APPENDIX 7-39

EROSION CALCULATION METHODOLOGY
BLIND CANYON WATERSHED

06/04/93

7-39.1.0 INTRODUCTION

The study referenced in Section 7.42.2 is designed to aid in determining the effects of retreat-mining produced subsidence on overlying watersheds. Specifically, this study investigates the effects of subsidence on erosion within the overlying Blind Canyon watershed. The portion of the Blind Canyon watershed most intensively investigated is State Section 36 in T15S-R6E, which is contained within the Manti-La Sal National Forest. The following Manti-La Sal areas of the Blind Canyon drainage will also be studied: T15S-R7E-Sec31, T15S-R7E-Sec 29 SW1/4, and T15S-R7E-Sec32 NW1/4 NE1/4. Modeling of the pre- and post-mining erosion rates have been completed and appear in Appendices 7-27 through 7-37. Appendix 7-38 calculates Blind Canyon channel erosion and the potential cumulative erosion of the drainage in Section 36. This appendix presents the methodology used in determining the pre- and post-mining erosion rates and sediment production. Genwal Coal has committed to funding and partaking in a U.S.F.S. Intermountain Research Station Study (Appendix 7-25) to conduct a study to monitor the actual effects of mining on the overlying Blind Canyon drainage. Approximate locations cross-sections to be measured by the Intermountain Research Station personnel appear on Plate 7-17. The number and locations of these cross-sections may be modified as a result of ground conditions. In addition to these cross-sections, approximately 25 cross-sections will also be measured in Crandall Canyon to serve as a control.

Due to the inability to perform sediment control measures within the Blind Canyon drainage for fear of influencing the U.S.F.S. Intermountain Research Project, Genwal Coal has committed to provide the Manti-La Sal National Forest with $15,000 to perform a sediment control measure in the Nuck Woodward Canyon, whereby an equal or greater amount of sediment that could potentially be shed from the Blind Canyon drainage as a result of retreat-mining, will be prevented from entering Huntington Creek. The erosion control measure to be implemented by the Manti-La Sal National Forest is to gravel approximately 1/2 mile of the U.S.F.S. road from the intersection with Route 31, to the trailhead area of the Nuck Woodward Canyon. This erosion control measure of the Castle Valley Ridge Trail System will result in improved water quality and fish habitat. Resulting in a "Net Beneficial Impact," satisfying the U.S.F.S.'s "Net Beneficial Impact Policy." A letter from the Manti-La Sal National Forest Service agreeing with this enhancement procedure to mitigate any possible detrimental effects of retreat-mining is found in Appendix 7-44.

This U.S.F.S. Intermountain Research Station's investigation serves as part of a continuing study of the effects of subsidence on overlying watersheds. The Research Station will conduct hydrologic investigations of the Blind Canyon watershed prior to, during, and following subsidence. Studies conducted by the Research Station will be aided by water quality/quantity data collection conducted by Genwal Coal Company. In addition, to assess effects of subsidence on erosion, Genwal Coal Company has performed pre- and will perform post-subsidence aerial subsidence surveys in Section 36 for ten years starting in 1992.

Erosion magnitudes were obtained using United States Forest Service erosion loss calculations (Tew, 1973), and a computer model (SEDROUTE) obtained from the Manti-La Sal National Forest (Kelly, 1976). Discussions with Dennis Kelly as well as a SEDROUTE user's guide, and examples of how Dennis Kelly has used SEDROUTE in other sites, proved invaluable in applying SEDROUTE to the Blind Canyon drainage. In general, SEDROUTE takes soil loss data and calculates the amount of sediment yield within a watershed. Inputs into erosion calculations include, land types (and their respective curve numbers), vegetation types, and soil types (inherent soil erodibilities). Many of these integral data inputs into the erosion calculations were provided by personnel from the Manti-La Sal National Forest Service. The variability of scales, and the large scales of the data obtained from the Manti-La Sal National Forest Service necessitated rescaling the above-mentioned data to a scale with which representative land types could be delineated. As a result, composite land types for the Blind Canyon watershed were delineated. The mapped Manti-La Sal National Forest land types, vegetation, and soil data served as the base upon which the composite land types were delineated. Plates 7-8 and 7-10 show the Manti-La Sal Forest vegetation, soil, and land type boundaries, as well as the composite land type boundaries. Eight composite land types, numbered one through eight, were delineated within Section 36.

SEDROUTE erosion calculations were added to worst-case erosion conditions that could occur in the Blind Canyon stream drainage. A pre- and post-mining profile of the Blind Canyon drainage appears in Plate 7-11. Calculations of stream bed erosion that may occur are found in Appendix 7-38.

7-39.2.0 EROSION CALCULATION METHODOLOGY

Tew (1973) provides soil loss rates via a nomograph beginning with inherent soil erodibility, and progressing through rainfall factor, percent slope, percent ground cover, and percent crown cover, to yield a soil loss rate in inches per year for each land type. The soil loss rate for each land type is then inputted into SEDROUTE, to yield an annual sediment yield rate in acre-feet.

An integral step in calculating projected magnitudes of erosion that may occur as a result of subsidence is to determine the magnitude of subsidence, and the resultant change in slope of the overlying composite land types. To determine subsidence magnitudes, TerraTek Research Company was contracted by Genwal to determine subsidence magnitudes in the Blind Canyon Watershed. Modeling was conducted using a Boundary Element Model (BEM), Finite Element Model (FEM), as well as comparisons with actual subsidence magnitudes that have occurred and previously been quantified at Genwal Coal Company's Crandall Canyon Mine, and the neighboring Deer Creek Mine (TerraTek, 1993). The TerraTek subsidence modeling results appear in Appendix 7-40. Due to the liberal nature of the subsidence magnitude results produced by the FEM (TerraTek, 1993), the FEM subsidence results were used to assess subsidence magnitudes. Subsidence transects and the magnitudes of subsidence appear on Plate 7-9.

7-39.2.1 Soil Loss Determination

7-39.2.1.1 Inherent Soil Erodibility

Inherent soil erodibilities for each composite land type were obtained by calculating a weighted average soil erodibility. Soil erodibilities were obtained from the soil data provided by the Manti-La Sal National Forest. Manti-La Sal National Forest soil data appears in Appendix 7-27. Soil erodibility calculations appear in Appendix 7-28.

7-39.2.1.2 Rainfall Factor

The rainfall factor for the entire area encompassing the Blind Canyon Watershed is 0.045 (Tew, 1973).

7-39.2.1.3 Percent Slope

Both pre- and post-subsidence percent slopes for each composite land type were determined. Subsidence magnitudes (see Appendix 7-40 and Plate 7-9) were used to determine the post-mining percent slope of each composite land type. Land slopes were obtained for each composite land type using method seven as outlined by the Water Resources Bulletin (Chang et al, 1989). Pre- and post-mining percent slope calculations for each composite land type are found in Appendix 7-29

7-39.2.1.4 Percent Ground and Crown Cover

Weighted averages of both percent ground and crown cover were calculated from vegetation date provided by the Manti-La Sal National Forest (Appendix 7-30). Weighted averages for the composite land types were calculated for both percent ground and percent crown cover. Appendix 7-31 contains weighted percent ground and crown cover calculations.

7-39.2.1.5 Soil Loss Nomograph

Nomographs (Tew, 1973) of inherent soil erodibility, rainfall factor, percent slope, percent ground, and crown cover, yielding soil loss rates (inches/year), were plotted for each composite land type. The pre- and post-mining nomographs appear in Appendices 7-32 and 7-33, respectively. A table summarizing and comparing the pre- and post-mining soil loss calculations appear at the end of Appendix 7-33.

7-39.2.2 SEDROUTE

Weighted average runoff curve numbers for each composite land type were calculated using the curve numbers of the Manti-La Sal National Forest land types. Manti-La Sal National Forest land types appear in Appendix 7-34 and on Plate 7-8. The runoff curve numbers associated with each Manti-La Sal National Forest land type were provided by the Forest Service. Calculations of the weighted runoff curve numbers for the composite land types appear in Appendix 7-35.

7-39.2.2.1 Stream Channel Density

Stream channel density, defined as the stream channel length (miles) divided by the area (square miles) of each composite land type were calculated. Calculations of stream channel density are found in Appendix 7-36. Plate 7-10 shows the drainages in each land type.

7-39.2.2.2 SEDROUTE Calculations

For each of the eight composite land types the following data were entered into the SEDROUTE program: land type number, area (acres), runoff curve number, erosion rate (IN), percent slope, and stream channel density (MI/SQ MI). SEDROUTE then calculated annual erosion (AC-FT), pollution hazard index, delivery coefficient (%), sediment yield rate (IN/YR), and annual sediment yield rate (AC/YR).

Appendix 7-37 contains pre- and post-mining SEDROUTE outputs. The difference in pre- and post-mining SEDROUTE outputs is 0.006 AC-FT.

2-39.2.3 STREAM BED EROSION CALCULATIONS

A pre- and post-mining profile of the Blind Canyon drainage appear in Plate 7-11. Worst-case calculations of stream bed erosion that may occur are found in Appendix 7-38. The vertical amount of subsidence is used to obtain the vertical amount of erosion that may occur in the drainage channel. Channel width and side slopes equal to those currently present are used as the conditions present after mining. The volume of material within the downcut drainage is calculated. Calculations of headcutting erosion volumes was calculated for rills A through E (Plate 7-9). Erosion volumes were also calculated for the Blind Canyon drainage between stations 14.5 and 19 at the eastern end of Section 36. These calculations were reduced by the amount of gravel material present in the downcut volume of soil (Soil Taxonomy, 1975). The estimate of the percent of coarse material was obtained from the Manti-La Sal soil surveys of the area to be subsided. In calculating the amount of material too coarse to be transported, worst-case values of the Manti-La Sal Forest Service data were used.

The Manti-La Sal National Forest Service requires an equal or greater amount of sediment to be trapped elsewhere in the Manti-La Sal National Forest to offset potential increases of sedimentation on Forest Service land that could result from retreat-mining of State Section 36. As discussed with the U.S.F.S. Research Station personnel, and officials of the Manti-La Sal National Forest Service, erosion control measures cannot be implemented within the Blind Canyon drainage, on the State of Utah or Manti-La Sal National Forest Service lands, due to potential impacts on the U.S.F.S. Intermountain Research Station's study. Consultations with Manti-La Sal National Forest Service personnel have resulted in identification of a site, Nuck Woodward Canyon, where an erosion enhancement procedure can be conducted to reduce an equal or greater amount of sediment that may enter Huntington Creek. The enhancement procedure consists of graveling approximately 1/2 mile of the U.S.F.S road from the intersection of Route 31 to the trailhead area of the Nuck Woodward Canyon. An agreement whereby Genwal donates $15,000 to the Manti-La Sal Forest to fund the Forest Service graveling of this road appears in Appendix 7-44. This mutually agreed upon action by Genwal Coal Company and the Manti-La Sal National Forest, satisfies the U.S.F.S.'s "Net Beneficial Impact Policy."

7-39.2.4 DISCUSSION

As discussed in Appendix 7-40 and shown on Plate 7-9, the maximum subsidence occurs where the overburden is greatest. Consequently the magnitude of subsidence over the ridges (maximum 40.3 inches) is greater than that at the lower stream drainage elevations (minimum 16 inches). Due to the presence of a barrier pillar being left in-place beneath the eastern edge of Section 36, no subsidence is anticipated in this region (Plate 7-9). In general the south-slope of Blind Canyon is somewhat flattened, while the north-slope remains unaltered. As a result, the percent slopes of the vast majority of the composite land types remain constant or decrease. The percent slope of the land types is the only parameter that changes as a result of retreat produced subsidence in the calculation of soil loss (Appendix 7-29). Of the eight composite land types, the percent slopes remained constant in four, decreased in three, and increased in only one. The three land types that exhibit a decrease in percent slope, experience minor reductions. Land type eight experiences an increase of 5.9%. This increase in the percent slope of land type eight can be partially attributed to the absence of a subsidence modeling transect in the western third of section 36, where the overburden and expected subsidence magnitude is expected to be greatest.

SEDROUTE requires a channel density for each land type in order to calculate erosion values. There is no stream in all land types, consequently, rill and ephemeral drainage densities were calculated in order to obtain a SEDROUTE output. The resultant output gives an erosion rate greater than that realized if all the landtypes did contain stream drainages.

Comparison of the pre-and post-mining SEDROUTE erosion calculations for the Blind Canyon Watershed reveal an increase in annual sediment yield of only 0.006 acre-feet(Appendix 7-37). Worst-case stream channel erosion is 0.145 acre-feet of sediment, yielding a total of 0.151 acre-feet of potentially erodible material that could result from retreat mining of State Section 36 (Appendix 7-38).

In order to calculate a worst-case erosion value the following have been assumed:

1) all potentially erodible material is transported down the Blind Canyon drainage off of State Section 36 onto Manti-La Sal National Forest Service land,

2) headcutting erosion is calculated on rills (A, B, C, and D) (Plate 7-9), all ephemeral drainages,

3) headcutting is calculated for drainage "E" (Appendix 7-9), a drainage reach that also exhibits ephemeral flow, and

4) erosion is calculated at the eastern edge of Section 36 (stations 14.5 through 19) (Plate 7-9), over an area where a barrier pillar exists and erosion is extremely unlikely. Drainage erosion between stations 14.5 and 19 is extremely unlikely given the absence of a nick-point produced by retreat-mining (downward hydraulic jump),

from which erosion can advance from in an upstream direction resulting in erosion. The more likely occurrence is for sediment to be deposited upstream of station 14.5, and not reach Manti-La Sal Forest Service land further downstream.

APPENDIX 7-44

MANTI-LA SAL NATIONAL FOREST SERVICE LETTER REGARDING EROSION CONTROL ENHANCEMENT PROCEDURE IN NUCK WOODWARD CANYON