ANALYSIS OF SEDIMENTATION POND CAPACITY FOLLOWING WASTE ROCK PILE EXPANSION, SKYLINE MINE, SCOFIELD, UTAH

Prepared for

CANYON FUEL COMPANY
Skyline Mine
Scofield, Utah

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CHAPTER 1

INTRODUCTION

The Canyon Fuel Company Skyline Mine has plans to expand its waste-rock disposal pile approximately 0.5 mile southeast of the town of Scofield in Carbon County, Utah. This document provides calculations that show that the existing waste rock pile sedimentation pond and its associated drainage ditches will continue to sufficiently contain runoff from the site. This report has been prepared for Canyon Fuels by EarthFax Engineering, Inc., and contains hydrologic analyses to determine runoff and sediment discharge for design storm events. Engineering calculations included as appendices of this document show that the pond and ditches will continue to conform to the applicable criteria outlined in the Utah Administrative Code Title R645-301.

CHAPTER 2
LOCATION AND BACKGROUND INFORMATION

2.1 WASTE ROCK PILE DESCRIPTION

The Canyon Fuels Skyline Mine waste rock pile is located approximately 0.5 mile southeast of Scofield, Utah near the bottom of a small ephemeral drainage. The site is a former open pit coal mine that has been filled with waste rock from the active Skyline Mine. The inactive pit has been nearly completely backfilled, and future plans for storing additional waste rock call for expanding the waste rock pile upslope for approximately 120 feet.

Expansion of the waste rock pile will increase the size of the watershed contributing to the pond, but should not significantly increase the area of exposed high erosion/runoff materials. The top of the current waste rock pile is at approximately 8,050 feet. The top of the planned expansion will be at approximately 8,170 feet. Increasing the size of the waste rock pile will increase the contributing watershed area from 17.8 acres to 18.7 acres. Since the outslopes of the pile are contemporaneously covered with topsoil and revegetated during construction, no more than approximately 3 acres of unvegetated waste rock will be exposed at the ground surface. This will minimize runoff and erosion contributing to the pond. The waste rock pile has been constructed this way since the 1980s, and the existing sedimentation pond has never discharged since it was constructed (Galecki, personal comm.).

2.2 DESIGN CRITERIA

The calculations in this report indicate that the pond and the drainage ditches that report to it will contain storm runoff and sediment discharge from the expanded waste rock pile as specified in the Utah Administrative Code Titles R645-301-742 and 743. These specifications include the following criteria:

- The pond must contain the runoff from a 10-year, 24-hour storm event and provide volume for the storage of sediment from its catchment area.
- The pond must safely convey the peak flow from a 25-year, 6-hour storm event.
- Drainage ditches must safely contain the peak flow from a 10-year, 6-hour storm event

In its current configuration, the pond has a total capacity of approximately 61,850 cubic feet (ft^3). A swale along the northwestern edge of the pond serves as a spillway that will adequately pass the design outflow event. Additionally, an 8-inch diameter steel decant pipe has been installed with an inlet near the bottom of the pond. The inlet is kept closed with a butterfly valve, which can be opened to drain the impoundment.

The pond is fed by two drainage ditches. Drainage ditch DD-16 is located along the base of the north side of the waste rock pile, and then descends a short, steep slope to reach the sedimentation pond. The steep section of the DD-16 is a trapezoidal channel that is armored with riprap (D_{50} = 9 inches). The upper section of DD-16 that parallels the access road is a vee-shaped channel that contains no riprap lining. Drainage ditch DD-17 is located along the western side of the waste rock pile. This ditch is vee-shaped, and contains no riprap lining.

CHAPTER 3
HYDROLOGY CALCULATIONS

3.1 METHODS

Storm discharge for the area contributing to the new sedimentation pond was calculated using the Soil Conservation Service curve number methodology as described in the National Engineering Handbook, Section 4 (Mockus, 1972). Design storm magnitudes were taken from the National Oceanic and Atmospheric Administration (NOAA) ATLAS 14 Point Precipitation Frequency Estimates web page (NOAA, 2006). Watershed areas, average slopes, and hydraulic lengths were calculated from large-scale site maps using AutoCAD 2007 software. Runoff curve numbers (CN) for undisturbed areas were based on observed vegetation and soil types as described in the National Resources Conservation Service (NRCS) soil survey map for the area (Jensen and Borchert, 1988). Typical CN values for disturbed areas were taken from Mockus (1972) and from the Utah Department of Transportation (2006). Detailed hydrology calculations are presented in Appendix A.

3.2 HYDROLOGY CALCULATIONS RESULTS

The sedimentation pond is fed by two watersheds. One watershed drains to the north over the waste rock pile into drainage channel DD-16, and one watershed drains to the west over the waste rock pile into drainage channel DD-17. Runoff calculations for both watersheds are summarized in Table 1 and provided in detail in Appendix A. As indicated in Table 1, runoff volumes total 35,036 cubic feet (0.80 acre-foot) for the 10-year, 24-hour event and 20,108 cubic feet (0.46 acre-foot) for the 25-year, 6-hour event.

CHAPTER 4
SEDIMENT VOLUME CALCULATIONS

4.1 METHODS

The sediment yield of the watersheds draining to the pond was calculated using an adaptation of the U.S. Department of Agriculture (USDA) Universal Soil Loss Equation (USLE) that was developed by the Utah Water Research Laboratory (Israelsen et al., 1984). This method assumes that all of the soil mobilized by erosion in the entire catchment area travels downslope to the proposed sediment pond. Thus, the sediment volume predicted by this equation is conservatively high. In the past 20 years, the sedimentation pond has been cleaned out only two or three times (Galecki, personal comm.).

To assist in calculating sediment yield from the area, the contributing watersheds were divided into seven sections based on soil type, vegetation coverage, and slope angle. The average annual sediment yield was then summed for each section to determine the total annual yield of the area draining into the pond. The sections included undisturbed areas with different NRCS soil types, disturbed revegetated areas, and a disturbed non-revegetated area. It was assumed that due to contemporaneous revegetation of the site that a maximum of approximately 3 acres of non-revegetated waste rock would be exposed at any one time. Additional assumptions used in calculating erosion volumes are detailed in Appendix B.

4.2 EROSION VOLUME CALCULATIONS RESULTS

The estimated annual sediment discharges for each of the two watersheds reporting to the sediment pond are summarized in Table 1. Detailed calculations of sediment discharge are presented in Appendix B. The total calculated annual sediment volume reporting to the sedimentation pond is 10,330 ft^3.

CHAPTER 5

SEDIMENTATION POND AND DRAINAGE DITCH HYDRAULICS

5.1 METHODS FOR DETERMINING HYDRAULIC CAPACITY OF THE SEDIMENTATION POND AND DRAINAGE DITCHES

The hydraulic capacities of the existing sedimentation pond and drainage ditches was evaluated by modeling the design storm events with the waste rock pile at its maximum extent. The storage capacity of the sedimentation pond was configured to contain the runoff from a 10-year, 24-hour precipitation event in addition to a sufficient volume of sediment yield. Furthermore, the spillway was designed to convey the peak flow from the 25-year, 6-hour precipitation event that immediately follows the 10-year, 24-hour event. The drainage channels DD-16 and DD-17 were evaluated for peak flow depths and velocities in response to the 10-year, 6-hour precipitation event. The flow calculations considered the type of channel armor (or lack thereof) that is present at the site. The upper segment of DD-16 was assumed to be "self-armored" with $D_{50} = 4$ inch riprap that will likely result from finer materials being washed into the sedimentation pond during discharge events. The waste rock contains a large fraction of coarse materials, which are expected to accumulate in this channel, which is located at the base of the pile. This channel will be closely monitored to see if this assumption is correct. Pond and channel hydraulics were determined with HydroCAD 2005 software using the hydrologic and erosion information discussed in Chapters 2 and 3 of this report. The dimensions of the existing sedimentation pond and the layout of its outlet structures were re-surveyed on April 9, 2007 so that these parameters could be used in the HydroCAD 2005 calculations.

5.2 RESULTS OF SEDIMENTATION POND HYDRAULICS CALCULATIONS

The existing sedimentation pond can sufficiently contain the runoff from the 10-year, 24-hour precipitation event (35,036 ft^3) and will also contain an additional volume of 6,170 ft^3 of sediment yield. The stage corresponding to 60% of the sediment storage capacity (3,700 ft^3) is 7,857.7 feet elevation, which is the current sediment cleanout level for the pond. This level is approximately 5 inches below the bottom of the pond decant pipe, which is at 7,858.1 feet elevation. The peak stage corresponding to the 100% of the sediment yield volume in addition to the volume of the 10-year, 24-hour precipitation event is 7,862.2 feet elevation. The peak stage corresponding to the 100% of the sediment yield volume in addition to the volume of the 100-year, 6-hour precipitation event is 7,863.9 feet elevation Refer to Table 2 for a summary of the sediment pond design configuration and Appendix C for pond hydraulics calculations.

.Raising the elevation of the inlet of the decant pipe will increase the sediment storage capacity of the pond, and will help prevent the decant pipe inlet from being buried by additional sediment. If the bottom of the inlet is raised 1.9 feet from 7,858.1 feet elevation to 7,860.0 feet elevation, the total sediment storage capacity of the pond would increase from 6,170 ft^3 to 20,787 ft^3. This volume exceeds two years of calculated annual sediment yield. The sediment cleanout elevation (the stage corresponding to 60% of the sediment storage volume) would then increase from 7,857.7 feet elevation to 7,859.0 feet elevation. If the decant pipe inlet is raised to 7,860.0 feet elevation, the peak stage corresponding to 100% of the sediment storage capacity (20,787 ft^3) combined with the 10-year, 24-hour precipitation event (35,036 ft^3) would be 7,863.5 feet elevation. This stage is below the elevation of the spillway (7,864.0 feet elevation).

Assuming the pond is initially full to the elevation of the spillway (7,864.0 feet elevation), its peak outflow during the 25-year, 6-hour precipitation event was calculated to be 6.60 cubic feet per second (cfs) at a velocity of 1.3 feet per second (fps). This discharge is low enough to be considered nonerosive, and thus no erosion protection is required on the embankment. The peak stage in this scenario is 7,864.28 feet, which is 0.72 feet below the crest of the embankment.

5.3 RESULTS OF DRAINAGE DITCH HYDRAULICS CALCULATIONS

The hydraulic analysis of the drainage ditches confirms that they will sufficiently contain the design precipitation event. Drainage ditch DD-16, which drains the northern slope of the waste rock pile, was modeled as two segments. An upper segment represented the vee-shaped channel that parallels the access road north of the waste rock pile and a lower segment represented the steep, armored trapezoidal channel that leads from this road down to the sedimentation pond. Drainage ditch DD-17, which drains the western slope of the waste rock pile, was modeled as a single vee-shaped channel.

The peak stage in the upper segment of DD-16 during the design precipitation event was calculated to be 0.71 feet deep with a peak flow velocity of 4.9 feet per second (fps). The peak stage in the lower segment of DD-16 during the design precipitation event was calculated to be 0.1 feet deep with a maximum flow velocity of 3.4 fps. The peak stage for the same event in DD-17 was calculated to be 0.51 feet deep with a maximum flow velocity of 4.1 fps. All flows are considered to be non-erosive and are contained within their respective channels. Refer to Table 3 for a summary of drainage ditch hydraulics and to Appendix C for hydraulics calculations.

CHAPTER 6
CONCLUSIONS

This report confirms that the existing sedimentation pond and drainage ditches at the Canyon Fuels Skyline Mine waste rock pile will continue to adequately contain precipitation runoff and sediment yield during expansion of the pile for the design events specified in Utah Administrative Code Title R645-301. By raising the decant inlet in the sedimentation pond 1.9 feet to an elevation of 7860.0 feet, the pond will be able to contain over two years of calculated sediment yield in addition to the design runoff event. Hydraulic calculations indicate that the drainage ditches should safely convey flows to the waste rock pile. The upper section of drainage ditch DD-16 was assumed to become "self-armored" due to finer particles being transported into the sedimentation pond. This channel will be closely monitored, especially after snowmelt and rain storms, so that appropriate actions can be taken if excessive erosion occurs.

CHAPTER 7

REFERENCES

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TABLES

Table 1
Summary of Hydrology and Erosion Volume Calculations

Watershed	Area (acres)	Average Soil Conservation Service (SCS) Curve No. (CN)	10-yr, 24-hr Runoff Volume (ft^3)	25-yr, 6-hr Runoff Volume (ft^3)	Annual Sediment Yield (ft^3)
WS-1	14.9	79	27,938	16,034	10,290
WS-2	3.8	79	7,098	4,074	40
TOTAL	**18.7**		**35,036**	**20,108**	**10,330**

Note
Refer to Appendices A and B for hydrology and erosion volume calculations, respectively

Table 2
Summary of Sedimentation Pond Hydraulics

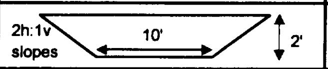
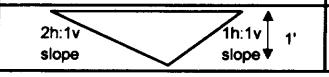
Current bottom of pond elevation (ft)	7,857
Top of embankment elevation (ft)	7,865.0
Existing spillway (swale/weir) elevation[1] (ft)	7,864.0
Decant pipe inlet elevation (ft)	7,858.1
Decant pipe outlet elevation (ft)	7,856.0
Length of decant pipe (ft)	29.0
Current sediment storage volume (ft^3)	6,170
Current sediment storage cleanout elevation (ft)	7,857.7
Current sediment storage cleanout volume (ft^3)	3,702
2 X Annual sediment storage elevation (ft)	7,860.0
Sediment storage volume if decant pipe inlet raised to 7,860.0 feet (ft^3)	20,787
Sediment storage cleanout elevation if decant pipe inlet raised to 7,860.0 feet (ft^3)	7,859.0
Sediment storage cleanout volume if decant pipe inlet raised to 7,860.0 feet (ft^3)	12,463
Current 10-year, 24-hour precipitation event plus 6,170 ft^3 sediment storage peak stage elevation (ft)	7,862.2
10-year, 24-hour precipitation event plus 20,787 ft^3 sediment storage peak stage elevation - assumes decant inlet raised to 7,860.0 feet (ft)	7,863.5
100-year, 6-hour precipitation event plus 20,787 ft^3 sediment storage peak stage elevation - assumes decant inlet raised to 7,860.0 feet (ft)	7,863.9
Spillway design event peak elevation[2] (ft)	7,864.28
Spillway design event peak flow[2] (cfs)	6.6
Spillway design event peak flow velocity[2] (fps)	1.3

Notes:

[1] The existing spillway is a 1 ft deep X 18 ft long X 10 ft broad swale on the top of the pond embankment.

[2] Includes 25-year, 6-hour precipitation event with the pond initially full to the spillway elevation.

Table 3
Summary of Drainage Ditch Hydraulics

Channel	X-section	10yr 6hr Max Flow (cfs)	Avg. Slope (ft/ft)	Max Depth (ft)	Max Vel. (fps)	D_{50} Riprap (in)	Manning's n*
Upper DD-16		4.66	0.083	0.71	4.9	4	0.038
Lower DD-16		3.66	0.33	0.10	3.4	9	0.054
DD-17		1.83	0.041	0.51	4.1	none	0.025

*Adjusted for riprap size according to USDOT FHWA HEC No. 11 and NUREG/CR 4651, unless no riprap exists (See Appx C). Note that a D_{50} of 4 inches was assumed for upper DD-16, due to the erosion of fines and the raveling of coarse material from the waste rock pile into the ditch

$n = 0.0456 X (D_{50} X S)^{0.159}$ where D_{50} (inches) is the mean riprap diameter and S (ft/ft) is the channel slope

Calculations assume bottom of channel is graded at a relatively constant slope

APPENDIX A

Hydrology Calculations

Table A-1
Hydrology Calculations

Storm (Rec. Int. - Duration)	Watershed	Watershed Area (sq. ft.)	Watershed Area (acres)	Precip. P (in)	Hydraulic Length - I (ft)	Avg watershed slope - Y (%)	Duration of stom (hr)	Curve Number (CN)	Potential Max. retention S (in.)	Lag - L (hr)	Time of Concentration - Tc (hr)	Runoff - Q (in)	Runoff Volume - V (ft3)
10-24	WS1	648,910	14.9	1.99	2,056	35.8	24	79	2.66	0.10	0.16	0.52	27,938
10-24	WS2	164,873	3.8	1.99	900	51.9	24	79	2.66	0.042	0.07	0.52	7,098
												TOTAL	**35,036**

25-6	WS1	648,910	14.9	1.58	2,056	35.8	24	79	2.66	0.10	0.16	0.30	16,034
25-6	WS2	164,873	3.8	1.58	900	51.9	24	79	2.66	0.042	0.07	0.30	4,074
												TOTAL	**20,108**

Notes

Refer to attached figure for locations of watersheds and NRCS soils units

Calculations based on Soil Conservation Service (SCS) Method, National Engineering Handbook Section 4, Chapters 9 & 10 by Victor Mockus, 1972

S = (1000/CN) - 10

L = [(I0.8 (S+1)0.7]/(1900Y0.5)

Tc = 1.67L

Q = (P - 0.2*S)2 / (P + 0.8*S)

V = Area * Q

Average Watershed Slope Calculation (Sum of lengths of contour lines X contour interval / Area)

Operational Conditions
WS1

Contour	Length
7900	295
8000	633
8100	796
8200	470
8300	132
TOTAL	**2,326**
AvgSlope	**35.8%**

WS2

Contour	Length
7900	326
8000	348
8100	182

TOTAL	**856**
Avg Slope	**51.9%**

Table A-1 (continued)
Hydrology Calculations

Operational Conditions: Curve Number Calculations

Hyd Soil Group	B	C
Undist, tree Cover	NA	77
Undist., no tree cover	79	NA
Disturbed, no reveg.	85	NA
Disturbed, reveg.	79	NA

WS1

Area No.	Area (ft2)	CN
1a	304,530	79
1b	130,680	85
2	153,401	77
3	60,300	79
TOTAL	648,911	
Avg CN	79	

WS2

Area No.	Area (ft2)	CN
1	151,860	79
2	13,013	79
TOTAL	164,873	
Avg CN	79	

Avg CN = (Σ $Area_i$ X CN_i)/ Total Watershed Area

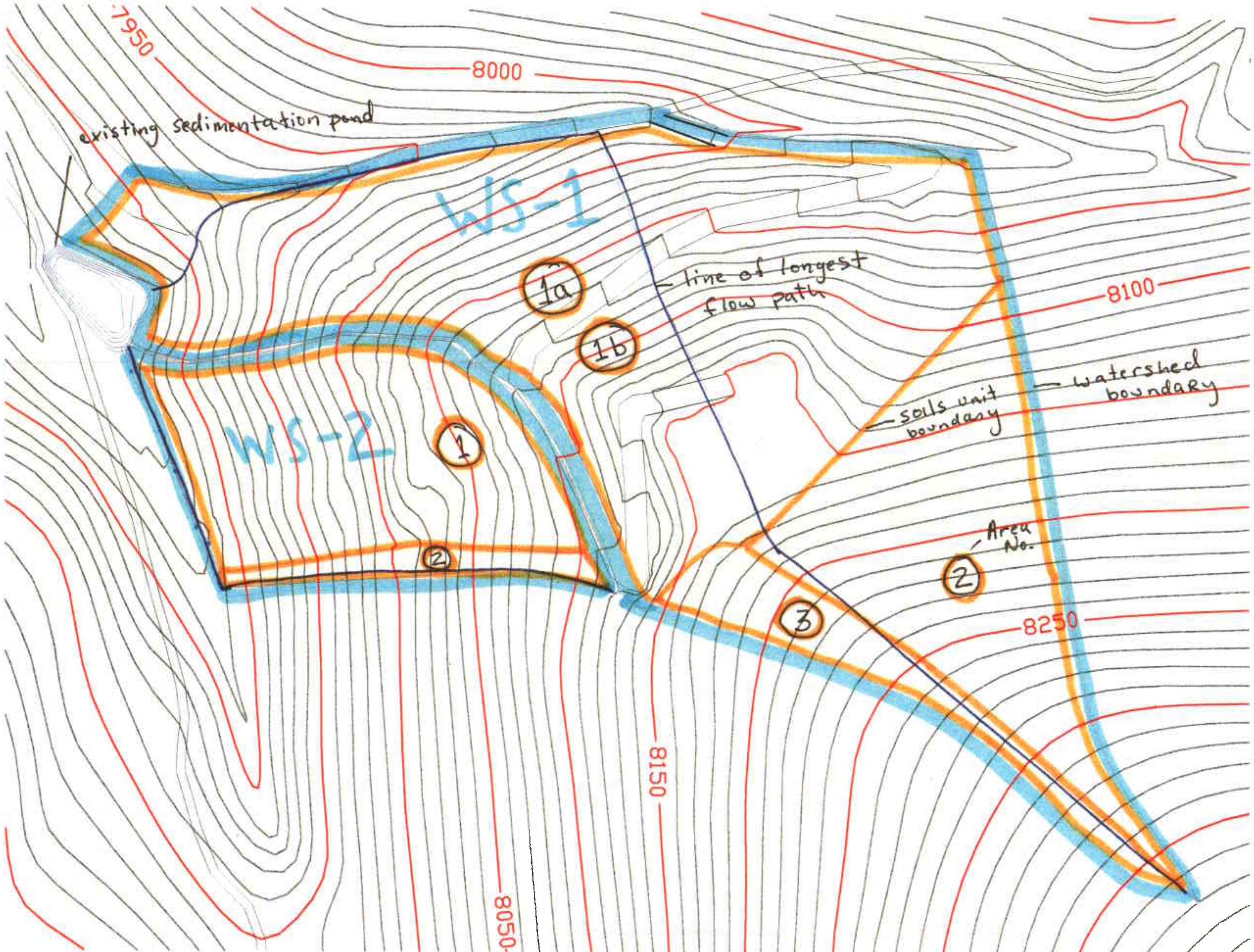
Notes

Refer to atached figure for locations of numbered areas

Curecanti soils in hydrologic soil group C (from NRCS soil survey)

Trag soils in hydrologic soil group B (from NRCS soil survey)

Curve Numbers for non disturbed areas from UDOT Manual of Instruction Table 7-14 (no trees = Pasture, poor condition; trees = woods, poor condition). Curve Number for disturbed areas taken from National Engineering Handbook Section 4 Table 9.1 (no reveg. = unpaved road, hard surface, reveg. = pasture/range, poor condition, uncontoured).



EXPANDED WASTE ROCK PILE HYDROLOGY CALCS.

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 39.72 N 111.151 W 8106 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Mon Dec 18 2006

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.21	0.26	0.34	0.43	0.51	0.57	0.74	0.93	1.16	1.36	1.70	1.98	2.26	2.97	3.65	4.55	5.28
2	0.17	0.27	0.33	0.44	0.55	0.65	0.72	0.91	1.15	1.44	1.69	2.10	2.45	2.80	3.70	4.54	5.65	6.56
5	0.24	0.37	0.45	0.61	0.76	0.86	0.92	1.13	1.39	1.75	2.05	2.56	2.98	3.42	4.53	5.51	6.86	7.98
10	0.30	0.45	0.56	0.76	0.94	1.06	1.11	1.31	1.60	1.99	2.34	2.92	3.41	3.89	5.19	6.26	7.79	9.06
25	0.39	0.59	0.73	0.99	1.22	1.36	1.41	1.58	1.90	2.33	2.73	3.42	3.99	4.53	6.05	7.23	9.00	10.45
50	0.47	0.71	0.88	1.19	1.47	1.63	1.67	1.83	2.13	2.57	3.02	3.80	4.43	5.00	6.71	7.95	9.89	11.47
100	0.56	0.85	1.06	1.42	1.76	1.95	1.98	2.12	2.38	2.83	3.32	4.18	4.87	5.48	7.37	8.66	10.76	12.47
200	0.67	1.01	1.26	1.69	2.09	2.31	2.33	2.46	2.69	3.08	3.62	4.57	5.32	5.96	8.02	9.35	11.61	13.44
500	0.83	1.27	1.57	2.12	2.62	2.88	2.90	3.02	3.22	3.41	4.01	5.08	5.91	6.57	8.87	10.23	12.69	14.66
1000	0.98	1.50	1.86	2.50	3.09	3.41	3.43	3.53	3.72	3.76	4.31	5.47	6.36	7.04	9.51	10.89	13.48	15.55

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

Table 9.1.--Runoff curve numbers for hydrologic soil-cover complexes

(Antecedent moisture condition II, and $I_a = 0.2 S$)

Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group: A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	" and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	" and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	" and terraced	Poor	63	73	80	83
	" and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

Source: National Engineering Handbook
Section 4: HYDROLOGY Chap 9: Hydrologic soil-cover complexes
by Victor Mockus, 1964, rev 1969

TABLE 7-14 — Other Agricultural Lands[1]

Cover Description	Hydrologic Condition	Curve Numbers for Hydrologic Soil Group			
Cover Type		A	B	C	D
Pasture, grassland, or range — continuous forage for graving [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	30[4]	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	30[4]	55	70	77
Farmsteads — buildings, land, 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

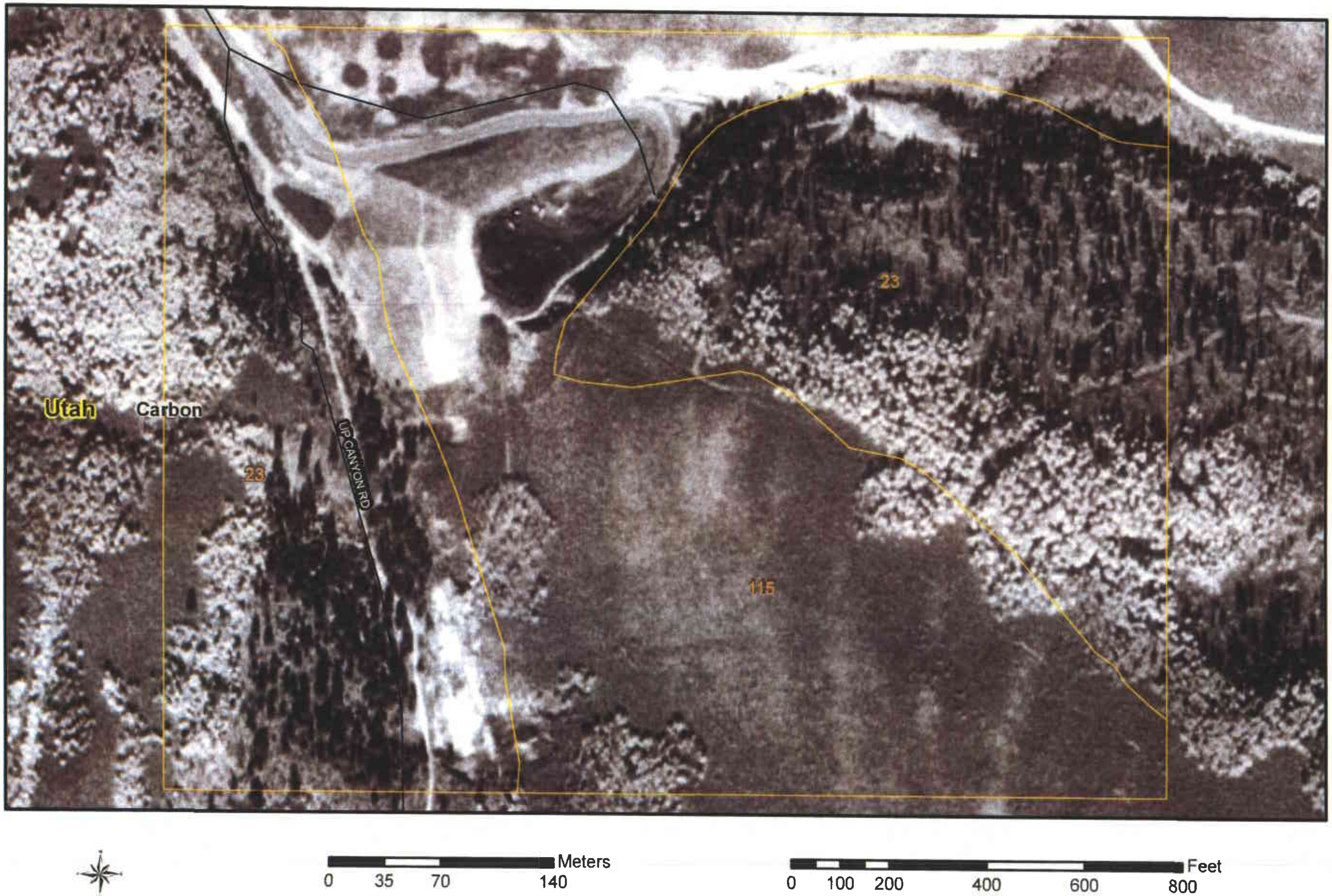
[3] Poor: < 50% ground cover
Fair: 50% to 75% ground cover
Good: > 75% ground cover

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

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

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

SOIL SURVEY OF CARBON AREA, UTAH, PARTS OF CARBON AND EMERY COUNTIES



MAP LEGEND

- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans
- Escarpment, bedrock
- Escarpment, non-bedrock
- Gulley
- Levee
- Slope
- Blowout
- Borrow Pit
- Clay Spot
- Depression, closed
- Eroded Spot
- Gravel Pit
- Gravelly Spot
- Gulley
- Lava Flow
- Landfill
- Marsh or Swamp
- Miscellaneous Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Slide or Slip
- Sinkhole
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Perennial Water
- Wet Spot

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 12

Soil Survey Area: Carbon Area, Utah, Parts of Carbon and Emery Counties
Spatial Version of Data: 1
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
9/30/1997; 10/5/1997

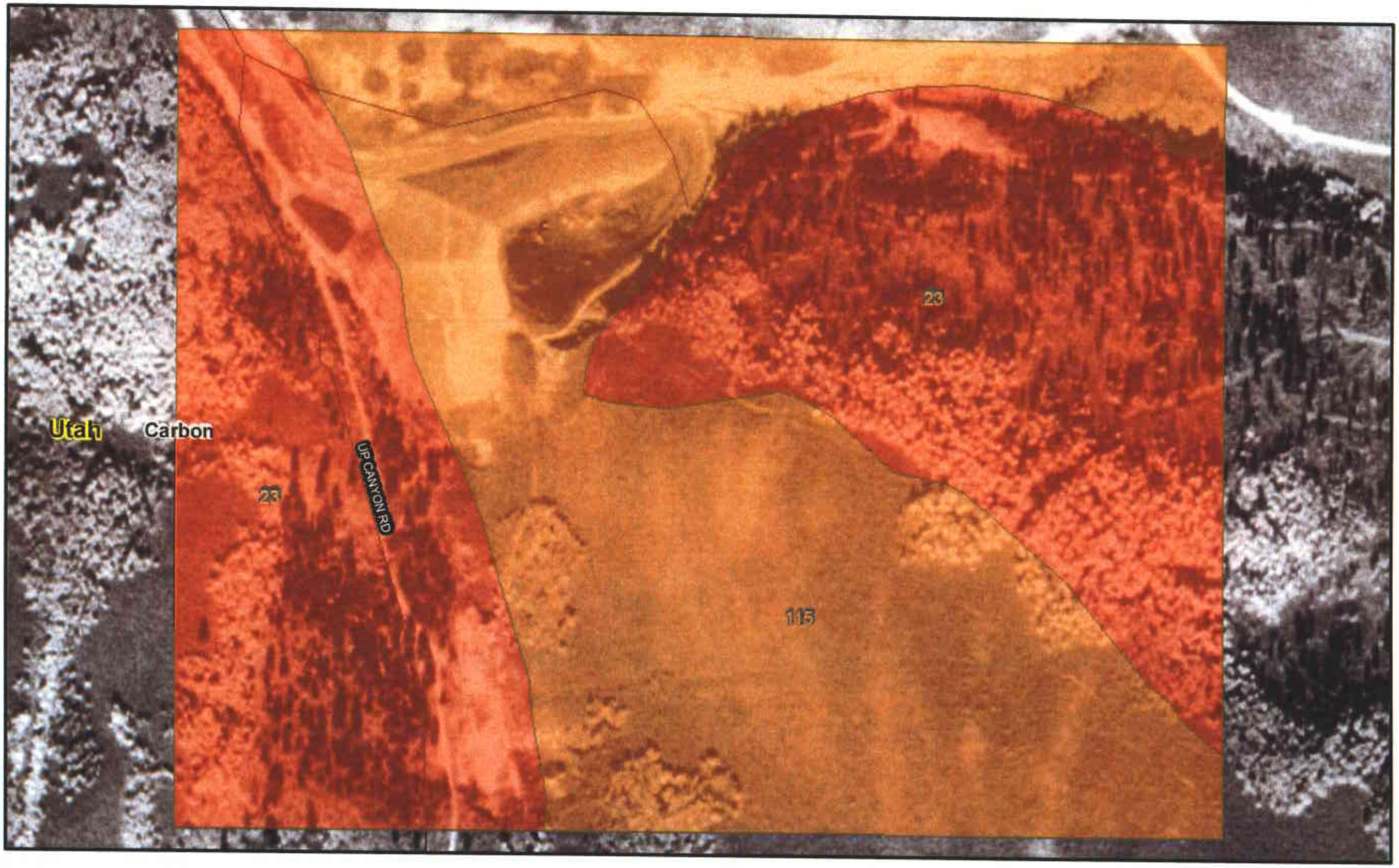
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend Summary

Carbon Area, Utah, Parts of Carbon and Emery Counties

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
23	Curecanti family-Pathead complex	38.6	52.8
115	Trag stony loam, 30 to 60 percent slopes	34.5	47.2

K FACTOR - WHOLE SOIL RATING FOR CARBON AREA, UTAH, PARTS OF CARBON AND EMERY COUNTIES



USDA Natural Resources Conservation Service

MAP LEGEND

K Factor - Whole Soil

(Surface Layer), {Dominant Condition, >}

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available
- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 12

Soil Survey Area: Carbon Area, Utah, Parts of Carbon and Emery Counties
Spatial Version of Data: 1
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
9/30/1997; 10/5/1997

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables - K Factor - Whole Soil

Summary by Map Unit - Carbon Area, Utah, Parts of Carbon and Emery Counties

Soil Survey Area Map Unit Symbol	Map Unit Name	Rating (K)	HYD SOIL GROUP	Total Acres in AOI	Percent of AOI
23	Curecanti family-Pathead complex	.05	C	38.6	52.8
115	Trag stony loam, 30 to 60 percent slopes	.10	B	34.5	47.2

Description - K Factor - Whole Soil

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Parameter Summary - K Factor - Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff:

Tie-break Rule: Higher

Layer Options: Surface Layer

APPENDIX B

Sediment Yield Calculations

Table B-1
Erosion Calculations

A = R K LS VM
Annual Sediment Volume = A X Area / Soil Density

	Area No.	Area (ac)	Description	Avg. Slope Y (%)	Slope Length (ft)	Slope Segment Length (ft)	LS	R	K	VM	A (t/ac/yr)	Soil Density (pcf)	Annual Sediment Volume (ft^3)
Area Draining to DD-16	1a	2.11	Side of pile: not reveg.	45.0	400	135	45.70	17	0.25	1.00	194.23	84	9,736
	1b	6.99	Side of pile: reveg	45.0	400	135	45.70	17	0.1	0.01	0.78	110	99
	2	0.89	Top of pile	9.5	210	210	1.85	17	0.25	1.48	11.64	84	248
	3	3.52	Undist above pile: Curecant	31.1	900	75	6.08	17	0.05	0.35	1.81	110	116
	4	1.38	Undist above pile: Trag	31.1	900	75	6.08	17	0.1	0.35	3.62	110	91
	TOTAL	14.90											**10,290**

	Area No.	Area (ac)	Descr.	Avg. Slope Y (%)	Slope Length (ft)	Slope Segment Length (ft)	LS	R	K	VM	A (t/ac/yr)	Soil Density (pcf)	Annual Sediment Volume (ft3)
Area Draining to DD-17	5	3.49	Side of Pile: waste rock	51.9	500	500	34.23	17	0.1	0.01	0.58	110	37
	6	0.30	Side slope: undisturbed	51.9	500	500	34.23	17	0.1	0.01	0.58	110	3
	TOTAL	3.78											**40**

GRAND TOTAL	**18.7**	**10,330**

Notes

LS values calculated in Table B-2.

R is taken from isoerodent map of Utah as 17.

K is taken from NRCS soil surveys as 0.05 for Curecanti Family loam, 0.1 for Trag Family, and 0.25 for waste rock based on grain size data from soil samples (HLA Report) and Figure 2 nomograph (Isrealsen, 1984; Wischmeier, 1971). Reclaimed outslopes of pile are assumed to have the K value of the Trag loam (0.1).

VM values are taken from Table 3 (Isrealson et al, 1984) as follows: 0.35 for undisturbed areas (brush), 1.48 for the top of the waste rock pile (compacted fill), 1.0 for pile outslopes (freshly disked soil), and 0.01 for revegetated slopes (permanent >12 mo. seedings). Note that the entire 2:1 outslope of pile reporting to DD-17 and all but three acres of the 2:1 outslope reporting to DD-16 (Area No. 1a) are taken as revegetated.

Soil density assumed to be the saturated density for each soil type (110 pcf for native soil, 84 pcf for waste rock). Density of waste rock taken from soil sample collected from upper waste rock pile in 1998 (HLA, 1998).

Table B-2
LS Calculations for Erosion Calculations

Areas Draining to DD-16 (North)

Undisturbed Area above Pile

slope (%) 27.8
LS (900 foot long slope) 21.05
LS (12 75-ft segments) 6.08

Notes:
LS = ((65.41s^2/s^2+10,000) + 4.56s/(s^2+10,000)^0.5 + 0.065) / (l/72.6)^0.5 for slopes > 5%
s= slope (%), l = length (ft)
Total LS = LS900ft / (No. segments)^0.5 = LS900ft / (12^0.5), as per Isrealson et al, 1984
This calculation assumes that the runoff from this area is primarily directed away from the waste rock pile, either towards (1) the drainage channel along the WRP access road or (2) along the western perimeter of the WRP.

Waste Rock Pile

segment (n)	vertical drop	cum. Vert drop	l_n	λ_n	slope (s)	LS ($s_n\lambda_n$)	LS ($s_n\lambda_{n-1}$)	LS_n	
0	0	0	0	0					
1	20	20	210	210	9.5	1.85	0.00	1.85	
2	200	220	410	620	48.8	42.77	24.89	64.68	45.7

Notes:
Assumes runoff flows down the relatively flat top (segment 1) of the WRP and down the outslope
LS_n for segment 2 has been divided by $2^{0.5}$ due to the presence of the access road which serves to break this slope into 2 parts
ln = length of slope segment (ft).
λn = cumulative length of slope to end of ln (ft)
LS = ((65.41s^2/s^2+10,000) + 4.56s/(s^2+10,000)^0.5 + 0.065) / (l/72.6)^0.5 for slopes > 5%
LSn = (LS(lnsn)ln - LS(ln-1sn)ln-1) / ln
Erosion calculation as per Isrealson et al, 1984

Disturbed Area Draining to DD-17 (West)

slope (%) 45.8%
LS (500 foot long slope) 34.23

Notes:
LS = ((65.41s^2/s^2+10,000) + 4.56s/(s^2+10,000)^0.5 + 0.065) / (l/72.6)^0.5 for slopes > 5%
s= slope (%), l = length (ft)

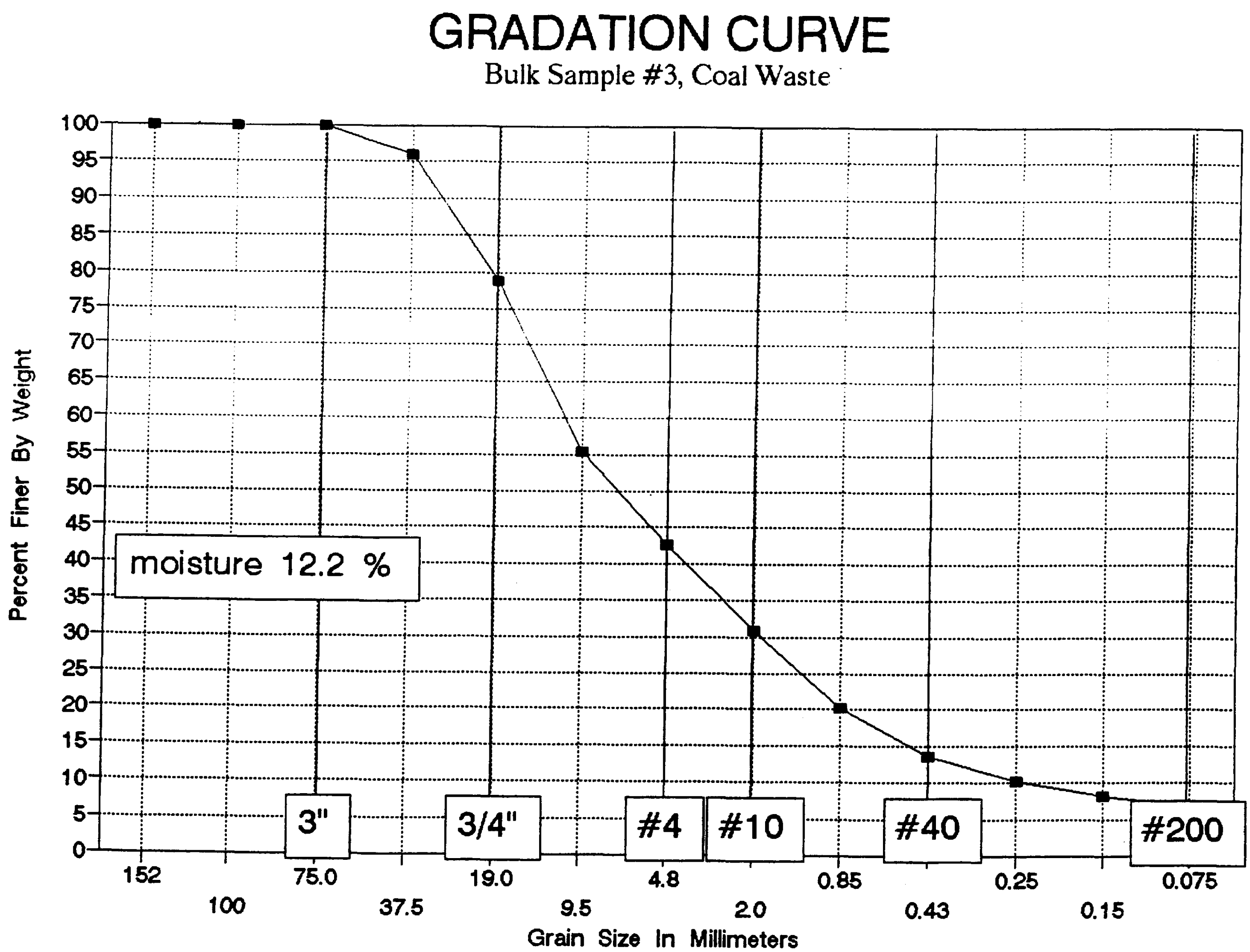
EXPANDED WASTE ROCK PILE EROSION VOLUME CALCS.

1" = 200' ↑N

Source: SLOPE STABILITY ANALYSIS OF COAL REFUSE PILE SKYLINE MINE, near the community of SCOFIELD, UTAH

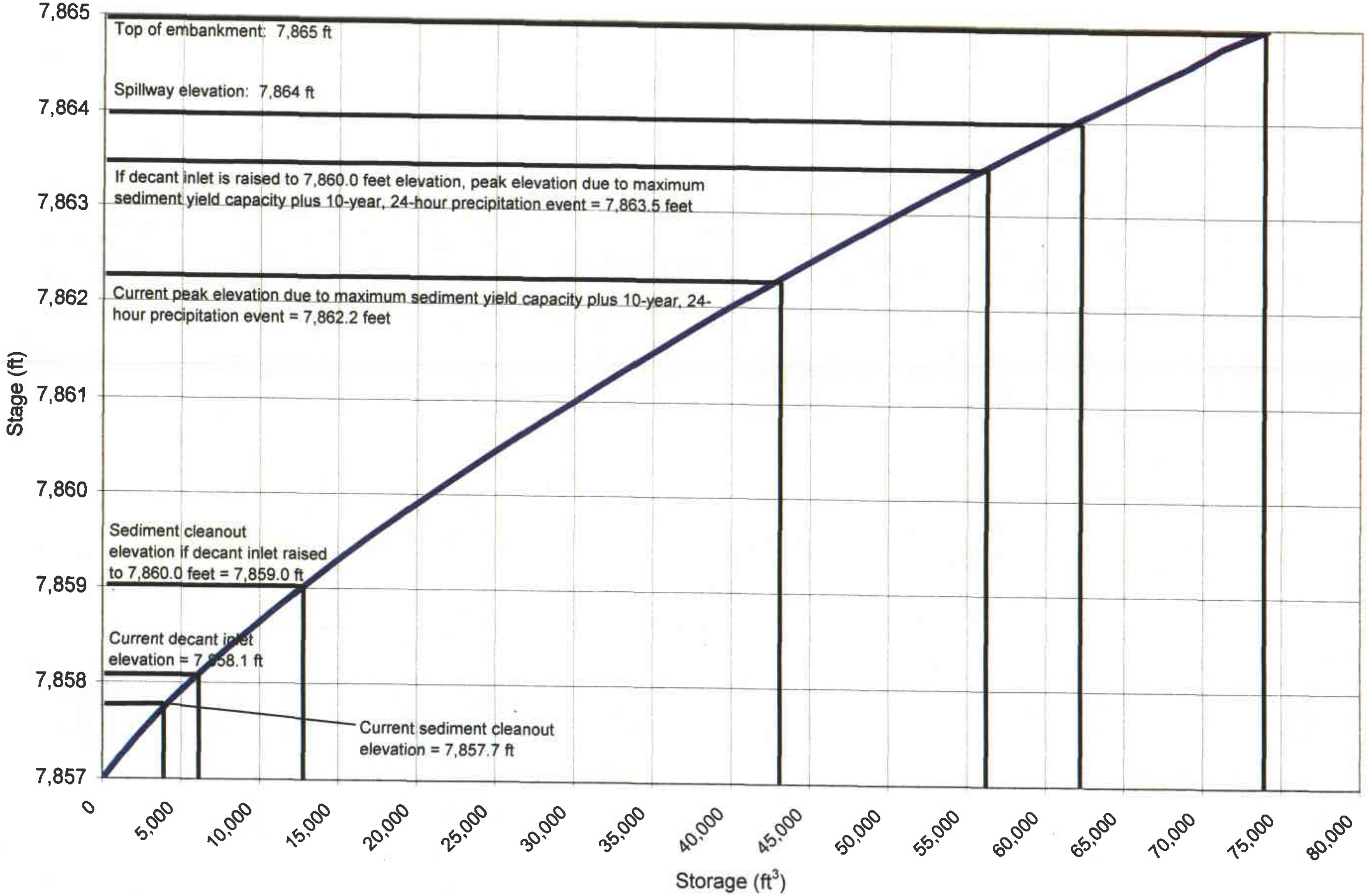
UNPUBLISHED REPORT BY HARDING LAWSON ASSOCIATES

Sept. 1997

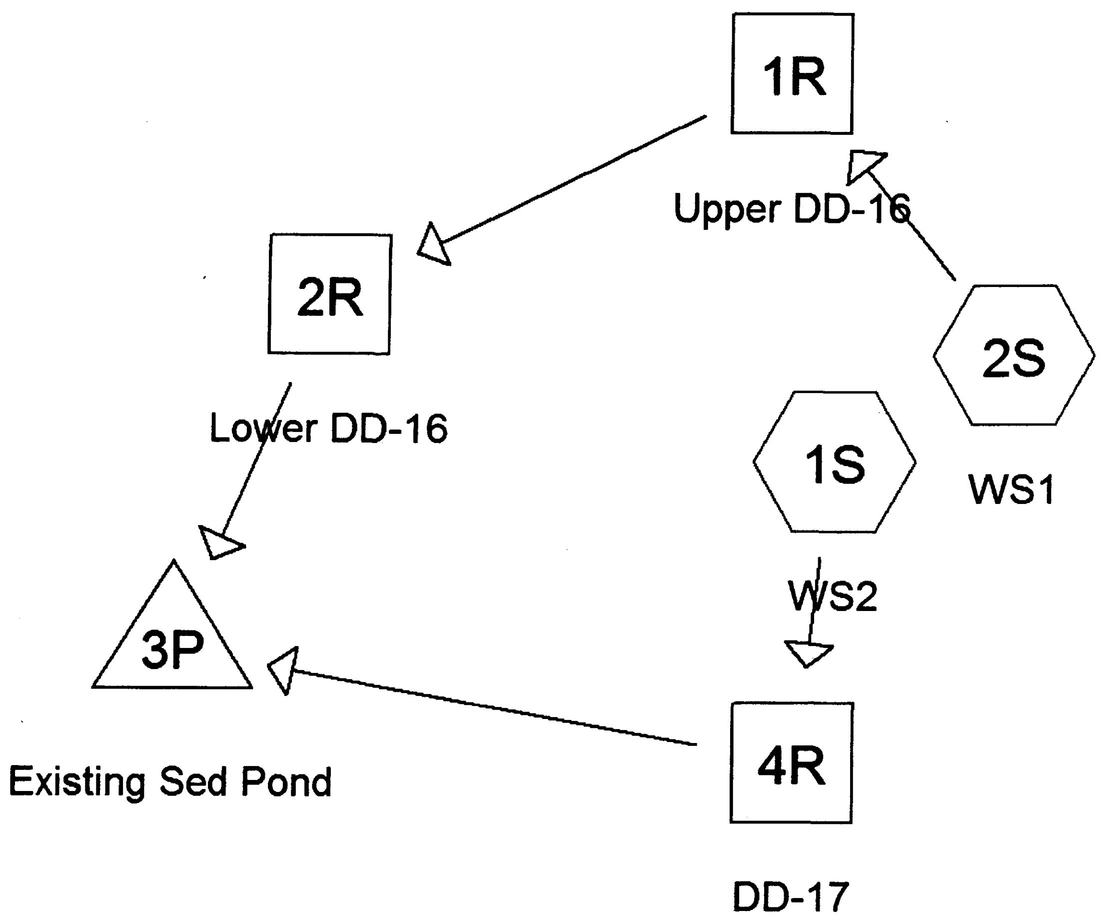


APPENDIX C

Hydraulics Calculations



Sedimentation pond storage vs. elevation curve



Schematic drawing of HydroCAD Model

Subcatchment 2S: WS1

Runoff = 11.04 cfs @ 12.03 hrs, Volume= 0.641 af, Depth= 0.52"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=1.99"

Area (sf)	CN	Description
648,910	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	2,056	0.3580	3.5		**Lag/CN Method,**

Subcatchment 1S: WS2

[49] Hint: Tc<2dt may require smaller dt

Runoff = 3.53 cfs @ 11.96 hrs, Volume= 0.163 af, Depth= 0.52"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=1.99"

Area (sf)	CN	Description
164,873	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	900	0.5190	3.6		**Lag/CN Method,**

Reach 1R: Upper DD-16

Inflow Area = 14.897 ac, Inflow Depth = 0.18"
Inflow = 4.66 cfs @ 3.12 hrs, Volume= 0.219 af
Outflow = 3.66 cfs @ 3.26 hrs, Volume= 0.219 af, Atten= 21%, Lag= 8.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.9 fps, Min. Travel Time= 4.0 min → peak vel ≤ 5.0 fps, considered non-erosive, no armor req'd
Avg. Velocity = 2.0 fps, Avg. Travel Time= 10.2 min

Peak Depth= 0.71' @ 3.19 hrs
Capacity at bank full= 27.59 cfs
Inlet Invert= 8,010.00', Outlet Invert= 7,910.00'
0.00' x 1.1 deep channel, n= 0.038 → $n = 0.0456 (D_{50} \times S)^{0.159}$
Side Slope Z-value= 2.0 1.0 '/' Top Width= 4.50'
Length= 1,200.0' Slope= 0.0833 '/'

where D_{50} is in inches (assume 4'
S = slope of channel (0.083)

(from Abt et al, 1987)

Reach 2R: Lower DD-16

Inflow Area = 14.897 ac, Inflow Depth = 0.18"
Inflow = 3.66 cfs @ 3.26 hrs, Volume= 0.219 af
Outflow = 3.52 cfs @ 3.28 hrs, Volume= 0.219 af, Atten= 4%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 0.7 min → peak vel. ≤ 5.0 fps, considered non-erosive. no armor req'd
Avg. Velocity = 1.5 fps, Avg. Travel Time= 1.5 min

Peak Depth= 0.10' @ 3.27 hrs
Capacity at bank full= 577.22 cfs
Inlet Invert= 7,910.00', Outlet Invert= 7,865.00'
10.00' x 2.00' deep channel, n= 0.054
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 135.0' Slope= 0.3333 '/'

→ $n = 0.0456\,(D_{50} \times S)^{0.159}$
where D_{50} is in inches (9")
S is slope of channel (0.333)

(from Abt et al, 1987)

Reach 4R: DD-17

Inflow Area = 3.785 ac, Inflow Depth = 0.18"
Inflow = 1.83 cfs @ 3.05 hrs, Volume= 0.056 af
Outflow = 1.43 cfs @ 3.10 hrs, Volume= 0.056 af, Atten= 22%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.1 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 3.1 min

→ peak vel. ≤ 5.0 fps, considered non-erosive, no armor req'd

Peak Depth= 0.51' @ 3.07 hrs
Capacity at bank full= 9.92 cfs
Inlet Invert= 7,880.00', Outlet Invert= 7,865.00'
0.00' x 1.00' deep channel, n= 0.025 Earth, clean & straight
Side Slope Z-value= 1.0 2.0 '/' Top Width= 3.00'
Length= 370.0' Slope= 0.0405 '/'

Reference: Use of Riprap for Bank Protection
Hydraulic Engineering Circular No. 11
US DOT Federal Highway Adm. 1978

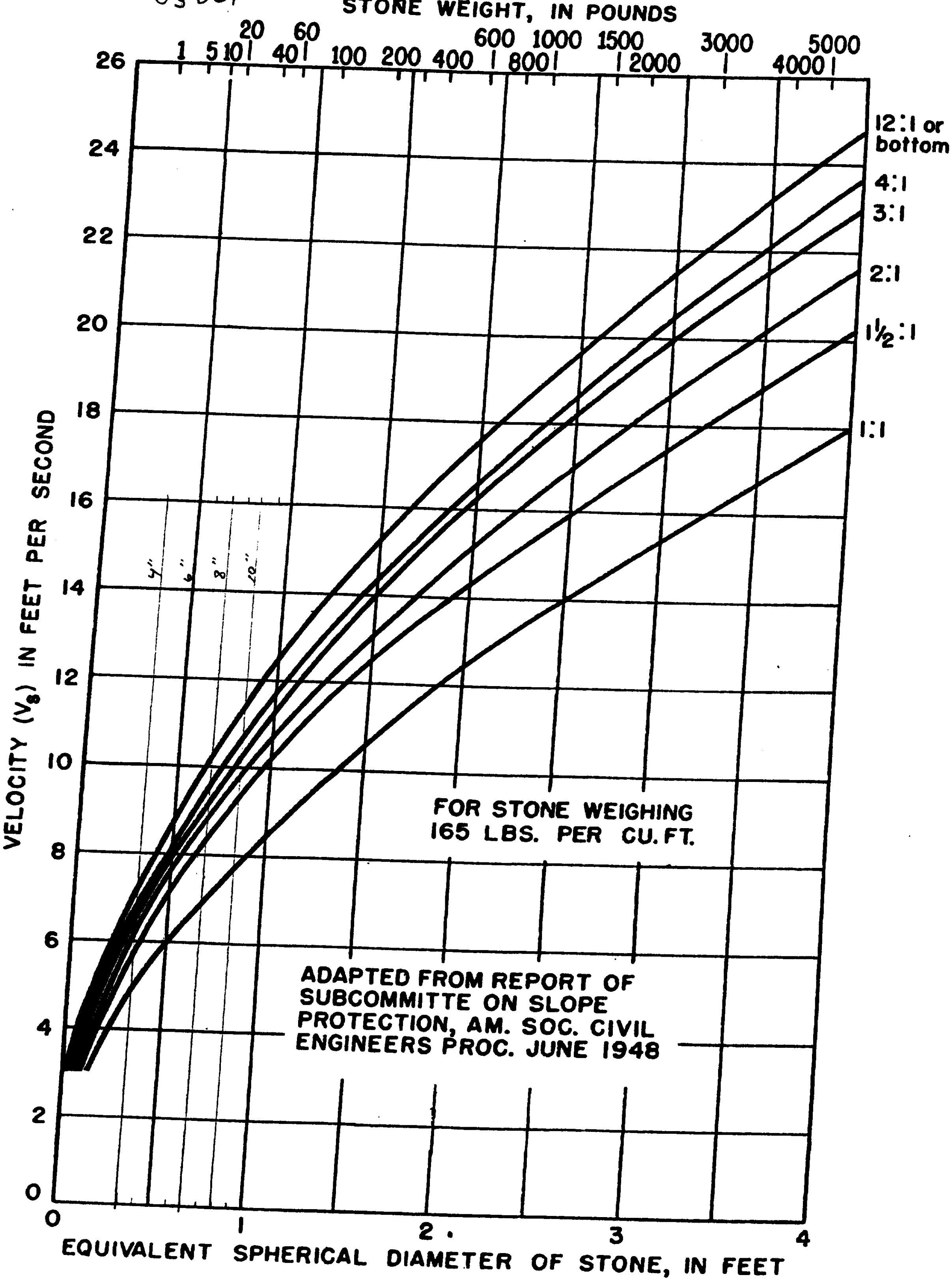


FIG. 2 - SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

4.3.1 Estimating Manning's n for Cascading Flow

The average Manning's roughness value, n, was computed for each failur test based on flow velocities and depths measured prior to failure, and are plotted versus the median stone size, D_{50}, in Fig. 4.7. It is observed in Fig. 4.7 that the n values for 1% and 2% slopes fall closely to the solic line representing a relationship developed by Anderson et al. (see Section 4.3.2). However, the n value for each stone size increased as the slope of the embankment increased, and the n value is over 40% higher when Depth/D_{50} < 2 (cascading flow conditions) than when Depth/D_{50} is greater than 2 (Table 4.8).

A median stone size-slope parameter ($D_{50} \times S$) was correlated to the Manning's n value for the CSU data as presented in Fig. 4.8. Combining the median stone size and slope in one parameter appears to have reduced the data scatter. The relationship can be expressed as:

$$n = 0.0456\ (D_{50} \times S)^{0.159} \qquad (4.8)$$

where D_{50} is in inches. The correlation coefficient, r^2, is 0.90. Therefore, a Manning's n value can be estimated for a riprapped surface in cascading flow as a function of the median stone size and slope.

4.3.2 Comparison of Procedures

A commonly used expression for determining Manning's n for riprap was presented by Anderson et al. (1970) as

NUREG/CR-4651 ORNL/TM-10100
Reference: Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase 1
SR Abt et al CSU, Oak Ridge Nat'l Lab USNRC, 1987

Table 4.13 Calculations for Example Problem 4.19

D_{50}[a]	Manning's n	Depth to convey flow (ft)	Maximum tractive force on channel bed (lb/ft²)	Channel bed stability factor (η_b)	Safety factor for channel bed (SF_b)	Maximum tractive force on walls (lb/ft²)	Channel wall stability factor (η')	Channel wall safety factor (SF)
1.7	0.043	0.72	4.49	0.541	1.53	3.41	0.308	1.36
2.0	0.044	0.73	4.58	0.467	1.72	3.48	0.268	1.45
2.5	0.046	0.75	4.68	0.382	2.02	3.56	0.220	1.56
2.2	0.045	0.74	4.62	0.429	1.84	3.51	0.247	1.50

[a]Use a riprap with a D_{50} of 2.2 ft for both channel sides and bottom.

From Eq. (4.46),

$$\beta = \tan^{-1}\left[\frac{\cos\lambda}{2\sin\alpha/\eta\tan\phi + \sin\lambda}\right]$$

$$= \tan^{-1}\left[\frac{\cos(5.71)}{2\sin(21.8)/(0.408\tan(42)) + \sin(5.71)}\right].$$

$$\beta = 25.1°$$

From Eq. (4.48),

$$\eta' = \eta\left[\frac{1+\sin(\lambda+\beta)}{2}\right] = 0.408\left[\frac{1+\sin(5.71+25.10)}{2}\right]$$

$$\eta' = 0.308.$$

From Eq. (4.45),

$$SF = \frac{\cos\alpha\tan\phi}{\eta'\tan\phi + \sin\alpha\cos\beta}$$

$$= \frac{\cos(21.8)\tan(42)}{0.308(\tan(42)) + \sin(21.8)\cos(25.1)}$$

$$SF = 1.36.$$

Thus the riprap is stable, but does not have the required safety factor of 1.5. The selection of an acceptable riprap for the channel side slopes will be made using trial and error. The calculations are in Table 4.13. It is assumed that the riprap on the channel bed will be the same as that used on the side slopes. It would obviously be possible to vary the side slopes and channel width to obtain a smaller D_{50}. The final selection of channel dimensions and riprap size would have to be based on economics.

Selecting Proper Gradation

It is important for a riprap to have a gradation such that the voids between the larger particles are filled with smaller particles to reduce flow beneath the riprap and the formation of open pockets. A suggested gradation for riprap has been made by Simons and Senturk

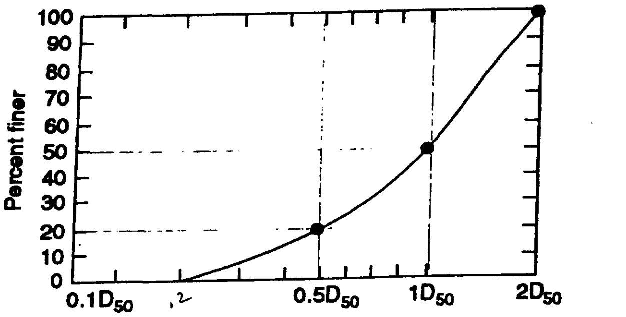


Figure 4.19 Suggested size distribution of riprap (after Simons and Senturk, 1977, 1992).

(1977, 1992) based on studies at Colorado State University. The proposed gradation is shown in Fig. 4.19.

Selecting an Underlying Filter

The placement of a properly designed filter blanket underneath the riprap is necessary when the particle size of the riprap is much larger than that of the base material. The following criteria have been established for sizing the filter, based on the size distribution of the riprap and the base material:

(1) $$\frac{D_{50}(\text{filter})}{D_{50}(\text{base})} < 40 \quad \text{also} \quad \frac{D_{50}(\text{riprap})}{D_{50}(\text{filter})} < 40$$

(2)

$$5 < \frac{D_{15}(\text{filter})}{D_{15}(\text{base})} < 40 \quad \text{also} \quad 5 < \frac{D_{15}(\text{riprap})}{D_{15}(\text{filter})} < 40$$

(3) $$\frac{D_{15}(\text{filter})}{D_{85}(\text{base})} < 5 \quad \text{also} \quad \frac{D_{15}(\text{riprap})}{D_{85}(\text{filter})} < 5.$$

These criteria were developed for sizing filters around drain pipe to prevent piping of the soil into the

Pond 3P: Existing Sed Pond

Inflow Area =	18.682 ac,	Inflow Depth = 0.52"		
Inflow =	11.72 cfs @	12.08 hrs, Volume=	0.804 af	
Outflow =	0.00 cfs @	0.00 hrs, Volume=	0.000 af,	Atten= 100%, Lag= 0.0 min
Primary =	0.00 cfs @	0.00 hrs, Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 7,860.00' Surf.Area= 8,755 sf Storage= 20,787 cf
Peak Elev= 7,863.48' @ 34.75 hrs Surf.Area= 11,388 sf Storage= 55,823 cf (35,036 cf above start)
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	7,857.00'	73,982 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
7,857.00	4,488	300.0	0	0	4,488
7,858.00	6,582	346.0	5,502	5,502	6,875
7,860.00	8,755	388.0	15,285	20,787	9,435
7,862.00	10,279	417.0	19,014	39,801	11,460
7,864.00	11,792	444.0	22,054	61,854	13,500
7,865.00	12,466	454.0	12,127	73,982	14,344

Device	Routing	Invert	Outlet Devices
#1	Primary	7,864.00'	**18.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=7,860.00' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 3P: Existing Sed Pond

Inflow Area =	18.682 ac,	Inflow Depth = 0.30"		
Inflow =	9.22 cfs @	3.19 hrs, Volume=	0.462 af	
Outflow =	6.69 cfs @	3.28 hrs, Volume=	0.462 af,	Atten= 28%, Lag= 5.4 min
Primary =	6.69 cfs @	3.28 hrs, Volume=	0.462 af	

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 7,864.00' Surf.Area= 11,792 sf Storage= 61,854 cf
Peak Elev= 7,864.28' @ 3.28 hrs Surf.Area= 11,978 sf Storage= 65,172 cf (3,318 cf above start)
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 12.2 min (247.6 - 235.4)

Volume	Invert	Avail.Storage	Storage Description
#1	7,857.00'	73,982 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
7,857.00	4,488	300.0	0	0	4,488
7,858.00	6,582	346.0	5,502	5,502	6,875
7,860.00	8,755	388.0	15,285	20,787	9,435
7,862.00	10,279	417.0	19,014	39,801	11,460
7,864.00	11,792	444.0	22,054	61,854	13,500
7,865.00	12,466	454.0	12,127	73,982	14,344

Device	Routing	Invert	Outlet Devices
#1	Primary	7,864.00'	**18.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=6.60 cfs @ 3.28 hrs HW=7,864.28' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 6.60 cfs @ 1.3 fps)

Pond 3P: Existing Sed Pond

Inflow Area =	18.682 ac,	Inflow Depth = 0.59"		
Inflow =	20.77 cfs @	3.20 hrs,	Volume=	0.925 af
Outflow =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af, Atten= 100%, Lag= 0.0 min
Primary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 7,860.00' Surf.Area= 8,755 sf Storage= 20,787 cf
Peak Elev= 7,863.93' @ 26.60 hrs Surf.Area= 11,740 sf Storage= 61,075 cf (40,288 cf above start)
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	7,857.00'	73,982 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
7,857.00	4,488	300.0	0	0	4,488
7,858.00	6,582	346.0	5,502	5,502	6,875
7,860.00	8,755	388.0	15,285	20,787	9,435
7,862.00	10,279	417.0	19,014	39,801	11,460
7,864.00	11,792	444.0	22,054	61,854	13,500
7,865.00	12,466	454.0	12,127	73,982	14,344

Device	Routing	Invert	Outlet Devices
#1	Primary	7,864.00'	**18.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=7,860.00' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)