SECTION 3.6

GRAVEL CANYON

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Diversion GCD-1 conveys the runoff from an undisturbed area (7.81 acres). The peak discharge, based on a 10-year 6-hour storm event, is 2.01 cfs. The design discharge will flow at a maximum depth of approximately 0.6 feet along the flatter reaches of the diversion, and at a velocity of approximately 6.3 feet per second along the steepest reach of the diversion. The existing diversion has adequate freeboard provided above the design flow depth.

Diversion GCD-2, along the south side of ancillary road A-1, collects runoff from both disturbed and undisturbed areas and channels it to the ditch along US Highway 6. This diversion also prevents runoff from crossing road A-1. The peak design flow from the 9.6 acre watershed is 2.66 cfs. The geometry of the diversion is summarized in Table 3.6-2 (Exhibit 19).

Berm ACB-1 is constructed along the north side of road A-1 to contain the storm runoff that falls on the road. For simplicity of design, the berm was designed to contain the runoff from all of watershed GCWS-D1. The minimum berm geometry is summarized in Table 3.6-3 (Exhibit 19).

3.6-3(2) <u>Alternative Sediment Controls</u>

There are no sediment ponds in Gravel Canyon. Currently the area is revegetated and thus no alternative sediment control structures are necessary.

3.6-4 <u>Reclamation Plan</u>

The reclamation work in Gravel Canyon will be done contemporaneously with the disturbance of the site. After material is taken from an area within the site, the area will be graded for overland flow and the site revegetated. The site will not be ready for final reclamation until all of the disturbed area sites in the Willow Creek Mine are reclaimed. A total of approximately 97,000 cubic yards of resoiling material is available for use based on the postmining topography shown on Exhibit 3.6-3 (Exhibit 19). If however, there is approximately 37,000 to 65,000 cubic yards of resoiling material utilized, then the postmining topography will be similar to that shown on Exhibit 3.6-4, or somewhere in between. See Table 3.6-6 and Figure 3.6-5 (Exhibit 19) for the 97,000 cubic yard mass balance calculation summary and the grading cut/fill grid, respectively. Table 3.6-6 also presents the mass balance for the 37,000 and 65,000 cubic yard scenarios.

The land use for this area is wildlife habitat.

3.6-4(1) Reclamation Work

The reclamation work consists of the following:

Demolition: Any crushing or screening facilities which may be used will be removed. The existing retaining wall along US Highway 6 and 50 will also be removed.

Grading: Grading will be done to establish drainage and maximize the amount of material to be used as resoiling material. Access road A-1 will be removed in the process. The scheduling of the grading work will minimize the disturbance to the hydrologic balance. Prior to the start of grading work, alternative sediment control structures will be installed.

The grading plan as shown in the postmining topography, Exhibit 3.6-3 and 3.6-4 (Exhibit 19), meets the criteria set forth in R645-301-553, Backfilling and Grading. The disturbed areas are graded to approximate the original contours by blending spoil into the surrounding area which creates a landform which complements and resembles the surrounding terrain. There are no cut slopes or highwalls within the disturbed area boundary.

Resoiling: The 5 acres of disturbance which are to be reclaimed were disturbed prior to SMCRA. No topsoil was salvaged from the site. The existing soils at the site will be used for resoiling material. The resoiling material will be analyzed for the following parameters: Ph, electrical conductivity, sodium absorption ratio, texture, nitrate-N, available phosphorous and extractable potassium. Two composite samples of the regraded surface will be taken. Analyses are presented in Appendix 3.4M.

Seeding and Mulching: The Upland Seed Mixture (Table 5.3-2b,Section 5.3, Willow Creek Permit) will be used in Gravel Canyon. Prior to application of the reclamation seed mix, hay will be incorporated into the growth media at a rate of 2 tons per acre. This will be done to improve soil structure for aeration purposes, increase micropore space, and improve the water holding capacity of the soil. Incorporation of the mulch will occur through deep gouging. No fertilizer will be used during the reseeding activities.

Following seeding, an additional 1.0 to 1.5 tons per acre of certified noxious weed free straw mulch will be spread over the seeded growth media mostly be mechanical blowers with occasional hand spreading. The straw mulch will then be sprayed with a tackifier and mulch mixture at about 500 lbs per acre following spreading to retain it on the reseeded slopes. The tackifier and mulch technique provides a better means for retaining the straw mulch onto the reseeded areas than did the crimping technique.

3.6-4(2) Reclamation Hydrology

Reclamation Channel Design: The reclamation channels were designed to approximate the geometry of the natural stream channel. The natural channel sections were measured in the field and approximated with a trapezoidal cross section. The reclamation channels were designed with a 3H:1V side slope to provide channel stability. The hydraulic slope of each channel was measured from the postmining topographic maps (Scale: 1" = 100').

The natural streambed that exists upstream of the disturbed area in Gravel Canyon can be considered ephemeral since it carries water only in direct response to a precipitation event, or the melting of snow and ice, and is above the local water table. Ephemeral streams are classified as carrying miscellaneous flows, per R645-301-742.330, which requires that permanent diversions be sized for the 10-year 6-hour storm event. Thus, the reclamation channels are designed to transport the peak discharge of a 10-year 6-hour precipitation event of 1.4 inches (Miller et. al, 1973). Riprap sizing for these drainages was also based on the peak discharge rates from the 10-year 6-hour precipitation event. A description of the methods used to determine the peak discharge rates is presented in Chapter 7 (Exhibit 19).

The reclamation channel drainage areas for Gravel Canyon are presented on Exhibit 3.6-3 (Exhibit 19). The large drainage areas not fully contained on Exhibit 3.6-3 (Exhibit 19) can be found on Exhibit 3.4-8 (Exhibit 19).

Curve numbers for the undisturbed drainage areas were estimated from vegetation data assumed to be similar to that of the Adit No.1 Canyon, as shown on Exhibit 9-1 (Exhibit 19). Therefore the same curve number for the Adit No. 1 Canyon was used for the undisturbed area of Gravel Canyon. A curve number of 75 was calculated for the undisturbed drainage areas and a curve number of 80 was assumed for the reclaimed areas. Curve number calculations are presented in Appendix 3.6B.

The following general approach was used during design of the reclamation channels:

- o The design capacity of the ephemeral reclamation channels was based on the 10-year 6-hour storm and the <u>minimum</u> channel slope.

- o Riprap was sized based on the 10-year 6-hour storm and the <u>maximum</u> channel slope for ephemeral drainage channels.

- o The roughness coefficient (Manning's "n") for riprapped channels was determined according to the equation (Barfield et al., 1981):

$$n = 0.0395 D_{50}^{1/6}$$

where, n = Manning's roughness coefficient
D_{50} = median riprap diameter (ft)

- o Designs are based on channel construction on fill. Where the reclamation channel construction occurs on rock, riprap quantities will be reduced or eliminated (depending on the competency of the rock).

- o Riprap sizing is based on the methodology presented in U.S. Department of Transportation Hydraulic Engineering Circular No. 11 (1967).

- o When transitioning downstream from a steep channel slope to a flat channel slope, the larger riprap from the steep section will be extended for 15 feet into the channel section with the flatter slope to minimize erosion.

- o Riprap volumes were calculated assuming a thickness of 6 inches, or 2.0 times the D_{50} value, whichever is greater. The filter blanket volume for the main channel was calculated assuming a filter thickness equal to one half the thickness of the over-lying riprap, but not less than 6 inches (Barfield et al., 1981).

Calculations regarding design of the Gravel Canyon reclamation channels are presented in Appendix 3.6B. A summary of the reclamation channel design is presented in Table 3.6-4 (Exhibit 19).

The reclamation channels were designed to pass the peak discharge with a minimum freeboard of 1 foot. It should be noted that those ephemeral channels designed based on the 10-year 6-hour storm will have adequate channel capacity to contain the 100-year 6-hour peak discharge with no freeboard.

A detailed riprap and filter blanket design is not presented in Appendix 3.6B. The riprap and filter blanket gradations for the channels have been engineered based on methods presented in Barfield et al. (1981). The filter blanket will consist of a 6-inch thick layer of UDOT 1" base mix and a synthetic fabric will not be used. The channel design presented in Appendix 3.6B is appropriate for both of the reclamation scenarios presented in Exhibits 3.6-6 and 3.6-4 (Exhibit 19). The channel design is for the scenario that removes approximately 97,000 cubic yards of topsoil. This represents the worst case condition because it has both flatter and steeper slopes as well as having the largest water shed area. The reclamation channel for the option that removes approximately 37,000 cubic yards of topsoil ends in an existing pre-SMCRA undisturbed diversion channel.

Estimates for riprap and filter blanket volumes were prepared and are presented in Table 3.6-5 (Exhibit 19). Approximately 7,560 cubic feet of riprap and 7,088 cubic feet of filter material will be required to construct the reclamation channels associated with removing approximately 97,000 cubic yards of topsoil. To construct the reclamation channel associated with removing approximately 37,000 cubic yards of topsoil, approximately 6,347 cubic feet of riprap and 5950 cubic feet of filter material will be required.

3.6-4(3) <u>Alternative Sediment Control Measures</u>

The reclamation plan calls for the disturbed area of Gravel Canyon to be regraded to allow storm runoff to overland flow to the permanent reclamation channel. Incorporation of sediment ponds and associated diversion ditches into the relatively small area of Gravel

Canyon would result in redisturbance of these areas when these structures are removed after establishment of permanent vegetation. The use of a sediment pond would simply lengthen the time necessary to establish permanent vegetation throughout the permit area. In addition, a combination of alternative sediment control measures can achieve the same success in preventing sediment transport on the reclaimed area. Therefore, ponds will not be used to control sediment during Phase I of reclamation.

Castle Gate Mine proposes to employ the following alternative methods in varying degrees to limit and control sediment runoff:

1. Placement/Redistribution of growth media,
2. Incorporation of hay mulch into growth media,
3. Deep gouging of the growth media,
4. Seeding the prepared soil,
5. Addition of more mulch following seeding, and
6. Physically or chemically anchoring the final mulch layer.

Based on Simons, Li & Associates (1983, Table 8.1), these methods constitute some of the best available control technology for the purpose of mining reclamation. These methods have been very successful at recently reclaimed sites and are expected to work well at this site.

Alternative sediment control measures can be classified into three categories: filtering structures, mechanical treatment, and surface protection measures. Filtering structures inhibit runoff and sediment transport capacity by reducing flow velocity. They also physically trap sediment in the filter openings while allowing water to pass through. Mechanical treatment increases surface roughness thereby reducing overland flow velocity, which minimizes the sediment transport capacity. Detaining some of the would-be runoff also improves soil moisture for plant germination. Surface protection measures include mulching, mulch binders, netting, and seeding. These measures are the most effective controls since they minimize the amount of soil detached by raindrop impact, and thus limit soil loss at the source. Surface protection measures also increase the surface roughness and increase water infiltration into the ground. The above listed alternative sediment control methods combine mechanical and surface protection measures.

Mechanical treatment of slopes will be performed by ripping and/or deep gouging the soil to a depth of 18 inches to 24 inches. Ripper shanks, if used, should be spaced about seven feet apart, or as allowed by the piece of equipment, and create parallel slots four to ten inches wide. Ripping and or deep gouging will loosen the soil and allow root penetration increase surface roughness, and increase moisture storage. This will allow for quicker vegetation establishment, which will reduce erosion. The depressions from roughening trap sediment dislodged by raindrop impact and overland flow. They also shorten the exposed reaches over which runoff will flow, thereby reducing the sediment carrying capacity of the runoff.

In regard to surface protection measures, the incorporation of the mulch into the surface roughening will ensure that the major portion of mulch is anchored on site, The mulch itself can significantly reduce the amount of sediment yield from an area (Simons, Li & Associates, 1983, p. 4.30) The mulch also helps retain moisture to allow for seed germination. Based on a rainfall intensity factor of 0.61 inches per hour, the minimum mulch application rate is 0.9 tons per acre to prevent mulch removal by rainfall (Simon et al., 1983, Figure 4.14). The referenced figure assumes that no chemical binder will be used. The intensity factor corresponds to a 10-year 6-hour storm event. Mulch, with a tackifier, will be applied at the rate of 2,000 pounds per acre.

Permanent plant growth is the best method of controlling erosion from slopes, according to Simons, Li & Associates (1983, p.4.44). Upon completion of the grading in accordance with the plan depicted in Exhibit 3.6-3 and 3.6-4 (Exhibit 19), and mechanical treatment of the soil, the reclaimed area will be seeded with grasses, shrubs and forbs. Seeding will be performed at the appropriate time of the year in consideration of available moisture for germination. Areas in which the seed does not germinate will be reseeded. Following seeding the area will be mulched again at a rate of 1.0 to 1.5 ton per acre.

Appendix 3.6C presents calculations that quantify the sediment yield that could be expected annually under pre-mining conditions, immediately after reclamation, and after vegetation establishment, as 24.2 tons/acre/year, 0.14 tons/acre/year, and 20.7

tons/acre/year, respectively . These calculations were performed to compare the sediment yield during each of the time periods to demonstrate that the reclaimed surface will produce less sediment than the same area under undisturbed conditions. The cumulative implementation of each sediment control measure substantially reduces the amount of sediment eroded from the reclaimed areas, to the point that the mulch and roughening theoretically inhibits soil loss more effectively than the undisturbed ground cover. Since the undisturbed areas contributing sediment to the stream channels are larger than the reclaimed areas, most of the sediment erosion will occur from the undisturbed areas. As long as the depressions from surface roughening are in place, the sediment yield from up gradient areas will be prevented from reaching any stream channles.

Whenever possible, a minimum of one method of sediment control will be in place during reclamation construction. Upon completion of the grading and soil ripping, the reclaimed area will be seeded and mulched.

The possibility exists that a 10-year 6-hour storm (or larger) will occur during the grading operation and before the alternative sediment control measures are in place. Although every reasonable effort will be made to have at least one sediment control measure in place, there may be a period of time when that is not feasible. However, the probability that a 10-year event will occur during the construction period of approximately six months is only 5.1% (Linsley and Frazini, 1979, Eq. 5-3). This probability is relatively small, and thus no special measures will be taken to address this possibility.

The alternative sediment controls constructed during reclamation will be inspected quarterly or after every major storm event. Observations made during these inspections, as well as corrective actions taken, will be recorded. Corrections to any weaknesses in the implementation of the sediment control plan will be remedied immediately to prevent future silt runoff into the main stream channel. Corrective action will be taken when a gully greater than nine inches in depth is created due to lack of vegetation establishment, or when the mulch and seed have been transported by wind or overland flow. Corrective action will consist of regrading of the ground surface only as necessary to fill in nine inch gullies caused by erosion, and reseeding and mulching, as warranted, to reestablish vegetation.

3.6-5 Reclamation Timetable

The following timetable can be used to estimate the total amount of time needed to reclaim Gravel Canyon once the material to be placed on the Preparation Plant Refuse Pile has been removed.

1. Demolition - Removal of structures and roads	Week 1
2. Grading and channel construction	Week 1-4
3. Seed bed preparation	Week 3-4
4. Seeding and mulching	Week 3-4
5. Vegetation Monitoring	Until Bond Release

3.6-6 Transportation Facilities

Beltlines: There are no beltlines used in Gravel Canyon.

Roads: One ancillary road is used to access the Gravel Canyon Area. The road location is shown on Exhibit 3.6-2 (Exhibit 19). A typical cross section is found on Figure 3.6-1 (Exhibit 19). The primary purpose of this road is to access the site by mine personnel in light vehicles for inspection.

The ancillary road was constructed using non-toxic and non-acid bearing materials in the road's surface. No embankments were constructed to support this ancillary road. The side slopes of the road are revegetated. Erosion is controlled or prevented by channeling water in ditches or overland flow. Small road ditches that convey flow from one acre or less may use the minimum size of a generically designed diversion. A "generic" ditch must be a minimum of 1.0 feet deep, triangular in cross section, have 2:1 horizontal to vertical side slopes and be lined with a minimum D_{50} equal to 2.5". This design assumes a curve number of 90, one acre of drainage, a minimum channel slope of 2% and a maximum channel slope of 15% (see Table 3.6-2, Exhibit 19). The road will be maintained by grading when necessary to provide a driveable surface.

A primary road may be constructed for use when material is removed to cover the refuse pile at the Castle Gate Preparation Plant site (see Figure 3.6-2, Exhibit 19). No embankments will be needed to support this primary road. Erosion will be controlled or prevented by channelling water in ditches or by overland flow across side slopes which utilize alternative sediment controls. The ditch design will be "generic" as described for ancillary road A-1 above. The maximum road grade will be 5%. The road will be maintained by grading when necessary to provide a driveable surface.

3.5-7 References

Barfield, B.J., R.C. Warner, and C.T. Hann. 1981. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press. Stillwater, Oklahoma.

Chang, M., S.P. Watters and A.K. Sayok. 1989. A Comparison of Methods of Estimating Mean Watershed Slope. Water Resources Bulletin. Volume 25, No. 2.

Linsley, Ray K. and Joseph B. Frazini. 1979. Water-Resources Engineering. McGraw-Hill Book Company. New York.

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-Frequency Atlas of theWestern United States. Volume VI-Utah. National Oceanic and Atmospheric Administration. National Weather Service. Silver Spring, Maryland.

Simons, Li & Associates, Inc. Design of Sediment Control Measures for Small Areas in Surface Coal Mining. 1983. Prepared for the Office of Surface Coal Mining, Washington, D.C..

U.S. Department of Transportation. 1967. Use of Riprap for Bank Protection. Hydraulic Engineering Circular No. 11. Washington, D.C..

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TABLE 3.6-4

GRAVEL CANYON
RECLAMATION CHANNEL SUMMARY

Reclamation Channel	Minimum Bottom Width (FT)[a]	Side Slopes (H:V)	Minimum Channel Depth (FT)	Minimum Bottom Slope (%)	Maximum Flow Depth (FT)	Freeboard (FT)	Maximum Bottom Slope (%)	Maximum Velocity (FT/S)	Riprap Max D_{50} (IN)
GCRD-1 [b] [c]	3	3:1	1.5	2.0	0.43	1.07	25	6.7	4

(a) Minimum bottom width measured at minimum depth from top of channel.
(b) Design based on 10-year 6-hour storm (Permanent structure fro ephemeral drainage).
(c) This channel design is appropriate for the presented reclamation options.

TABLE 3.6-5

GRAVEL CANYON
RECLAMATION CHANNELS RIPRAP AND FILTER BLANKET VOLUMES

Channel	Riprap D_{50} (IN)	Length (FT)	Perimeter (FT)	Riprap Thickness (IN)	Riprap Volume (FT^3)	Filter Thickness (IN)	Filter Volume (FT^3)
GCRD-1 [a]	4	*810*	12.5	8	*7088*	6	*7088*
GCRD-1 [b]	*4*	*840*	*12.5*	*8*	*7840*	*6*	*7350*
GCRD-1 [c]	*4*	*680*	*12.5*	*8*	*6347*	*6*	*5950*

(a) 97,000 CY Option
(b) 65,000 CY Option
(c) 37,000 CY Option

TABLE 3.6-6

GRAVEL CANYON
RECLAMATION MASS BALANCE SUMMARY

OPTION	CUT (CY)	FILL (CY)	NET (CY)
Exhibit 3.6-3 Option A	**101,732**	**4,639**	**97,093 Cut**
Exhibit 3.6-4 Option B	**65,103**	**126**	**64,977 Cut**
Exhibit 3.6-4 Option C	**37,228**	**150**	**37,078 Cut**

Excess cut is topsoil hauled from the topsoil stockpile for the reclamation of other Mine properties.

Gravel Canyon Topsoil Stockpile
Reclamation Channel Filter Design

The soil sample taken from the Gravel Canyon soil is described as a Clayey Sand with Gravel with 30% gravel, 30% sand and 40% silt and clay. The majority of the silt and clay fraction being silt instead of clay.

Evaluate a UDOT 1" base mix for the filter for a $D_{50} = 4"$ riprap. Since the soil has such a large percentage of silt and clay a filter is assumed to be necesary.

Use the criteria presented in Barfield et. al. (1994). This criteria was developed for sizing filters around drain pipes to prevent piping of the soil into the drain. Using this criteria gives a conservative filter design since we are not concerned with sediment accumulation in the filter only that velocities in the filter are not such that the base soil erodes.

The criteria are:

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

(2) $\frac{D_{15}\,(\text{filter})}{D_{15}\,(\text{base})} > 5 + < 40$ and $\frac{D_{15}\,(\text{Riprap})}{D_{15}\,(\text{filter})} > 5 + < 40$

(3) $\frac{D_{15}\,(\text{filter})}{D_{85}\,(\text{base})} < 5$ and $\frac{D_{15}\,(\text{riprap})}{D_{85}\,(\text{filter})}$

Riprap
$D_{85} = 7.2"$
$D_{50} = 4"$
$D_{15} = 1.7"$

Filter
$D_{85} = 0.5"$
$D_{50} = 0.15"$
$D_{15} = 0.007"$

base
$D_{85} = 0.55"$
$D_{50} = 0.006"$
$D_{15} = 0.0006"$

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$$\frac{D_{50}\ (\text{riprap})}{D_{50}\ (\text{filter})} = \frac{4''}{0.15} = 26.7 < 40 \quad \text{ok}$$

$$\frac{D_{15}\ (\text{riprap})}{D_{15}\ (\text{filter})} = \frac{1.7}{0.007} = 243 \quad > 40 \qquad \text{concern}$$

$$\frac{D_{15}\ (\text{riprap})}{D_{85}\ (\text{filter})} = \frac{1.7}{0.5} = 3.4 \quad < 5 \quad \text{ok}$$

Comparison of riprap to filter meets all criteria.

$$\frac{D_{50}\ (\text{filter})}{D_{50}\ (\text{base})} = \frac{0.15}{0.006} = 25 < 40 \quad \text{ok}$$

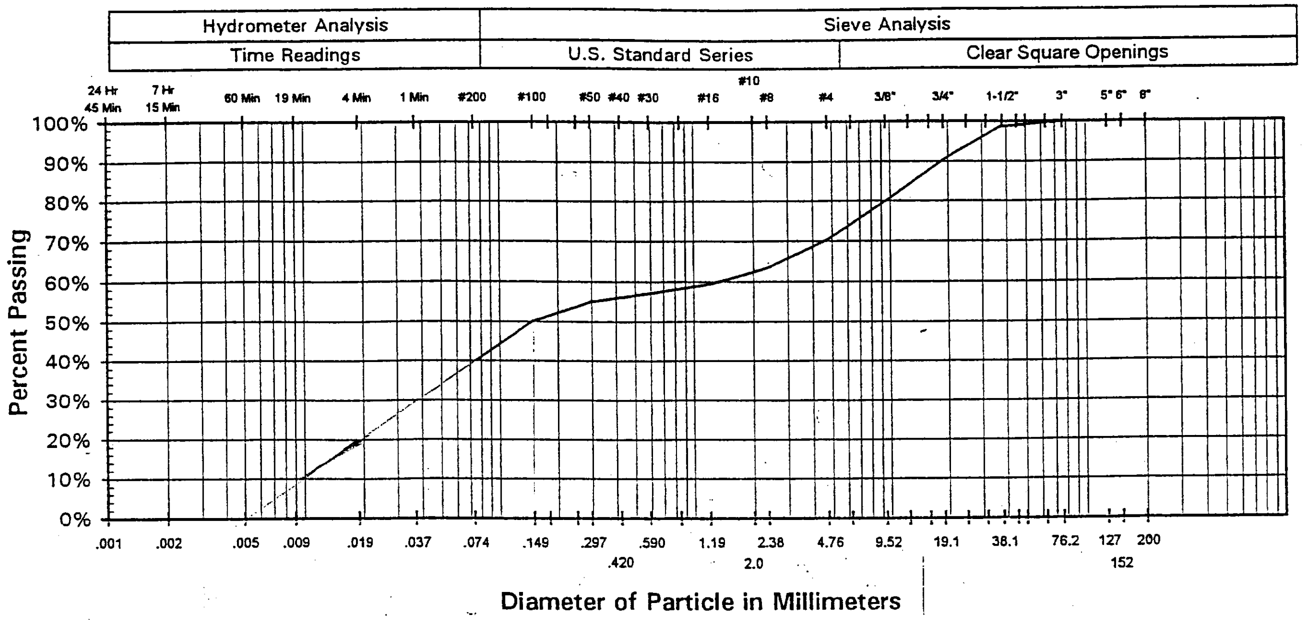
$$\frac{D_{15}\ (\text{filter})}{D_{15}\ (\text{base})} = \frac{0.007}{0.0006} = 11.7 \quad > 5 + < 40 \quad \text{ok}$$

$$\frac{D_{15}\ (\text{filter})}{d_{85}\ (\text{base})} = \frac{0.007}{0.55} = 0.013 < 5 \quad \text{ok}$$

To address the one concern the riprap should be filled in with soil and seeded. The gravel and sand in the soil will fill in the spaces in the riprap and allow vegetation to further stabilize the channel

The Filter layer should 6" thick.

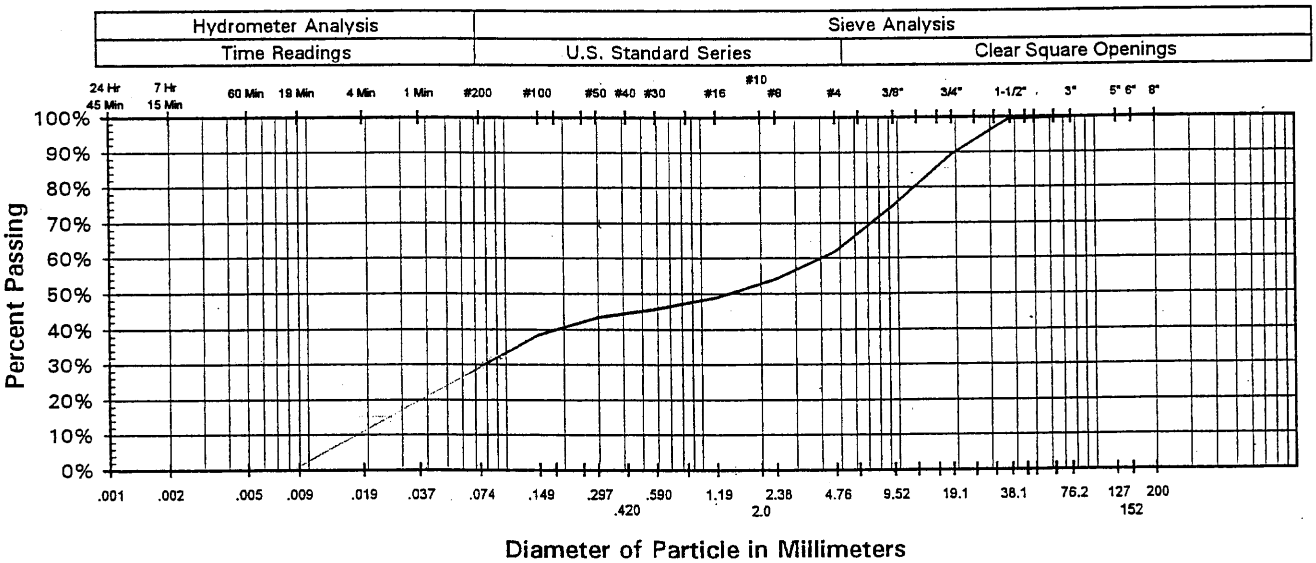
APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	30%	Liquid Limit	-
Sand	30%	Plasticity Index	-
Silt and Clay	40%	Sample Location	Gravel Canyon Soil

Sample Description Clayey Sand with Gravel (SC)

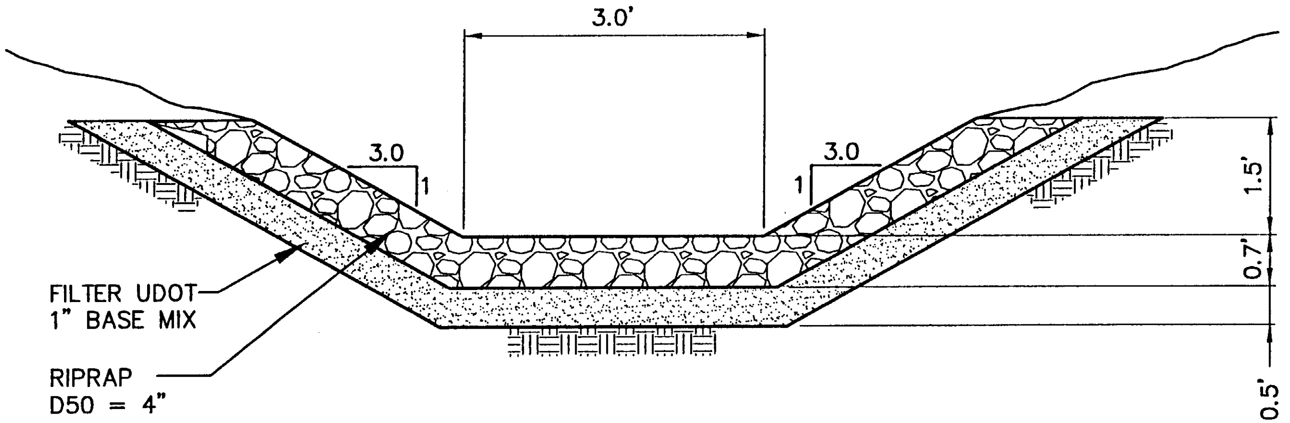


Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	38%	Liquid Limit	-
Sand	32%	Plasticity Index	-
Silt and Clay	30%	Sample Location	School House Canyon Soil

Sample Description Clayey Gravel with Sand (GC)

Project No. 1040006 **GRADATION TEST RESULTS** Figure 1



NO SCALE

CHANNEL CROSS-SECTION GCRD-1

EarthFax

G:\UC709\17\DWG\GRAVEL CANYON\CHAN-FIG.DWG

APPENDIX 3.6C

ALTERNATIVE SEDIMENT CONTROL MEASURES
CALCULATIONS

Comparison of Pre-Mining and Post-Reclamation Sediment Yields for the Gravel Canyon Topsoil Stockpile

Sediment control after reclamation of the Gravel Canyon Topsoil Stockpile will be by Alternate Sediment Control Measures ("ASCM"). The same reclamation methods will be used for the reclamation of this site as was used for the reclamation of Hardscrabble Canyon, Crandall Canyon, Adit No. 1, and Star Point Mines. Sediment control at these sites have been successful and the same methods are expected to be successful at this site as well. The sediment control methods to be applied at this site are as follows:

1. Deep gouging;
2. Mixing hay into the soil;
3. Mulching the gouged surface;
4. Securing the mulch with a tackifier; and
5. Revegetation.

The purpose of this calculation is to evaluate the sediment yield characteristics of the disturbed area under pre-mining and post-mining conditions. The three conditions to be evaluated will be as follows:

1. Pre-mining, This site was disturbed prior to 1977 and was likely disturbed during mining early in the 1900s. The site has likely been disturbed for over 100 years. Hence pre-disturbance information is not available and the pre-mining condition is a disturbed condition. Although the pre-mining condition is a disturbed condition where possible an undisturbed condition will be assumed for these calculations.

2. Immediate Post-Reclamation, after deep gouging, mulching and seeding but before vegetation establishment.

3. Long Term Post-Reclamation, after vegetation is well established and depressions from deep gouging are mostly gone.

Mixing hay into the soil consists of 2 tons/acre of hay being mixed into the soil during deep gouging. Another 1 to 1.5 tons/acre of straw mulch will be broadcast on the surface. The straw mulch will be secured with a tackifier when the site is hydroseeded. A small amount of wood fiber mulch will also be applied with the tackifier during hydroseeding.

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Methodology

Sediment yield calculations will be made using the Modified Universal Soil Loss Equation ("MUSLE") as presented by Israelsen et. al. (1984) and Barfield et. al. (1994)

$$A = R*K*LS*VM$$

where:

A = Sediment Yield (tons/acre/year)
R = Rainfall Factor
K = Soil Erodibility Factor
LS = Length and Steepness of slope factor
VM = Erosion Control Factor

Each of the above factors will be evaluated for each of the three conditions.

Rainfall Factor (R)

R=11 From Map R7 Israelsen et. al. (1984)

The same factor will apply for all three conditions.

Soil Erodibility Factor (K)

Pre-mining

As mentioned above the site has been disturbed for a long time and pre-disturbance data are not available. The Soil Survey of Carbon Area, Utah catagorizes soils in the vicinity of the site that were not disturbed at the time of the survey. The Gravel Canyon area is identified as map unit 72 Pathead-Curecanti Family Association. The Soil Survey identifies the bottom of the canyon to be predominantly a Curecanti family soil. The erodibility factor identified in Table 12 on page 277 is 0.28 for the surface sample.

Post reclamation

The soils used in the reclamation of Gravel Canyon Topsoil Stockpile will be a mix of the native soils and soil hauled from Crandall Canyon and the Preparation Plant area. The source area for the topsoil hauled from Crandall Canyon is identified as map unit 125 Uinta-Toze Families Complex. This soil has a surface soil erodibility factor of 0.24 with the lower soil layers having a factor of 0.15 and 0.1. These soils had high organic content and lower clay content than the soils in the Preparation Plant Area and should be excellent growth media. The soils from the Preparation Plant area were likely Map unit 121 Travisilla-rock outcrop-Gerst Complex. The near surface has some cementation and has a very low erodibility of 0.05 while soils 2 inches down have a much higher erodibility factor of 0.37. Since the Preparation Plant soils were near the top of the stockpile and have been hauled to the Refuse pile for reclamation it can be assumed that most of the soil used in reclamation is either native or from Crandall Canyon. The lower native soil layers in Gravel Canyon have a lower soil erodibility factor of 0.1. During reclamation the native soils and Crandall Canyon Soils will be mixed. I will assume a soil erodibilty factor of 0.22 since much of the reclaimed soil surface will be the less erodible sub soils from Crandall Canyon and Gravel Canyon.

Length-Steepness Factor (LS)

$$LS = \left(\frac{65.41 S^2}{S^2 + 10{,}000} + \frac{4.56 S}{\sqrt{S^2 + 10{,}000}} + 0.065\right)\left(\frac{l}{72.6}\right)^m$$

Where:

LS = Length Steepness Factor
S = Slope Gradient (%)
l = Slope Length (ft)
m = empirical exponent (function of slope)

Pre-mining

Since the site was likely disturbed about 1900 no pre-disturbance topography is available. However, using adjacent undisturbed topography the site had slopes between 10 and 100%. The site is located in the lower relatively flat area of Gravel Canyon. The slopes of the undisturbed areas on the canyon sides are mostly between 60% and 100%. In an undisturbed conditions the slopes extend unbroken from the ridge lines down to the channels in the canyons. These distances may be up to 1100'. However most slope lengths are 400' to 500' in length. The steepest slopes will generate the greatest erosion so I will focus on the steep areas when comparing sediment yield. For the undisturbed conditions I will assume a slope of 60% and a slope length of 400'.

LS = 46.3 (Table C-1 Israelsen et. al. (1984))

Immediate Post Reclamation

The reclaimed areas will be deep gouged prior to seeding. Deep gouging creates 1 to 3' deep holes that prevent runoff from concentrating and achieving an erosive velocity. In the early stages of reclamation the gouges prevent any water from running off the reclaimed areas. The gouges also stop any runoff from upgradient undisturbed areas. Therefore, the slope length is very short. I will assume a slope length of 10' although the distance is actually less. The maximum slope of reclamation is a 2:1 slope or 50%. I will assume the maximum slope of 50% and a slope length of 10'.

LS = 5.64 (Table C-1 Israelsen et. al. (1984))

Long-term Post Reclamation

In the long term the depressions from gouging will disappear leaving an unbroken slope with a maximum slope of 50%. I will assume a 50% slope and the same slope length as for the pre-mining condition (400').

LS = 35.65 (Table C-1 Israelsen et. al. (1984))

<u>Erosion Control Factor (VM)</u>

Pre-Mining

No pre-mining vegetation data is available. However, Map 6 and Appendix 9-1 of Exhibit 19 identifies adjacent undisturbed areas to be mostly mixed brush. I will use the Castle Gate Mixed Brush reference area (Appendix 9-1 Exhibit 19) to estimate the Erosion Control Factor.

Total vegetation cover = 40.9%	Grass density = 51% ==> 21%
Litter/rock cover = 35.2%	Sage brush = 26% ==> 10.6%
Bare soil = 23.9%	Other brush = 23% ==> 9.4%
	Total brush 20%

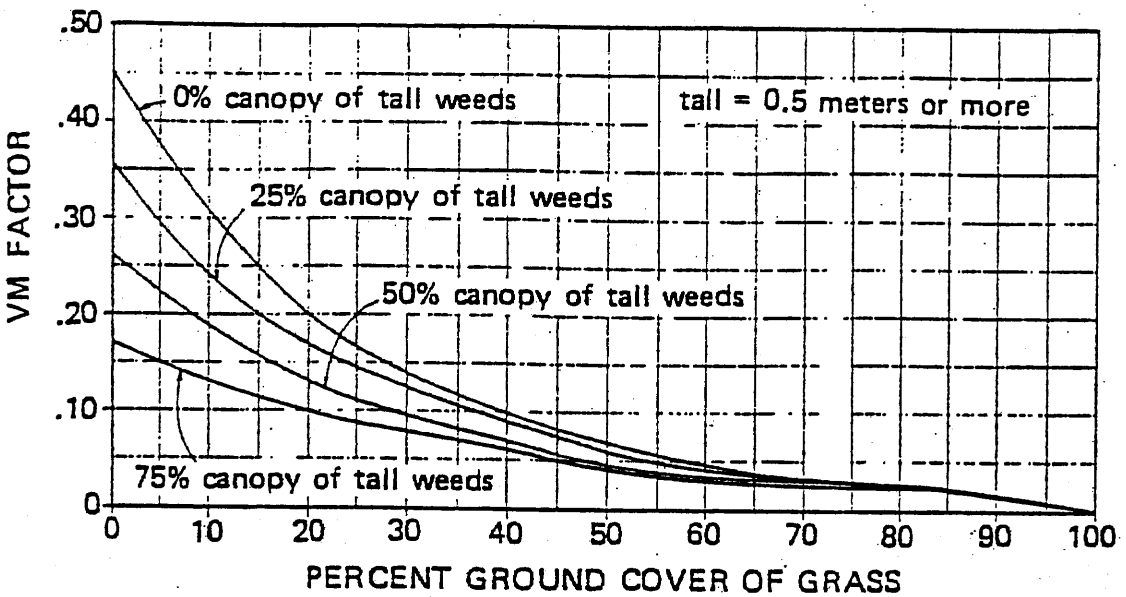

Figure 7. Relationship between grass density and VM factor.

VM = 0.17 Israelsen et. al. (1984)

Immediate Post Reclamation

$$R * K * LS = 11*0.22*5.64 = 13.65$$

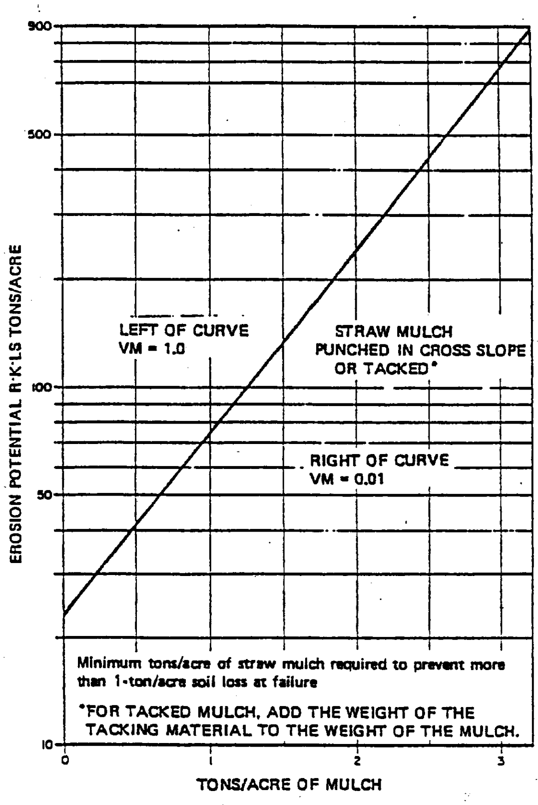

Figure 4. Straw mulch anchored vs. R·K·LS.

At least 1 ton/acre of mulch will be added with a tackifier to the reclaimed surface. Therefore, the point plots on the right side of the line.

$$VM = 0.01$$

Long-term Post Reclamation

Section 3.2.2.4 of the Willow Creek Permit describes the vegetation in an area near the site that has been reclaimed (The old Royal Refuse Pile). I will use that data to estimate the Erosion Control Factor although the Gravel Canyon reclamation area will be better vegetated.

Total plant cover = 30%
Brush density = 50% ==> 15.5%
Grasses density = 40% ==> 12.4%

VM = 0.24 (see figure 7 on page 4)

Calculation Summary

Time Period	R	K	LS	VM	A (tons/acre/yr)
Pre-Mining	11	0.28	46.3	0.17	24.2
Immediate Post Reclamation	11	0.22	5.64	0.01	0.14
Long-term Post Reclamation	11	0.22	35.65	0.24	20.7

Thus the reclaimed surface will generate far less sediment immediately after reclamation and will generate slightly less sediment for the long-term post reclamation period.

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Plateau Mining
Star Point Mine
P.O. Box 30
847 NW HWY 191
Helper, UT 84526
SOIL ID: Willow Creek Mine

Customer Sample ID	ppm P	ppm NO3-N	ppm K-av	pH	EC dS\M	%Sand
WC-GC-04-A	8.34	3.14	54.40	7.58	0.65	46.24
WC-GC-04-B	8.53	9.27	73.60	7.46	1.49	59.24

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SOIL ID: Willow Creek Mine

Customer Sample ID	%Clay	%Silt	ppm Ca-SAR	ppm Mg-SAR	ppm Na-SAR
WC-GC-04-A	22.56	31.20	55.11	46.75	43.20
WC-GC-04-B	18.56	22.20	159.20	86.56	85.28

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Customer Sample ID	SAR
WC-GC-04-A	1.03
WC-GC-04-B	1.35