Appendix M

Erosion Calculations

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri
December 2012

Amendments to Erosion Calculations
Appendix M

EROSION PROTECTION CALCULATIONS

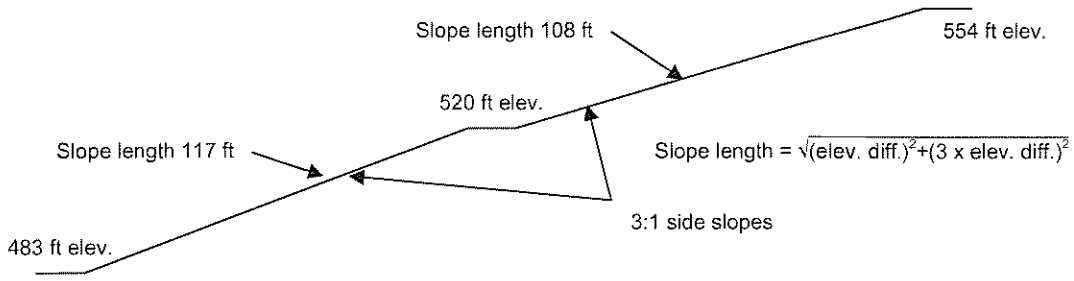
The stormwater drainage structures were checked for erosion control by utilizing the Erosion Control Materials Design Software 4.3 (ECMDS) by North American Green (NAG). This software analyzes erodibility of various channel/slope configurations. The channel/slope is analyzed for erodibility based upon soil type, cover, flow-rate, velocity, Manning's number and channel grade. Channel sections representative of the side slope benches and letdown ditches have been analyzed for erosion using riprap.

SUMMARY OF DESIGN ANALYSIS

1. Typical Landfill Slope Erosion Protection

The typical top of landfill was modeled for erosion using ECDMS, which uses a version of the Revised Universal Soil Loss Equation (RUSLE). The top of the landfill is designed with a minimum 2 percent slope. The maximum distance along the 2 percent slope is 550 ft. The annual soil loss of 0.013 inches per year is less than the permissible 0.03 inches per year, and is considered acceptable (a standard value in ECDMS; see Table 1 and Figure 1a).

The typical side slope was also modeled for erosion using ECDMS. The 3:1 side slope of 225 ft is broken into two sections of approximately 117 ft and 108 ft by a bench at 520 feet elevation. Both segments have annual soil losses less than 0.03 in. The segment with the larger annual soil loss eroded at a rate of 0.017 in/yr (see Table 1 and Figures 1a and 1b).



2. Typical Diversion Structure on Top of Landfill

Flow from the top of the landfill will be directed to the letdowns using diversion structures. The typical diversion structure would have a slope of up to 1 percent, a depth of 1 ft, and side slope of 50:1 and 3:1. ECMDS was used to calculate shear stress resulting from the maximum flow of 4.5 cfs (half the maximum flow in a letdown). Shear stresses were within permissible levels (see Table 1 and Figure 2).

3. Typical Landfill Letdown Structure

The standard letdown design to be utilized at the Ameren Missouri Labadie Power Plant Utility Waste Landfill (8 ft wide bottom and 3:1 side slopes) was checked for permissible shear stress using two types of cover (reinforced vegetation and 22-in riprap). ECMDS was used to calculate shear stress resulting from the maximum flow of 8.9 cfs on the 3:1 bottom slope of the letdowns. The letdown structure flow was calculated in Appendix N using the Rational method, a 25-year, 1-hour storm, the largest area drained by a letdown structure. Shear stresses were within permissible levels (see Table 1 and Figure 3a and 3b).

4. Typical Bench

Benches on the side slope are proposed. They will be at 520 ft elevation and have 1 percent bottom slopes. The bench side slopes will be 3:1 on one side and 10:1 on the other, with a depth of 1.5 ft. As with the letdown structures, these were modeled using ECMDS. The permissible shear stress for a fair stand of vegetation is greater than the estimated shear stress created by a flow of 4.5 cfs (half the maximum flow in a letdown; see Table 1 and Figure 4).

5. Perimeter Ditch

The standard perimeter ditch to be utilized at the Ameren Missouri Labadie Power Plant Utility Waste Landfill (9 ft wide bottom and 3:1 side slopes) was checked for permissible shear stress using a fair stand of unreinforced vegetation. ECMDS was used to calculate shear stress resulting from the maximum flow of 36 cfs. Shear stresses were within permissible levels (see Table 1 and Figure 5).

TABLES

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

Summary Table of Erosion Control
Table 1

	Structure	Description of Cover and Conditions	Safety Factor	Limitations		
				Limiting Factor	Permissible	Calculated
1a	Typical Top of Landfill	Unreinforced vegetation with a fair stand of bunch growth	2.232	Soil Loss	0.03 in/yr	0.013 in/yr
1b	Typical Side Slope Below Bench	117 feet of cover with an excellent stand of sod growth	2.284	Soil Loss	0.03 in/yr	0.013 in/yr
	Typical Side Slope Above Bench	108 feet of cover with a good stand of mixed bunch and sod growth	1.816	Soil Loss	0.03 in/yr	0.017 in/yr
2	Typical Diversion Structure on Top of Landfill	Unreinforced vegetation with a fair stand of bunch growth	9.04	Shear Stress	4.20 psf	0.46 psf
3a	Typical Letdown	Reinforced vegetation	1.55	Shear Stress	7.00 psf	4.52 psf
3b	Typical Letdown	RipRap	1.23	Shear Stress	7.33 psf	5.98 psf
4	Typical Bench	Unreinforced vegetation with a fair stand of bunch growth	6.49	Shear Stress	4.20 psf	0.65 psf
5	Typical Perimeter Ditch	Good stand of mixed bunch and sod growth	70.17	Shear stress	0.035 psf	0.000499 psf

FIGURES

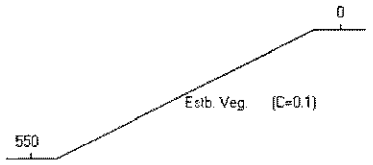
Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Top of Landfill
Figure 1a

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:10 AM | COMPUTED BY:

PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.: | SLOPE DESCRIPTION: Typical Top of Landfill

Country	United States
State/Region	Missouri
City	St. Louis
Annual R Factor	210
Total Slope Length (ft)	550
Protection Type	Permanent
Protection Period (months)	
Beginning Month	
Adjusted R Value	210.
Slope Gradient (H:1)	50
Soil Type	Silt Loam
K Factor	0.33
Soil Loss Tolerance (in)	0.03

Slope Gradient = 50:1



Not to Scale

Reach	Cum. Dist. Begin (ft)	Cum. Dist. End (ft)	Material	Vegetation Type Growth Habit	Density	ASL bare (in)	ASL mat (in)			SLT (in)	SF	Remarks
1	0	550	Estb. Veg.	Bunch Type	50-75%	0.134	0.013			0.03	2.232	STABLE
2												
3												
	0	550		Composite		0.134	0.013					

Vegetation Density=Percentage of soil coverage provided by vegetation
ASLbare=Average Soil Loss potential of unprotected soil (uniform inches)
MSLbare=Maximum Soil Loss potential on unprotected soil (uniform inches)
SLT=Soil Loss Tolerance for slope segment (uniform inches)
Composite=Average soil loss from total slope length (uniform inches)
C=Cover material performance factor (Fraction of soil loss of unprotected)
ASLmat=Average Soil Loss potential w/material (uniform inches)
MSLmat=Maximum Soil Loss potential w/material (uniform inches)
SF=Safety Factor

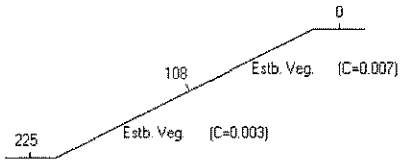
Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Side Slope
Figure 1b

North American Green - ECMDS Version 4.3 | 6/14/2012 | 04:31 PM | COMPUTED BY:

PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.: | SLOPE DESCRIPTION:

Country	United States
State/Region	Missouri
City	St. Louis
Annual R Factor	210
Total Slope Length (ft)	225
Protection Type	Permanent
Protection Period (months)	
Beginning Month	
Adjusted R Value	210.
Slope Gradient (H:1)	3
Soil Type	Silt Loam
K Factor	0.33
Soil Loss Tolerance (in)	0.03

Slope Gradient = 3:1



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Reach	Cum. Dist. Begin (ft)	Cum. Dist. End (ft)	Material	Vegetation Type Growth Habit	Density	ASL bare (in)	ASL mat (in)			SLT (in)	SF	Remarks
1	0	108	Estb. Veg.	Mix (Both Sod/Bunch)	>=95%	2.360	0.017			0.03	1.816	STABLE
2	108	225	Estb. Veg.	Sod Former	>=95%	4.378	0.013			0.03	2.284	STABLE
3												
	0	225		**Composite**		3.409	0.015					

Vegetation Density=Percentage of soil coverage provided by vegetation
ASLbare=Average Soil Loss potential of unprotected soil (uniform inches)
MSLbare=Maximum Soil Loss potential on unprotected soil (uniform inches)
SLT=Soil Loss Tolerance for slope segment (uniform inches)
Composite=Average soil loss from total slope length (uniform inches)

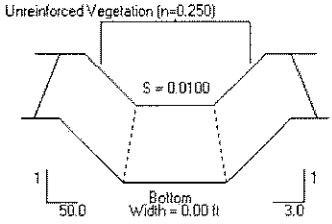
C=Cover material performance factor (Fraction of soil loss of unprotected)
ASLmat=Average Soil Loss potential w/material (uniform inches)
MSLmat=Maximum Soil Loss potential w/material (uniform inches)
SF=Safety Factor

Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Diversion Structure on Top of Landfill
Figure 2

North American Green - ECMDS Version 4.3 | 10/31/2012 08:15 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.:
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
4.5	1.0	0.31	14.68	0.37	0.74



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		C	Mix	50-75%	4.20	0.46	9.04	STABLE
		Soil	Silt Loam				0.035	0.001	48.47	STABLE

Back to Input Screer

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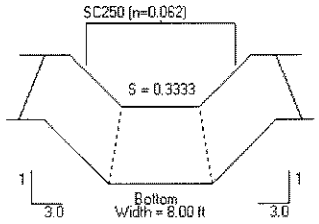
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Reinforced Vegetation Letdown Structure
Figure 3a

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:17 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.:
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
8.9	1.0	4.74	1.88	0.20	0.22



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	SC250	Vegetation	2	D	Mix	75-95%	7.00	4.52	1.55	STABLE
	Staple E	Soil	Silt Loam				2.500	0.470	5.32	STABLE

Back to Input Screer

SCHEDULE CJG-ST1

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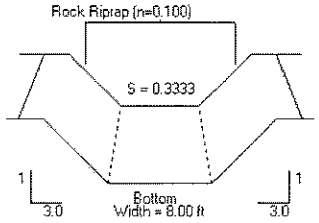
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Riprap Letdown Structure
Figure 3b

North American Green - ECMDS Version 4.3		10/31/2012 08:19 AM	COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie		PROJECT NO.:	
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
8.9	1.0	3.48	2.56	0.26	0.29



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Rock Riprap	Unvegetated					7.33	5.98	1.23	STABLE
	22in									

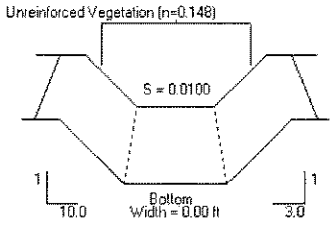
Back to Input Scree

Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Bench
Figure 4

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:20 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.:
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq ft)	Hydraulic Radius(ft)	Normal Depth (ft)
4.5	1.0	0.64	7.00	0.51	1.04



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		C	Bunch	50-75%	4.20	0.65	6.49	STABLE
		Soil	Silt Loam				0.035	0.004	8.06	STABLE

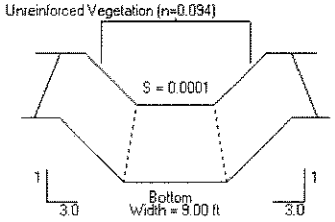
Back to Input Screen

Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Perimeter Berm
Figure 5

North American Green - ECMDS Version 4.3			10/31/2012 08:23 AM	COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie			PROJECT NO.:	
FROM STATION/REACH:	TO STATION/REACH:		DRAINAGE AREA:	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
36.0	1.0	0.32	112.74	2.86	4.81



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		C	Bunch	50-75%	4.20	0.03	139.90	STABLE
		Soil	Silt Loam				0.035	0.000499	70.17	STABLE

Back to Input Screen