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ACT/007/016
#2

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

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June 9, 1995

To: Daron Haddock, Permit Supervisor

From: J. Randall Harden, P.E., Sr. Reclamation Engineer

RE: Gordon Creek Reclamation Plans. Mountain Coal Company, Gordon Creek 2, 7 & 8 Mines, ACT/007/016, Carbon County, Utah, Folder #2

Summary

This memorandum reflects engineering analysis of the design information presented in the proposed reclamation plans for Mountain Creek Coal Company's Gordon Creek 2, 7 & 8 Mines (Gordon Creek). These analysis also respond to the analysis and comments presented by the Office of Surface Mining (OSM) pursuant to Gordon Creek's Proposal.

Analysis

This engineering analysis is based on information provided in the proposed plan by Gordon Creek. The surface configuration is based on the final reclamation surface configuration as provided on plates 3-7A and 3-7B in the proposal. These drawings were also provided on disk, and converted for use with Division software applications. Slope stability analysis was conducted using SB-SLOPE. Modeling of the surface was accomplished by conversion of the disk information into gridded data which was used to provide 3-dimensional models of the site and to determine volumetric quantities. These analysis were accomplished on EarthVision software as provided to the Division by OSM.

Stability Analysis:

Separate stability analyses were provided by the operator for the #2 Mine and the #7 Mine areas. Based on samples taken from the site, the #2 Mine area estimates soils values at 120 pcf dry density, 5.75 psi (828 psf) cohesion, and an internal friction angle of 23.8

degrees. The #7 Mine area samples yielded 120 pcf dry density, 3.5 psi (504 psf) cohesion, and an internal friction angle of 21 degrees.

Due to the steep and narrow canyon configuration in which the surface facilities exist, slope stability is a critical factor in determination of the extent to which highwalls and cutslopes can be backfilled. As indicated in the analysis, the #7 Mine area was evaluated for factors of safety of 1.25 and 1.5. The #2 Mine area was evaluated for factors of safety of 1.3 and 1.5. The minimum requirements for long-term stability as required under the regulations dictate a minimum factor of safety of 1.3. Slope charts, under saturated conditions, were used in the proposal to determine maximum embankment heights for varying slope angles under saturated conditions.

Information presented in the appendices of the proposal was found to be an accurate and reasonable representation of site conditions. Slope heights and limits proposed in the plan were found to closely compare with factor of safety calculations by the Division using SB-SLOPE.

Analysis of the Proposal by OSM was critical of the assumptions to use a factor of safety of 1.5 in the #7 Mine area and the evaluation of slopes based on saturated conditions. The Division agrees with the OSM that the factor of safety for the slope design should be reduced to 1.3 for the #7 Mine area, especially in regard to saturated slopes. Typically, engineering practices allow for a long term static factor of safety of 1.3 under normal conditions and a factor of safety of 1.1 for saturated conditions. However, regulatory requirements do not allow for factors of safety of less than 1.3. As further explained below, the Division also considers slope evaluation under saturated conditions as a valid precaution in design of these slopes for long-term stability.

Through modeling and analysis, it was found by the Division that saturated conditions dramatically affect the slope angle and height allowable in comparison to unsaturated conditions where cohesion can be developed. OSM analysis varied the extent to which the fill areas were saturated and theorized that a significant change in the slope could be obtained under certain circumstances. Under certain conditions, the Division agrees that such slopes could be achieved. However, modeling and analysis also indicated that only small changes in the phreatic line (saturation elevation and gradient) would drastically affect these assumptions. The conjecture made by OSM as to where saturation occurs within these fills cannot be reasonably assured on a long-term basis. In the event that saturation occurs in and through a critical failure surface, factors of safety were found to drop from 1.3 under dry conditions to less than 1 (failure) under saturation.

As an example of the problems associated with the saturation level, a cross section taken from the plan and indicated on the drawings as Section 3 was used to show how saturation can affect slope stability. The soil parameters used in the analysis are taken from

the plan and are shown in the sample data labeled as Gordon Creek #7 Portal Area, Saturation limited to top of MSHA bench. This example shows a slope from the top of the cutslope above the portal area projected at the least slope possible, to where it encroaches on the stream channel. The slope shown is a approximately 2:1 slope. Dry, the embankment exceeds a 1.3 FS. The graphic section provided with the example, with a phreatic line projecting from the MSHA bench to the toe of the fill indicates a FS of 1.2. A second graphic, with the slope fully saturated, indicates a FS of .69, resulting in slope failure. Refer to data and figures which follow this report.

While technically feasible, the use of underdrains, and rock buttressing of the slopes could be utilized to increase the slope angle of these fills, such practices are usually reserved for critical or high-risk construction sites. Extensive engineering and design requirements are necessary to build such structures and costs associated with construction are very high. Rock and underdrain material needed to construct such features would have to be brought in or developed elsewhere within the permitted area, thus further increasing the disturbed area. Such structures also require some degree of monitoring and maintenance in order to assure their proper function. Due to the remoteness of the site and the low hazards associated with the area, underdrains and rock toe buttresses of these slope is not warranted.

The Division agrees that due to varying climate and soils conditions within the Gordon Creek Area, that long-term static factors of safety should be evaluated under saturated conditions. Inaccessibility of the site following reclamation and the inability to maintain the site with major following revegetation warrant a conservative approach in stability design.

Terracing, benching and surface diversions are indicated in the rules and also mentioned by OSM as possible alternatives to alleviate problems with slope stability and saturation of fills. Known seeps within the fill areas are identified in the plan and have been developed in a manner that will endeavor to bring and keep these seep areas on the surface of the fills to reduce saturation. Benching and terracing of the slopes is not proposed in the plan. Because of the tight constraints within the canyon, development of benches in the fills would increase the lateral or base requirements for the fills in order to effectively decrease slopes and increase stability. Diversions along the tops of the slopes are considered impractical for several reasons. Because of the steep natural slopes above the fill areas, construction of diversion would further increase the disturbed areas and potentially decrease the stability of the natural slopes above the disturbed areas. Placement of diversions in the fill at the top of the slopes is also considered impractical due to the steepness of these backfilled areas. Differential settling between the fill and the adjacent natural materials can often cause cracks or voids in the fill material at the interface which if diversions were to be place in these areas could inadvertently divert water directly into and behind the filled areas. These diversions as well as diversions associated with the use of terraces also would require a higher degree of maintenance on the site. Diversions, benches and terraces, although

allowed in the regulations, are considered impractical based on site conditions.

These limitations do however restrict the amount of backfill material that can be placed along some of the cutslopes and above the highwalls within the mine site. In addition to the analysis performed for the fill areas, the cutslopes and cutslope areas above the highwalls were also evaluated by the operator for stability. These areas were found to have significantly higher factors of safety than the 1.3 minimum regulatory requirement. These high factors of safety are attributable to the high amount of bedrock in these cutslopes.

Although complete elimination of highwalls and cutslopes by backfilling those areas is the preferred alternative during reclamation, such practices cannot be achieved throughout the Gordon Creek Mine site due to factor of safety limitations, soils conditions and the geometry of the cutslopes in relationship to the natural slopes above the cuts and the establishment of permanent drainage channels below the cutslopes.

Backfilling and Grading:

Mine development wastes and spoils resulting from underground mining operations generally result in volumes of materials greater than the volumes originally excavated during mining operations. Use of all of these materials in backfilling and grading to achieve AOC is more desirable than the development of additional disturbed areas above or adjacent to highwalls for disposal. No historic maps of sufficient detail are available to show the pre-mining surface configuration for the entire mine site. Consequently, a detailed accounting of the location and extent of these materials is not available for evaluation.

OSM considers in their analysis that additional spoil is (or should be) reasonably available within the Gordon Creek Mine site. The Division agrees that, due to swell factors resultant from excavation of the mine facilities and that none of the materials excavated during mine development were removed from the area, that the volume of material currently placed as fill within the mine facilities is greater that the volume of the cuts that were concurrently developed during mine development. However, due to the limitations dictated by the factor of safety and site geometry, such fill material cannot effectively be used to eliminate all cut areas and cutslopes.

Natural conditions within this canyon would typically place slopes at angles with factors of safety at or near a FS of 1 to 1.1. Development of backfilled slopes to a factor of safety of 1.3 requires a reduction in the natural slopes which existed prior to mining and a significantly greater amount of material than would be available from mine development waste and fill. If such fill materials were readily available, it would have to be placed within the bottom of the canyon and would elevate the drainage areas, reducing the gradient in these fill areas, and over-steepening the gradient down stream of the fills. Such practices would not be conducive to re-establishment of the natural drainage patterns within the within the

canyon. Development of borrow areas for additional fill materials would further increase the disturbed area.

Surface contours within the site were revised by the Division to determine to what extent additional material may be available, within the currently disturbed area, to minimize or further reduce the extent and the height of the cutslopes associated with backfilling and grading. The Division found that material within the site is sufficient to further backfill the #7 Mine portal area to the extent that would be allowed by reducing the factor of safety from 1.5 to 1.3. The revised contours were used only to roughly approximate changes to the entire facilities that would occur. These revised contours, developed approximately 42,000 additional cubic yards of material which could be used for fill within the cutslope areas. Of this, approximately 14,000 cubic yards were used in the #7 Mine portal area with the remainder of the material used in and around the #2 Mine portal area. This material was derived from the gentle slopes adjacent to and to the southeast of the #2 Mine portal area. EarthVision volumetric mass balance calculations from revision of the surface contours are as found in the Volumetrics Report attached to this review. These calculations only consider the movement of material in comparison to the final reclamation contours proposed by the operator and as such do not relate to the mass balance calculations in the plan used in design earthwork from the mine operation stage to final reclamation. Revision of the proposed surface contours was accomplished by the Division only to determine whether or not additional material could be utilized from within the currently disturbed area. Contour maps showing the revised contour information in comparison to the reclamation plan proposed by the operator are available, but have not been attached to this report.

Placement of this additional material along the cutslopes within the site did not eliminate any significant amount of cutslope areas as delineated on the maps in the proposal. The additional fill material did help to reduce the vertical extent of some of these cutslopes. The cutslopes above the #7 Mine portal area were reduced from approximately 85 feet to 45 feet vertically, but due to factor of safety limitations, could not be completely eliminated. The cutslopes above the #2 portal area were also reduced by 10-15 feet but slopes were constrained by the main drainage channel located in the bottom of the canyon.

Variations in the soils characteristics in consideration of the placement of backfill material should also be noted. Analysis of the soils for the #7 Mine area and the #2 Mine area are different enough so as to affect the degree to which slopes can be developed and the extent to which cutslopes can be reduced. Refer to the tables and analysis in the plan indicating maximum slope angles and heights for fill materials. During field construction, the operator should be aware that the identification and location of materials which have the best characteristics for constructing slopes in critical areas may have a marked effect on the final slopes that can be attained during reclamation. Should higher quality materials be encountered during earthmoving activities, field amendments to the plan could enhance the final reclamation configuration.

AOC Requirements:

Backfilling and grading requirements regarding AOC are as discussed above in terms of meeting design standards for stability and highwall elimination. In most cases, backfilling provides the best and the most effective means of highwall elimination. However, based on limitations within the backfilling and grading plan, cutslopes will remain within the Gordon Creek Mine site. The location and extent of these cutslope areas are delineated on plates 3-7A and 3-7B in the proposed plan.

Retention of cutslopes associated with highwalls and other mine facilities areas play an important role in reclamation stability and success. Cutslope retention results in a lower gradient in reclamation areas that would have otherwise had excessively steep and long slopes if completely backfilled. This reduces surface erosion which should enhance plant production and the postmining land uses of livestock grazing and wildlife habitat. The Division considers these benefits from cutslope retention as necessary to meet AOC compliance.

In addition, the Division considers stability, vegetation, erosion control, drainage design and control, and other factors in determining whether the backfilling plan complies with AOC requirements. Consequently, slope reduction from stability limitations lends itself to backfilling and grading the site to the more moderate slopes which serve to enhance all of the above factors.

It should be noted that in regard to highwalls, the operator's proposal has effectively eliminated all highwalls associated with the #2 Mine, #7 Mine and the #8 Mine portals. All highwalls were, at a minimum, backfilled to exceed the elevation of MSHA safety benches located above the highwalls thereby eliminating all highwalls. Cutslope areas above the highwalls were reduced in slope at the time of portal development to meet long-term factor of safety requirements. Considerations made in this analysis are associated with general backfilling and grading requirements necessary to meet Approximate Original Contour (AOC) requirements. The operator has not requested a variance for highwall retention as allowed for previously existing (pre-SMCRA) highwalls and has not requested a variance from AOC requirements.

Although the incorporation of cutslopes into the reclamation design does have advantages as noted above, there are also adverse effects. Most important, is the consideration that due to the steepness of the cut slopes, their existence may pose a safety hazard to people, livestock and wildlife who encounter them. Because of the location of these cutslopes, the hazards associated with them are considered minimal. Steep natural slopes occur above these areas which limit access to the cutslopes. All access to the cutslope areas is below the cutslopes and no roads or trails are found immediately above these areas. Natural terrain in the area can be found as steep or steeper than the cutslope areas such that

the natural hazards are at least equal or greater to the hazards associated with the cutslopes.

Another adverse effect is the visual and esthetic impact from the retained cutslopes. The visual impact is that the cutslopes will remain visible following revegetation and will be most visible from the bottom of the canyon where the site is accessible. However, the cutslopes are not visible from other vistas or viewing areas which would be generally accessible to the public or within view of any residences. The cutslopes will also appear similar to scarps which are found throughout the region resulting from natural land surface failures. Accordingly, while the visual impact from the cutslopes is adverse, it is not considered as significant or limiting in regard to the post mining land use or as having any impact outside of the permit area.

As part of the backfilling and grading evaluation of the site, the Division considered the elimination or the reduction of cutslopes within the site. The visual effects regarding the placement of additional materials to reduce the vertical extent of cutslopes is not significant in comparison to the final surface configuration as proposed by the operator. To compare the difference, 3-D models looking at the #2 Mine area and the #7 Mine area were developed. Figure 1 shows the #2 Portal area as proposed in the plan while Figure 2 show the site following the relocation of the additional materials. Similarly, Figures 3 and 4, are shown for the #7 Portal area. Unfortunately, digital data was not made available to compare the pre-mining surface configuration or the operational surface configuration to the final reclaimed surface configuration.

Findings

Although OSM and Division disagree in part, to some of the assumptions used in the design and the development of the reclamation plan for the Gordon Creek 2, 7 & 8 Mines, the plan was found to meet the minimum regulatory requirements with respect to highwall elimination, backfilling and grading, and meeting AOC requirements. Additional materials potentially can be placed to reduce the vertical extent of cutslopes within the existing disturbed area. However, such considerations are not significant to warrant re-design and re-evaluation of the reclamation plan as proposed.

Backfilling in the #7 Mine portal area should be increased by reducing the factor of safety from 1.5 to 1.3. Evaluation of other areas, including the #2 Mine portal area are already proposed with a 1.3 factor of safety. Accordingly, the following permit condition is recommended:

R645-301-553, Backfilling and Grading, backfilled slopes in the #7 Mine portal area shall be backfilled to the extent possible while maintaining a factor of safety of 1.3. The operator shall determine, based on site conditions, where additional materials may be developed and placed as fill to further reduce or eliminate cut slopes associated with the reclamation plan. Slope measurements and stability analysis based on site conditions during construction shall be provided in conjunction with certified as built reports or plans demonstrating stability and that backfilling of cutslopes to the extent possible during reclamation activities has been accomplished.

Attachments: Slope stability reports and analysis
Volumetrics report
Figures 1 through 4

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GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Gordon Creek #7 Portal Area
Location: Saturation limited to top of MSHA bench.
Filename: 278S Description: Gordon Creek 278 Section 3

ANALYSIS DATA:

Point No.	Coordinates X	Coordinates Y	Line No.	Left Point	Right Point	Soil No.	Phreatic Line
1	157.0	8310.0	1	1	2	1	N
2	171.0	8300.0	2	2	3	1	N
3	181.0	8290.0	3	3	4	1	N
4	249.0	8208.0	4	4	5	1	N
5	280.0	8178.0	5	5	6	1	N
6	288.0	8177.0	6	6	7	1	N
7	316.0	8146.0	7	7	8	1	N
8	350.0	8141.0	8	8	9	1	N
9	480.0	8147.0	9	9	10	1	N
10	489.0	8145.0	10	10	11	1	N
11	491.0	8143.0	11	11	12	1	N
12	500.0	8143.0	12	12	13	1	N
13	550.0	8170.0	13	2	9	2	N
			14	5	9	2	Y

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	155.0	2000	35.0
2	120.0	504	21.0

SB-SLOPE

Simplified Bishop Slope Stability Analysis

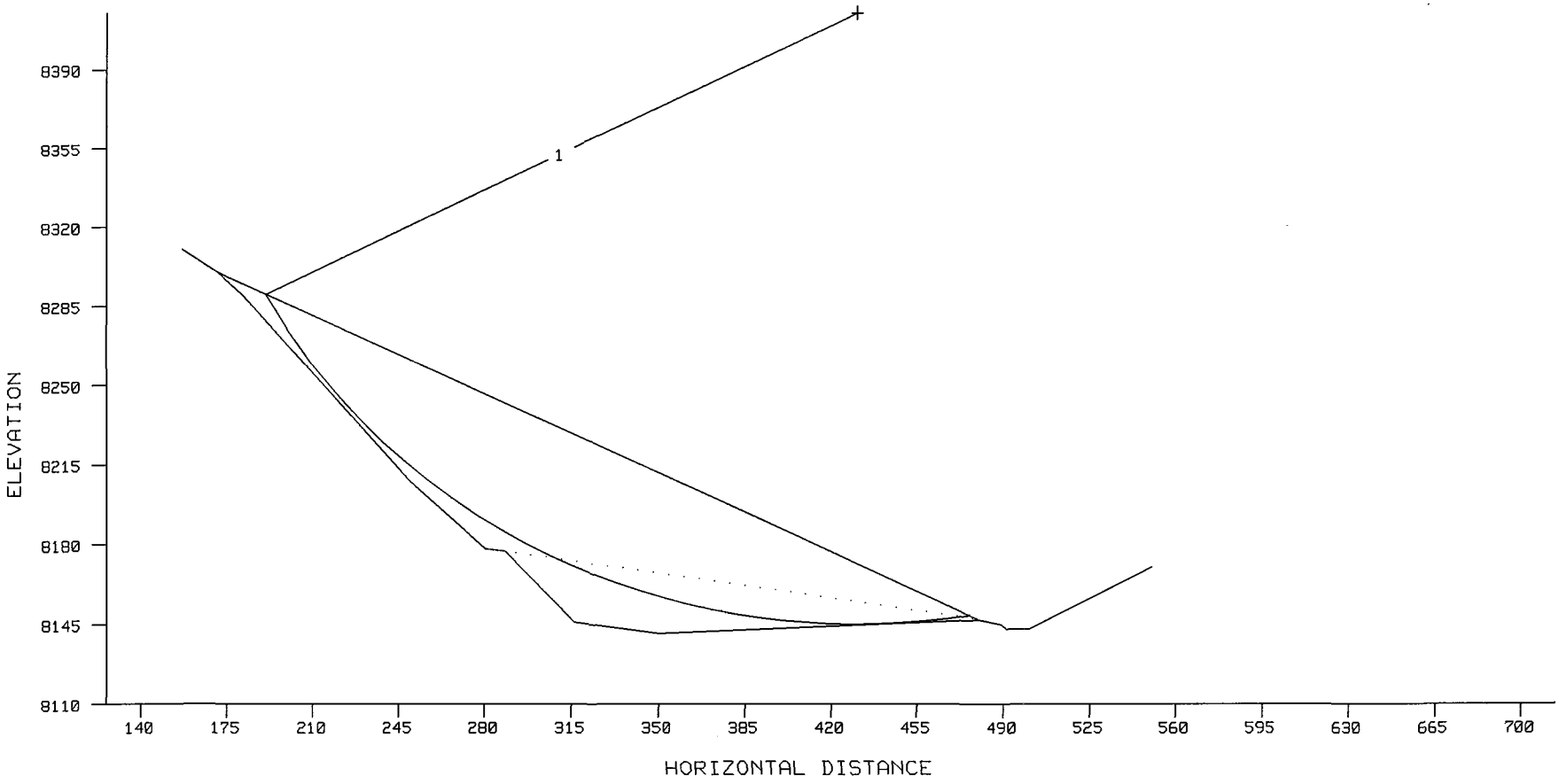
PROJECT: Gordon Creek #7 Portal Area

LOCATION: Saturation limited to top of MSHA bench.

FILE: 278S

COMPLETE SLOPE CROSS SECTION SHOWN

CIRCLE	X	Y	RADIUS	FS
1	430.0	8415.0	270.0	1.20



OSMRE - TIPS

SB-SLOPE

Simplified Bishop Slope Stability Analysis

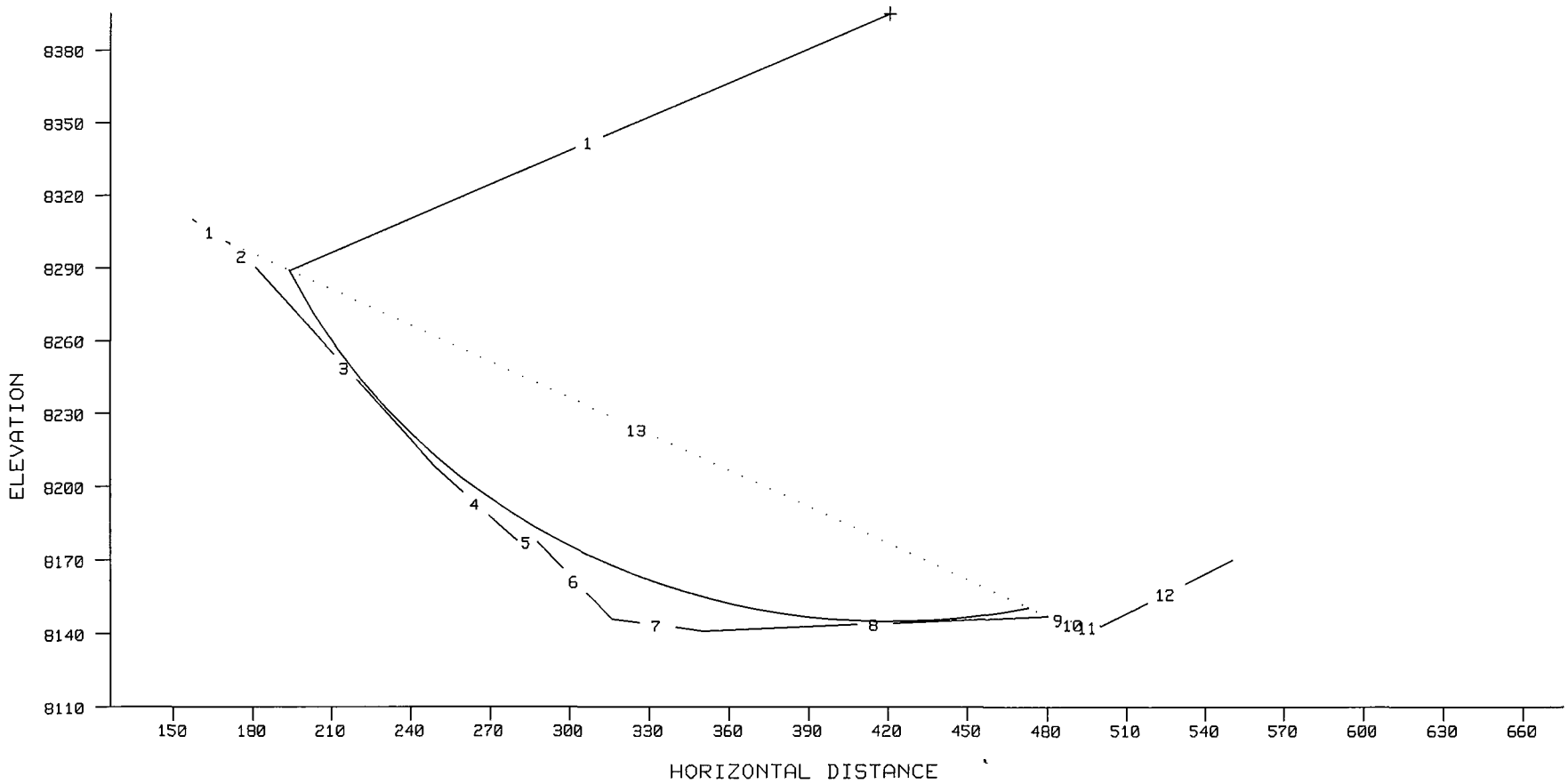
PROJECT: Gordon Creek #7 Portal Area

LOCATION: Section 3

FILE: 278S

COMPLETE SLOPE CROSS SECTION SHOWN

CIRCLE	X	Y	RADIUS	FS
1	420.0	8395.0	250.0	0.69



OSMRE - TIPS

VOLUMETRICS REPORT

Run by: rharden
Version: 2.0
Date: 06/07/95
Report file: t1.2vrpt

Polygon file: cutfill.vply
Zone definintion: Operational
Deposition operation: base.2grd
Unconformity operation: revised.2grd
Unconformity operation: base.2grd
Primary field: Polygon ID
Sorting method: Polygon order
Input units: feet square by feet
Volumetrics conversion factor: .037037037313
Output units: Cubic yards
Global minimum thickness: 0.0

---------- Zone name: cut ----------

Minimum z: none
Maximum z: none
Minimum thickness: 1
Yield factor: 1.0

---------- Zone name: fill ----------

Minimum z: none
Maximum z: none
Minimum thickness: 1
Yield factor: 1.0

Volumetrics Report

Zone name: cut

Polygon ID / Polygon Class	Polygon Area	Volume	Positive Area
Cutfill	1,901,825.6875	42,205.8104	148,064.882682
Subtotal for Cutfill	1,901,825.6875	42,205.8104	148,064.882682
Total for cut	1,901,825.6875	42,205.8104	148,064.882682

Zone name: fill

Polygon ID / Polygon Class	Polygon Area	Volume	Positive Area
Cutfill	1,901,825.6875	41,966.0424	186,808.363121
Subtotal for Cutfill	1,901,825.6875	41,966.0424	186,808.363121
Total for fill	1,901,825.6875	41,966.0424	186,808.363121

Figure 1 - #2 Portal Area as Proposed, Looking West

Figure 2 - #2 Portal Area as Revised, Looking West

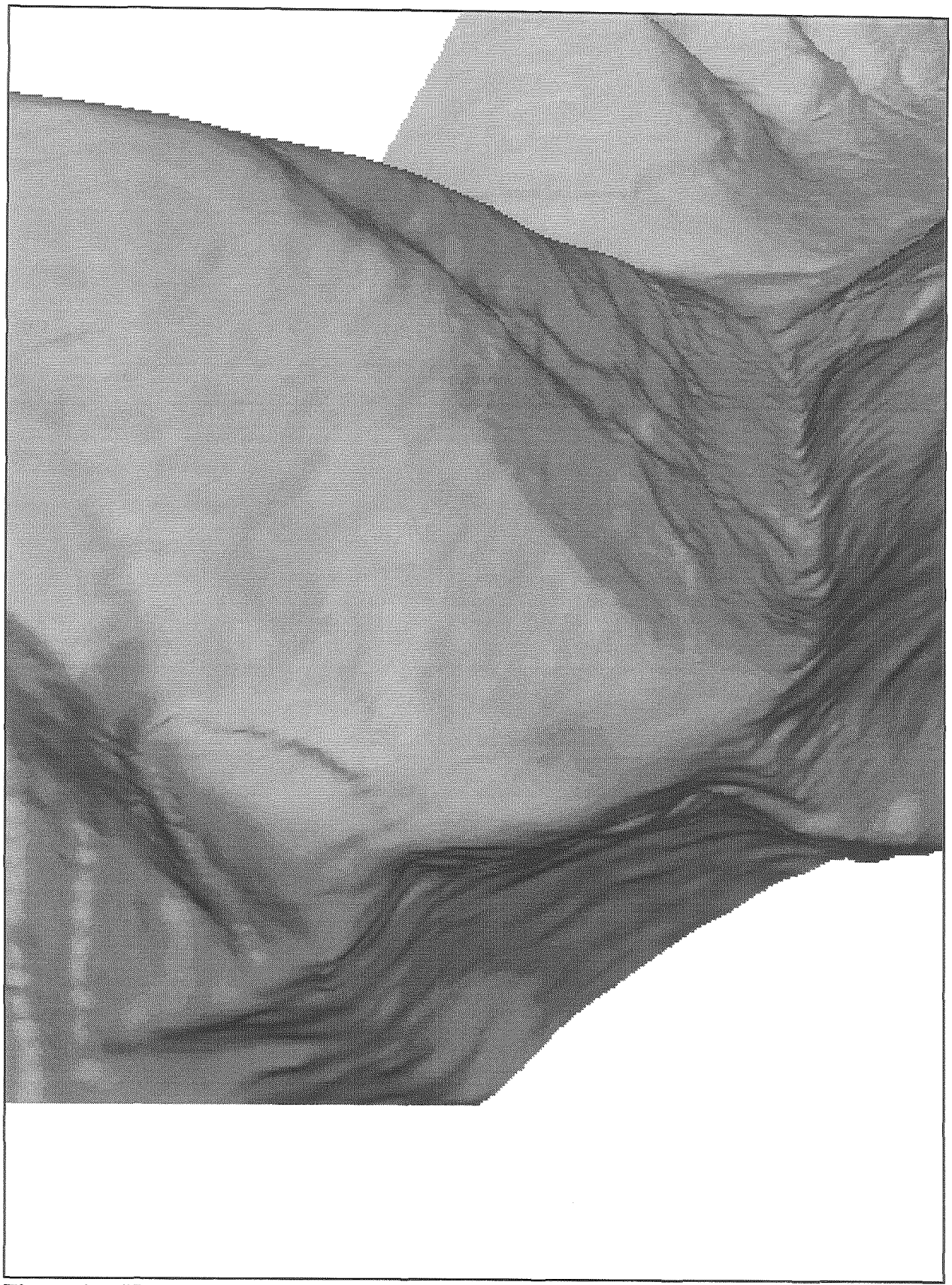


Figure 3 - #7 Portal Area as Proposed, Looking East

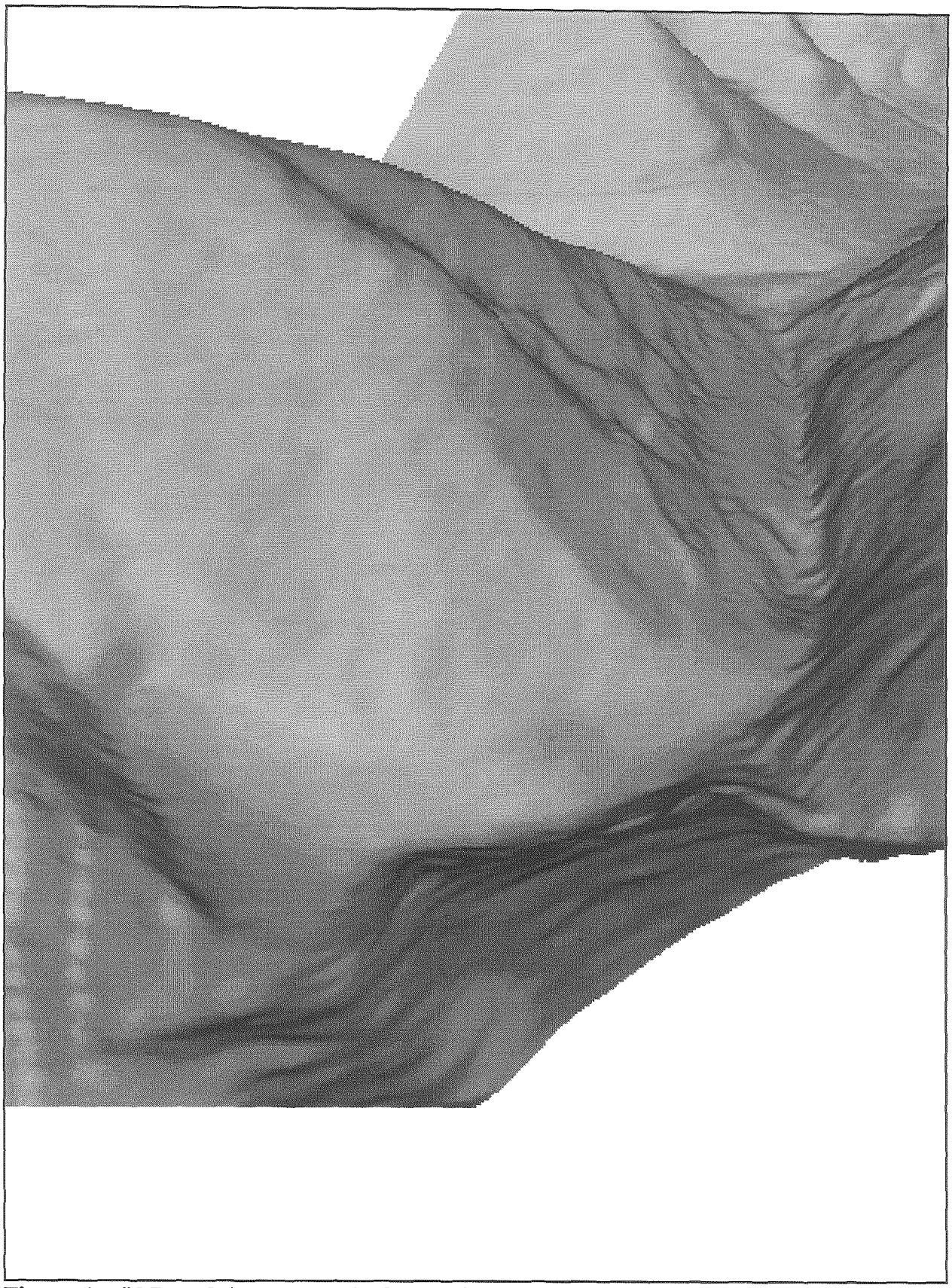


Figure 4 - #7 Portal Area as Revised, Looking East