Texas Natural Resource Conservation Commission - Use of the Universal Soil Loss Equation in Final Cover/Configuration Design - Procedural Handbook - Permits Section, Municipal Solid Waste Division - October 1993

8) Haan C.T., B. J. Barfield, and J.C. Hayes. 1994. Design hydrology and sedimentology for small catchments. San Diego CA: Academic Press Inc.

Figure 1: Flow Velocity of Shallow Concentrated Flow from TR-55