0046

CO-OP MINING COMPANY

P.O. Box 1245
Huntington, Utah 84528

Office (435) 687-2450
FAX (435) 687-2084

December 29, 2004

Incoming
C/015/0025

Coal Program
Utah Division of Oil, Gas & Mining
1594 West North Temple, Suite 1210
P.O. Box 145801
Salt Lake City, Utah 84114-5801

To Whom It May Concern,

Re: Application to Change Existing Mining Plan, Reformat and Digitization, Bear Canyon Mine, ACT/015/0025-Task ID #1989.

Enclosed are four digital copies and one hard copy of our response to the Technical Analysis dated September 1, 2004. Links have been provided as blue text to aid in the review process. Chapter 3 in both the electronic version and the hard copy has been scaled down and does not fit the entire page. This mistake was noticed after links had been set up in the electronic version. Since the contents of the page are exactly as they will be, just shrunk down, we left both the hard copy and electronic copies like this for the review. This mistake will be corrected with the clean copies.

We have included all parts of the MRP with the electronic copy so the reviewer can follow links between chapters if they want. Some links in chapters that have not been changed may not work. This will be corrected when clean copies are submitted. In this submittal we have not set up an index that allows you to search the entire eMRP for specific words. This index will be set up once the amendment is approved.

If you have any questions, please call me at (435) 687-5238.

Thank You,

Mark Reynolds

Enclosure(s)

File in:
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- ☐ Confidential
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Date 12/30/04 For additional information

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Chapter 3

R645-301-300 Biology

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321.100 Plant Communities

A reference area, approximately one acre in size was selected in July 1983, encompassing pinyon-juniper-grass and riparian vegetation types (Plate 3-1). The reference area was selected on the basis of similarity with vegetation types which were believed to have occurred within the disturbed area before mining. This was done in conjunction with Mr. Lynn Kunzler of the Utah Division of Oil, Gas and Mining (DOGM).

In 1993, reference areas were selected for the Shower House Pad disturbance and the Tank Seam Access Road disturbance. The areas were selected in conjunction with Susan White of the D.O.G.M. These areas are also shown on Plate 3-1.

In 1996, a reference area was selected by Patrick Collins for the proposed Wild Horse Ridge disturbance. In 2001 he selected a reference area for the Wild Horse Ridge Tank Seam Pad area. These areas are shown on Plate 3-1. Plant communities and productivity was determined from these studies.

OPERATION AND RECLAMATION PLAN

3.1 SCOPE

This Chapter describes the action and procedures of Co-op Mining Company (Co-Op) to satisfy the requirements for underground mining operations and reclamation.

3.2 SURFACE FACILITIES - EXISTING

The mine which existed at the present site when mining began had been abandoned for over 30 years and subsequently there is no evidence of long existing facilities.

3.3 SURFACE FACILITIES - NEW

3.3.1 Site Selection and Preparation of Proposed Facilities

Plates 2-4 show the location of all surface facilities. In addition, the maps show an accurate determination of where each facility is in relation to the existing topography as well as structural fixtures such as highways and stream buffer zones.

VEGETATION

SCOPE

A reference area, approximately one acre in size was selected in July 1983, encompassing pinyon-juniper-grass and riparian vegetation types (Plate 3-1). The reference area was selected on the basis of similarity with vegetation types which were believed to have occurred within the disturbed area before mining. This was done in conjunction with Mr. Lynn Kunzler of the Utah Division of Oil, Gas and Mining (DOGM).

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METHODOLOGY

A reconnaissance-type survey was conducted within each vegetation type believed to have been disturbed, then correlated to reference areas in undisturbed areas. Quantitative sampling was conducted by Larry Germain and Paige Waldvogel, under contract with Mel Coonrod in August 1983. Additional species composition information was compiled in 1982 by the Soil Conservation Service (SCS). Specific efforts were made to locate and identify species proposed or listed as threatened or endangered, noxious weeds and selenium indicators.

Sample Point Selection

Ground cover and woody plant density data were collected on pinyon/juniper-grass and riparian portions of the reference area using a random sampling technique. The starting point of each 50 m transect was randomly selected using random numbers, generating bi-directional coordinates. Points were located in the field by pacing. Orientation of each transect was selected, using random generation of compass bearings.

Sample Adequacy Determination

Utah DOGM guidelines (1982) dictate the following sampling adequacy requirements for estimates of cover, shrub density and tree density:

1. Grasslands. 90 pct confidence, 10 pct precision

2. Shrublands and forests. 80 pct confidence, 10 pct precision

(Shrublands are defined as areas where shrubs contribute over 20 pct of the total cover.)

However, the guidelines require that a minimum number of samples be taken. The guidelines identify the maximum number of sampling adequacy is not met with fewer samples.

Vegetation Cover Estimation

Cover data was obtained at 50 pts, spaced at 1 m intervals along a transect at each randomly selected sample point. A liner point-frequency frame (Mueller-Dombois and Ellenberg 1974) was used to accurately measure vertical hits on vegetation, litter-rock and bare ground. Crown or shoot cover was measured by counting only the first interception of the pin with a plant part. Overhead canopy cover was determined by recording the plant species hit when the vertical line of the pin was protected upward above the frame. Where crowns overlap in layered vegetation, the uppermost layer was considered the primary vegetation hit and subsequent hits on lower vegetation was recorded separately.

This technique provides frequency information for vegetative, litter-rock and bare ground components of total cover along a given transect. Frequency of individual plant species encountered along each transect was also determined to provide relative distribution information.

Shrub Density and Height Estimation

Shrub density and height were estimated along the same transects used for cover data. The height, number and species of shrubs whose stems rise within 50 cm on either side of the 50 m transect was recorded. Shrub heights were measured and recorded by two classes: less than 1 ft and equal to or greater than 1 ft. All data was recorded on standard forms.

Tree Density and Basal Area Estimation

A total count of all trees within the reference area was done.

Additional Reference Areas

Similar methodologies were used in measuring the Shower House Pad Reference Area, the Tank Seam Access Road Reference Area, and the Wild Horse Ridge Reference Area. The exact methodologies are described in Appendix 3-C (Shower House Pad), Appendix 3-A (Tank Seam Access Road) and Appendix 3-F (Wild Horse Ridge). All of these surveys were conducted by Patrick Collins.

EXISTING RESOURCE

SCS Productivity Estimates

Productivity estimates and range condition for the reference were obtained from the local SCS Range Conservationist. (See Appendix 3-B.)

Sampling Methodology

Plant Cover: 38-50 m transects; using a ten point frame at every 10 m interval.

Shrub Density: 24-1 x 50 meter transects, counting all shrubs rooted within the sampling area.

Formula for Sample Adequacy:

$$\frac{s\,t}{(0.1)\,(x)} = \frac{s2\,t2}{[(0.1)\,(x)]\,2} = \text{Number of Samples needed (n)}$$

where: t = 1.96 at 90 pct confidence (from t table)

s = standard deviation of sample

x = mean of sample

For Cover: (numbers from cover summary sheet)

$$\frac{(8.60)(1.96)}{(0.1)(28.52)} = \frac{16.856}{2.852} = 34.93$$

For Shrub Density: (numbers from Density Sheet)

$$\frac{(4.05)(1.96)}{(0.1)(19.13)} = \frac{7.938}{1.913} = 17.22$$

Example calculation for deriving pct vegetative composition:

Agsp $\frac{742}{38_{transects}} = 19.5 \qquad \frac{19.5}{*28.52} \times 100 = 68.37$ pct

all species' averages + bare ground + rock+ litter = 100 pct

*all species averages tataled = 28.52

Example calculation for percent shrub composition:

Chna $\frac{73}{24_{transects}} = 3.04 \qquad \frac{3.04}{*19.13} \times 100 = 15.89$ pct

* 19.13 derived by adding all species averages

Table 3-1 lists the vegetation types by total acres and acres of disturbance. Each type listed is described as follows:

Table 3-1 Vegetation Types

	Permit Area		Disturbed Area	
Vegetation Type	Acres	Disturbed	Drill Seeded	Hydro Seeded
Conifer	139.06	-0-	-0-	-0-
Grass	62.73	-0-	-0-	-0-
Riparian	7.46	1.0	-0-	1.0
Pinyon-Juniper	654.96	15.0	10.0	5.0
Sagebrush	4.3	-0-	-0-	-0-
Reclaimed	.65	-0-	-0-	.65
Bare	19.30	-0-	-0-	-0-
TOTAL	904.27	16.0	10.0	6.65

Conifer Vegetation Types

The conifer vegetation type (Plate 3-1) occurs on steep north and west-facing slopes such as at the bottoms of the lower cliffs and between the riparian type and the lower fringes of the PJ type. A mixture of conifer species such as Pinyon Pine Pinus edulis, White Fir Abies concolor, Douglas Fir Pseudotsuga menziesii, and Utah Juniper Juniperus osteosperma dominate the mature type. Primary under-story species are Bluebunch Wheatgrass Agropyron spicatum and Serviceberry Amelanchier alnifolia. Scattered Bristlecone Pine Pinus longaeva occurs throughout the small valleys and along the edges of cliffs in the conifer type. Lightning and fire scared trees are scattered throughout this type. Browsing and grazing by native or domestic herbivores appears to be light in this type.

Grass Vegetation Types

The grass vegetation type (Plate 3-1) occurs on the small knolls and benches of the upper slopes in the potential disturbed area as well as on ridge tops within the permit area. This type is dominated by Salina Wildrye Elymus salinus mixed with Bluebunch Wheatgrass Agropyron spicatum and Wild Bunchwheat Eriogonum corymbosum. Trees and shrubs common in the surrounding conifer type occasionally occur within the grass type but the overall appearance of the area is one dominated by grass species.

Riparian Vegetation Types

The riparian vegetation type (Plate 3-1) occurs as a narrow band in the moist bottoms of the canyons in the mine plan area. Although riparian species such as Narrowleaf Cottonwood Populous angustifolia and River Birch Betula occidentalis occur in the type, species such as White Fir Abies concolur and Douglas Fir Psuedotsuga menziesii, which are common in the surrounding conifer type, also dominate the riparian type. In some areas it is primarily the presence of the stream bottom and relatively robust growth form of the species that separate the riparian bottom from the surrounding conifer vegetation. Most of the vegetation cover in this type is provided by the trees. The under story in the riparian type consists of scattered shrubs such as Rocky Mountain Juniper Juniperus scopulorum and Woods Rose Rosa woodsii as well as a sparse cover of the grasses and forbs. Use of the riparian type by native and domestic herbivores appeared to be light.

Pinyon-Juniper Type

PJ habitats, prevalent on the south-facing slopes with rocky substrata of blocky sandstone, were extensive in the permit area (see Vegetation Map, Plate 3-1). Most PJ areas were dominated by open stands of the Pinyon Pine Pinus edulis, Rocky Mountain Juniper Juniperus scopulorum, and Utah Juniper Juniperus osteosperma, with large Curl-leaf Mountain Mahogany Cercocarpus ledifolius. In a few places, the conifers were essentially lacking, resulting in a Mountain Mahogany "woodland." Many of the Mountain Mahogany more closely resembled small trees than shrubs being over 3 m high and having a single large trunk near the ground. Scattered Ponderosa Pine Pinus ponderosa and Douglas Fir Pseudotsuga menziesii were

conspicuous in more mesic sites, especially valley bottoms, and Serviceberry Amelanchier spp,was occasionally present in significant numbers.

Prominent PJ understory species included Big Sagebrush Artemisia tridentata, Fringed Sage Artemisia frigida, Broom Snakeweed Xanthocephalum sarothrae, Salina Wildrye Elymus salinus, Indian Ricegrass Oryzopsis hymenoides, Skyrocket Gilia Gilia aggregata, and Gumweed Macheranthera grindelioides.

Sagebrush

The sparse distribution of the sagebrush habitat type appears to be controlled by exposure and moisture availability. The largest stands of sagebrush occur in the flat lower drainage of Bear Creek Canyon. This habitat type merges on both sides of the canyon bottom, with the PJ (See Vegetation Map, Plate 3-1).

Dominant vegetation species include Big Sagebrush Artemisia tridentat, Rubber Rabbitbrush Chrysothamnus nauseosus, Fringed Sage Artemisia frigida, Thistle Cirsium spp., Skyrocket Gilia Gilia aggregata, Plains Pricklypear Opuntia polyacantha, Cheatgrass Bromus tectorum, and Bluebunch Wheatgrass Agropyron spicatum.

Bare Cliffs and Talus

Vegetation is nonexistent or sparse and consists of a few grasses and forbs. Cliffs separate the Grassland vegetation type of the plateau from the more vegetated areas of the canyon bottoms.

Shower House Pad Vegetation

In 1994, Co-Op disturbed additional area for constructing a shower house and employee parking area. The baseline vegetation data is described in Appendix 3-C. Sampling was performed in the fall of 1992. A reference area for the Shower House pad is shown on Plate 3-1 and the reference area information is also included in Appendix 3-C.

Tank Seam Access Road Vegetation

In 1994, Co-Op constructed an access road to the Tank Seam. Construction of the Road is described in Appendix 3-H. The pre-disturbed vegetation data, sampled in the fall of 1992, is described in Appendix 3-D. A reference area was selected for the Tank Seam portal pad and access road, and is shown on Plate 3-1. Appendix 3-H contains sampling data from the reference area and a comparison to the pre-disturbed vegetation on the Tank Seam access road and portal pad is included in Appendix 3-D.

Wild Horse Ridge Vegetation

In 2001, Co-Op increased the disturbance to include access roads, portals and a conveyor corridor to access coal reserves in Wild Horse Ridge. The baseline vegetation data is described in Appendix 3-F. Sampling was performed in August of 1996. A reference area is shown on Plate 3-1, and sampling information for the reference area is included in Appendix 3-F. Production information was collected on the proposed disturbed area and reference area in August, 1999. This information will be included in Appendix 3-F.

Wild Horse Ridge Tank Seam Vegetation

The baseline data for the Wild Horse Ridge Tank Seam area is described in Appendix 3-G. Sampling was performed in August of 2001, a reference area is shown on Plate 3-1 and sampling information for the reference is included in Appendix 3-G.

C. W. Mining Company will assure that for the Tank Seam area there will be at least 1,000 plants per acre after reclamation, and that at least half of the woody plants (by number) will be comprised of Mountain Mahogany, Skunkbrush, and Vasey Big Sagebrush.

Mohrland Vegetation

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A summary of the reference areas are presented in Table 3-2.

Table 3-2 Vegetation Reference Areas

Reference Areas	Reference Type
Main Reference Area	Pinyon-Juniper-Grass-Riparian
Shower House Pad	Grass-Pinyon-Shrub
Tank Seam Access Road Reference Area	Pinyon-Juniper-Grass-Mt. Mahogany
Wild Horse Ridge Reference Area	Pinyon-Grass-Conifer
Wild Horse Ridge Tank Seam Area	Grass-Conifer-Mt Mahogany

321.200 Productivity of Land

See R645-301-321-100

R645-301-322 Fish and Wildlife Information

The information in Appendices 3-I, 3-J, 3-K, and 3-L was developed to address Division of Oil, Gas and Mining requirements in conjunction with recommendations by the Division of Wildlife Resources.

FISH AND WILDLIFE RESOURCES

SCOPE

The purpose of this report is to inventory the wildlife resources in the Bear Canyon Mine permit Area and to evaluate the impact of the operation of the mine on those resources. The study includes birds, amphibians, reptiles, and mammals. Analysis entailed a review of the applicable literature, consultation with the relevant agencies, field analysis, and impact evaluation. Input and recommendations from the Utah Division of Wildlife Resources (UDWR) can be found in Appendixes 3-I and 3-J.

In sum, this study uncovers min impact on wildlife from continued operation of the mine. Since the Bear Canyon Mine has been worked intermittently since 1896, the ecosystem has already stabilized to some degree with mining.

METHODOLOGY

Aquatic Resources

Bear Creek is the only water within the permit area that is perenial (class 3A). Runoff from the permit area flows into the Bear Creek and the Huntington Creek drainages. These are the only drainage which could potentially be affected by Co-Op's mining activities and the potential impact is expected to be insignificant. A discussion of the potential impacts can be found in Section 9 of Appendix 7-J.

The aquatic resource description of Bear Creek consists of a review of available information from previous surveys. Surveys have been conducted of both Bear and Huntington Creek although the potential for impact is considered to be minimal. Water quality determinations have been conducted by certified laboratories to establish baseline data and routine monitoring will continue as outlined in Chapter 7 on all surface and ground water within the permit area.

Terrestrial Resources

This research was designed to qualitatively evaluate the terrestrial vertebrate components in habitats which may be affected by the proposed expansion of the Bear Canyon mine. The following methodologies were used:

a. Conduct a literature review and detailed analysis of UDWR plan for the Bear Canyon Mine project and geographic area of concern.

A thorough literature review was conducted. The libraries at each of the major universities in Utah were surveyed. Special emphasis was given to location of published literature pertinent to the geographic area and habitat types in question. In addition, surrounding mine plans were reviewed for pertinent data.

Visits were also made to state and federal agencies that have jurisdiction or control over the study areas. All pertinent reports and management plans were reviewed, and appropriate personnel were questioned.

b. Contact the regulatory authorities to determine what wildlife information might be required.

The regulatory authorities were contacted by mail, phone, or personal visit to determine what wildlife information would be required.

c. Identify and cursorily inventory the terrestrial vertebrates by species for each of the habitats in the area of potential impact. Determine migratory utilization of the habitats.

Literature analysis and field observations were conducted to determine the probable and actual inhabitants of the area of potential impact and to identify habitats significant to their presence and/or persistence.

d. Categorize the status of each species and highlight those that deserve special attention because they are endangered or threatened or of economic or recreational value.

The methods and procedures essential to the accomplishment of this objective involved basically two things. First, all of the species observed or known to inhabit the potential areas of impact were identified to species through objectives a and d and listed phylogenetically in tabular form. Second, all species were categorized by: 1. habitat, 2. relative abundance, 3. resident species, 4. seasonal use, and/or 5. high interest species. The term "high interest species" designates those animals that require special attention by scientists and/or public management agencies because they are either endangered, threatened, protected game, or of economic or recreational value. The reasons for this high interest designation include: 1. ranges are small, thus restricting population to perhaps a few, 2. although populations may be numerically large, ranges

may be small within the entire represented area, 3. irrespective of population numbers or range, little is known of the current status and in some cases information suggests that populations are declining, 4. species are sensitive to impact and may be in danger of abnormal declines, 5. species are relict or may have aesthetic or scientific value, 6. economic or recreational importance, and 7. combinations of the above.

e. Evaluate and discuss in the report from the significant interactions on the terrestrial vertebrates present. High interest species are to be highlighted.

This objective is satisfied by discussions of the significant habitats, interactions, and potential results of the impacts on the terrestrial vertebrates. Appendix A outlines the procedures adopted by Co-Op as recommended by UDWR.

EXISTING WILDLIFE RESOURCES

Wildlife Habitat in the Mine Plan Area

The area of potential impact is covered by several important habitats that are used by species considered of "high interest" to various management agencies because of economic or recreation value. There are five major vegetation habitats from a faunal standpoint: pinyon-juniper, sagebrush, conifer, grass, and riparian.

Mine Site Location. This area is approximately 16 acres and is one area where surface construction will occur. It is covered primarily with pinyon and juniper trees, sagebrush, and rabbitbrush, with spruce trees in some of the side canyons. Basically it is a high, dry, desert environment.

Haul Road and Utility Corridors. Haul road and Utility corridors are both described as having the same general habitat as the Mine site with the addition of a narrow band of riparian habitat along Bear Creek.

Wildlife

Aquatic Wildlife Habitat and Value Determination

The only perennial stream that runs through the Bear Canyon Mine permit area is Bear Creek.

Bear Creek is a low-quality aquatic environment of little value to the aquatic resources of the area. A biological community most likely occurs in Bear Creek on an intermittent basis. Being present during a portion of those years when runoff is exceptionally high followed by wetter than usual summer and fall precipitation.

Even if the mine was removed, natural conditions would be stressful to aquatic life. Huntington Creek does receive runoff and/or groundwater from the permit area at some times during the yr, but because of Bear Canyon stream's quality, impact from mining will be minimal. All drainage from disturbed areas is passed through sedimentation ponds before discharge, reducing impact potential further.

Terrestrial Wildlife Habitat and Value Determination

Literature and field data were summarized for all terrestrial vertebrates of concern, the species status, and potential perturbation. Appendix 3-K list all of the vertebrate species of southeastern Utah according to their various ecological classification. All species whose ranges appear to overlap any or all of the potential area of impact are listed.

The permit area could potentially be inhabited by 239 species of vertebrate wildlife as detailed in Appendix 3-I and 3-J. Some of these are considered high interest species for the habitats and local area of concern. High interest wildlife are defined as all game species, any economically important species, and any species of special aesthetic, scientific or educational significance. This included all federally listed threatened and endangered species of wildlife. UDWR has determined that the permit area is of critical value for the elk and mule deer.

Mammals

The area of potential impact is likely to be inhabited by 84 species of mammals. The names of these animals and their habitat affinities are listed in Appendix 3-I and 3-J. They represent 6 orders and 15 families of mammals. Twenty-five species are considered high-interest species, 14 of which are protected by state or federal code. The conifer and high elev mountain grass areas near the Northern extreme of the permit area are used as summer range and fawning areas for mule deer. They are also utilized by cougar, bobcat, and possibly bear.

The low elev mountain grass and pinyon-juniper habitats in the foothills just above the Mine are utilized by elk, during winter and spring. The same area is used during spring, summer, fall and, as indicated by fallen antlers, during winter by a few of the larger deer. However, the major winter area for mule deer is in the pinyon-juniper and sagebrush habitats, along the lower hills and the entire foothill area. In all habitats, water is a critical resource and is possibly the limiting factor. The high interest species will be discussed individually in Section

10.4 of this report. It is doubtful that proposed expansions will seriously impact the other species sense no new surface disturbances are planned.

Birds

One species of involved birds are on the endangered species list: the peregrine falcon (thought to be a year-round resident in southeastern Utah). However, there are no known nesting sites for the peregrine falcon in this area. Because of the suspected transient nature or these birds, no problems are foreseen with the projected development. A Raptor survey was made during 1987 to confirm these assumptions. Potential areas of impact are shown on Plate 3-3. The areas designated for potential impact include the mine site location and the haul road and utility corridor.

The more important bird species of the area are listed in Appendix 3-K.

Amphibians and Reptiles

The material used in this portion of the report was derived from literature and a discussion with Dr. W. W. Tanner (retired) an internationally known herpetologist specializing in the reptiles and amphibians of Utah.

Increasing elev rapidly reduces the number and kind of reptiles and amphibians. In Utah, the more northern latitude reduces numbers of reptiles and amphibians in much the same way as does the increase in elev.

The geographical and associated climatic factors have eliminated most desert species, leaving species that are adapted either to mountain habitats or mountain type habitats developed in the more northern areas. Thus, the reptiles and amphibians of Utah, and particularly those inhabiting the areas under the consideration, have arrived in Utah by means of dispersal lanes coming from the northeast and the southeast. With few exceptions, the species listed have wide distribution and are versatile in their adaptive abilities.

Literature pertaining to the amphibians and reptiles is extensive, but much of it refers to species occurring in the desert areas and has only limited reference to forms inhabiting high elev in Utah. Most of the publication dealing with species lists for the state are old.[1]

The most up-to-date listing for the area under consideration may well be a checklist of Utah amphibians and reptiles (Tanner, 1975), and Utah Division Publication No. 78-16 (Dalton, 1978) (Appendix 3-K) which references a contiguous and similar geographic area.[2]

Amphibians. Based on the literature review, it was determined that probably six species of amphibians inhabit the proposed area of concern which provides substantial value habitat for the three species listed. All amphibians are legally protected in Utah, but since the species listed are all widespread throughout similar habitats in Utah, none are treated as high interest species, and therefore, are not individually discussed.

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[1]V. Tanner, Amphibians, 1931; Woodbury, Reptiles, 1931, and Pack, Snakes, 1930

[2]Other recent literature pertinent to this report are: Schmidt (1953); Stebbins (1954 and 1966); W. Tanner (1953, 1957 a and b, 1966 with Banta, 1969 with Morris and 1972 with Fisher and Willis); and Woodbury (1952).

Reptiles. Based on a review of the literature, it was determined that probably 18 species of reptiles occupy the expansion area; this area is considered to be a substantial value habitat for all species. All reptiles have some protection under the Utah code, but since the species listed are all widespread throughout similar habitats in Utah, none are treated as high interest species and, therefore, are not individually discussed

322.210 Listed or Proposed Endangered or Protected Species of Plants and Animals

There are no endangered or threatened species of mammals in the mine plan area, nor are there any in proximity close enough to be considered (Figure 3-1). Co-Op is committed to notify the Division in the event any T & E species were observed on the permit area, as well as any critical habitat.

Official U.S. Fish and Wildlife Service Section 7 opinions relating to the aquatic resources of Huntington and Eccles Canyon drainages have indicated that no threatened or endangered species of fish or other aquatic organisms have been found in waters upstream of the lowest 2 or 3 mi of the Price or San Rafael rivers. The organisms of Trail Creek, as presently known, are all common and widely distributed throughout streams of Utah. The aquatic organisms of Bear Creek have representatives of several taxonomic classifications that are limited to low quality environs, but none, as far as is presently known, are rare in the inter-mountain region.

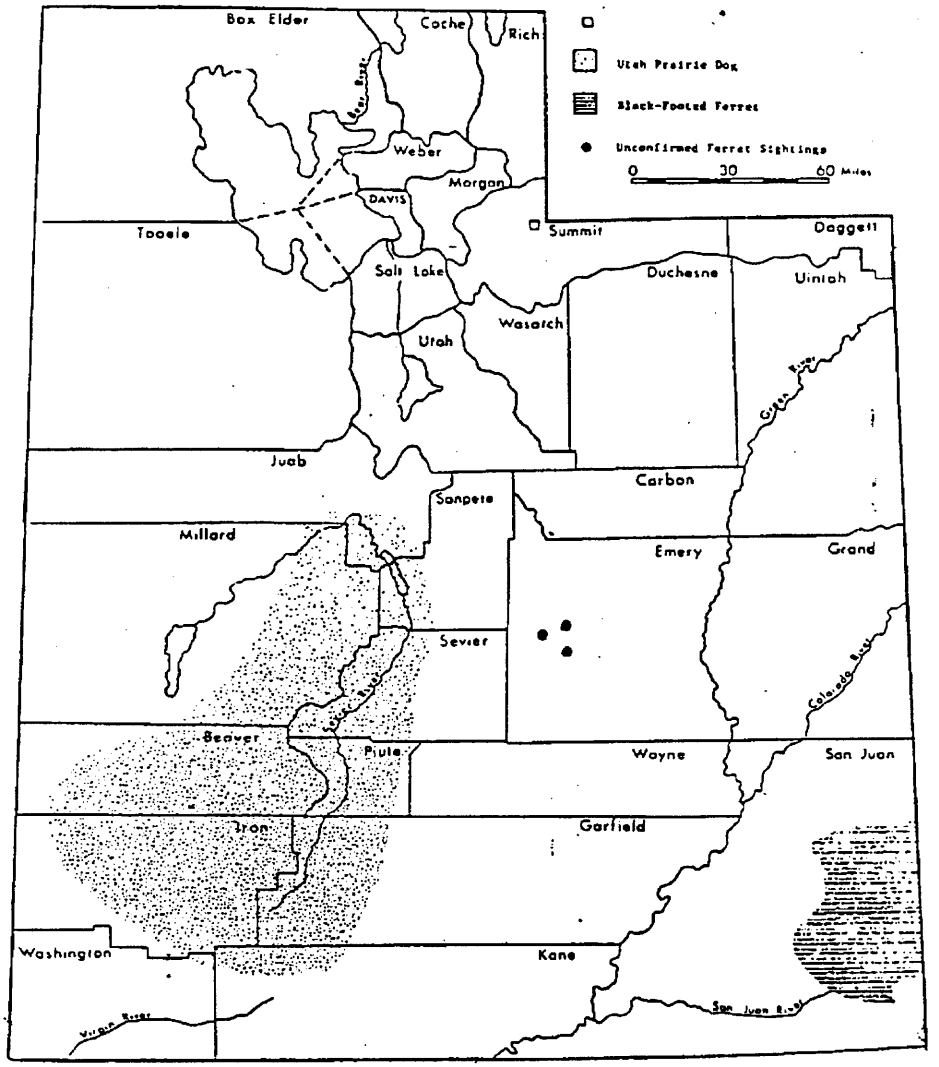


Figure 3-1 Endangered Mammalian Species in Relation to Permit Area

One species of endangered raptors, the peregrine falcon, may be found in the mine plan area. Known raptor nest sites within the permit area are shown in Appendix 3-L and on Plate 5-3, according to a survey conducted by the Raptor Biologist from the U.S. Fish and Wildlife Service.

According to the Utah Division of Wildlife Resources report, there are forty-six current or old raptor nest locations within or near the permit area. The location of the nests are shown on Plate 5-3 and a description of them and of the raptor surveys is in Appendix 3-L.

No plant species listed as threatened or endangered (U.S. Fish and Wildlife Service, 1982) or proposed for threatened or endangered status (Welsh and Thorne, 1979) was observed on the study area. No plants listed as threatened or endangered are known to occur in the Co-Op permit area (Thompson, personal communication, 1983). The U.S.D.A. Forest Service identified no threatened or endangered plants in their correspondence dated 29 Jan 1991 (Appendix 3-B). A survey on November 4, 1993 by Robert M. Thompson, USFS Botanist, revealed no threatened or endangered species within the proposed road extension area for the Tank Seam (letter, Appendix 3-B).

A sensitive species, Canyon Sweetvetch (*Hedysarum Occidental* Var *Canone*), was identified within and adjacent to the Bear Canyon disturbed area. Populations were found to be high, especially in the areas on Federal Lease U-024316. Information on this species is presented in Appendix 3-E. Locations of these plants are shown on Plate 3-1 and 3E-1. And is discussed in Appendix 3-F, populations were also observed within portions of the proposed Wild Horse Ridge disturbed area. Where these plants are located, Co-Op will avoid disturbing them to the extent possible during and subsequent to construction.

In order to re-establish the species in this area upon final reclamation, the topsoil stockpile will be seeded with the species to establish a community on the stockpile. This seed will be obtained from the Canyon Sweetvetch communities located in upper Bear Creek, shown on Plate 3E-1. During the season prior to final reclamation, seed will be harvested from the community established on the topsoil pile, as well as from the other communities within Bear

Canyon. These seeds will be incorporated into the seed mix during seeding following the topsoil redistribution.

Link Trail Columbine (*Aquilegia flavescens Var. rubicunda*) also classified as a sensitive species, has been found in three locations in Bear Canyon. The first location is in the vicinity of Big Bear Spring. The second location is in the riparian area of the right fork of Bear Canyon, located below spring SBC-14 near the Wild Horse Ridge Coal Storage Bin. The third site is at the confluence of Bear Creek and the right fork of Bear Creek. The third location is the only sight proposed to be disturbed, where two specimens are observed. Where these plants are located, Co-Op will avoid disturbing them to the extent possible during and subsequent to construction.

322.220 Habitats and Areas of High Value

These areas are shown on Plate 3-2.

R645-301-323 Maps and Aerial Photographs

323.100 Vegetation Reference Areas

The location of reference areas for determining the success of revegetation can be found on Plate 3-1.

323.200 Monitoring Stations

Not Applicable

323.300 Protection Facilities

Not Applicable

323.400 Plant Communities and Sample Locations

Vegetation areas of the mine plan site have been mapped and placed in the permit. This information can be found on Plate 3-1.

R645-301-330 Operation Plan

R645-301-331 Intrim Reclamation Plan

SCOPE

The following procedures are deigned to revegetate and control erosion. They will to a large degree satisfy the commitments made by the Co-Op in their permit wile also satisfying OSM regulations as pertaining to wildlife concerns and interim reclamation for those areas which will be utilized during mining operations.

Actual procedures involve a three phase program:

1. Earth work to prepare the site to be stable enough for a period of time to allow vegetation to become established.

2. Hydro-seed Mulch the entire area to supplement revegetation and control runoff until stabilization is complete.

3. Vegetation Monitoring will be continued on each site for 5 years or until vegetation standards have been met. Reseeding will be completed if required.

The operator will notify the division two weeks prior to all seeding work (interim or permanent), to allow the Division to be on site when the work is done.

METHODOLOGY

Phase 1 – Earth Moving

The pad down slopes will be brought back to a reasonable configuration by implementation of a crawler tractor. The actual method will involve smooth contouring of the existing soil and walking the crawler up and down the slope attempting to minimize compaction while at the same time creating small indentations by the grouser on the track. This methodology creates an enhanced micro-climate for the establishment of seed and guarantees sufficient compaction as to assure integrity and stability of embankment and prohibit failure.

Phase 2 – Seeding and Mulching

The entire disturbed area will be drilled or broadcast seeded (including hydro-seeding) during the mid fall season with a target completion date of 15 October. The seed mix and rate of application for interim reclamation is shown in Table 3-3. Hydro-seeding and mulching will be carried out in conjunction with the earth work of Phase 1. All Hydro-seed or hand seeded areas will be lightly raked to insure adequate soil/seed contact. Recommendations for the hydro-seeding and mulching operation are shown in Table 3-7.

Table 3-3 Recommended Seed Mix for Interim Reclamation

Species	Lbs/Acre PLS Hydorseed
Grasses	
Agropyron dasystachyum Thickspike wheatgrass	6.6
Agropyron spicatum Bluebunch Wheatgrass	8.7
Elymus cinerus Great Basin Wildrye	1.7
Oryzopsis hymenoides Indian Ricegrass	3.3
Poa secunda Sandberg Bluegrass	2.2
Cover Crop	
Avena sativa Oats	20

All seed obtained will comply with all state and federal seed laws. Copies of certificates for testing and poundage of seed purchased, will be submitted to the division.

Phase 3 – Monitoring

All interim seeded areas will be inspected at the end of each growing season to determine the success of the seeding program for a period of at least five years (reclamation years 1-5). Where success is not apparent, as represented by achievement of 80 pct original cover during the 5-year period, monitoring will be immediately investigated to determine the possible failure cause(s), so that positive steps can be taken to establish the desired interim vegetation during the next seasonal opportunity. The success of the interim seed mixture will be evaluated and areas that do not meet the success criteria will be reseeded. This effort will ensure a temporary cover of small grains, grasses or legumes until a permanent cover can be established.

Ocular estimates will be made to determine the degree of success for interim revegetation attempts.

R645-301-332 Subsidence Impacts and Mitigation

All subsidence will be monitored as shown on Plate 5-1. A detailed description of C. W. Mining Company's subsidence monitoring plan is included in old Appendix 3-C.

R645-301-333 Plant, Fish and Wildlife Impact Avoidance Plan

Protection of Vegetative Resources

Co-Op has maintained a commitment to reclaim the unused disturbed areas to the extent of the cover of the natural vegetation on the mine plan area.

Projected Impacts of Mining on Vegetative Resources

Since the Bear Canyon Mine is an underground mine, the overall impact on surface vegetation is minor. The effects of surface operations on vegetation from new construction are on-site erosion and reduction of desirable plant species which reduce forage production and wildlife capacity.

Vegetated areas adjacent to the disturbed areas are protected from coal fines primarily by utilization of dust controls, such as water sprays on the coal handling facilities and watering of the coal haul roads. One of the major areas that indicates collection of coal fines, is located in the canyon below the Upper Storage Pad. However, the actual impact has not been determined.

In order to eliminate the potential of coal fines migrating to surface waters, this area was added into the disturbed area boundary in 1992. Runoff will be directed to sediment ponds, see R645-301-742.300. Areas in Bear Canyon surrounding the mine site will be routinely monitored and additional preventative and/or control actions will be taken if additional affected areas are identified.

Waste dumping or other disturbance on undisturbed areas is not permitted. Disturbed area perimeter markers delineate the boundaries of disturbance. Employees are trained not to dump or otherwise disturb areas outside those boundaries.

Renewable vegetative resources exist within the wild Horse Ridge subsidence zone in the form of timber and grasslands which are used for grazing. As discussed in Appendix 3-C, minimal detectable subsidence is expected on the surface. Past experience has shown that tension fractures which result from subsidence are localized and minimal, so these resources should not be impacted. Further discussion is contained in Appendix 3-C.

Mitigating Measures to be Employed to Reduce Impacts on Vegetative Resources

All recontoured areas will be planted and revegetated during the first appropriate season following grading and redistribution of topsoil. This program will include any necessary addition of remedial treatments to the soil. A suitable, permanent and diverse vegetative cover has been selected on the basis of appropriate land management agency requirements and will be established on all reclaimed areas. The schedule of the program is presented in R645-301-

542.100. What follows is an outline of the major aspects of the revegetation plan. The specific measures involved will be addressed on a site specific basis.

Seeding and Planting. All plants used to revegetate the disturbed areas will be native or compatible species selected specifically for the vegetative community. Seed types may include wheatgrass, salina wildrye, sagebrush, pinyon and juniper and are listed in R645-301-340. Wherever possible, seed will be drilled or disked into the ground. In steep slope areas, where such techniques are difficult or impossible, hydro-seedings or cyclone spreader seeding will be done.

Native shrubs will be used for shrub replanting. These will be potted seedlings, if available. Bare-root trees will be used to some extent. Seedling will be planted during the months of April-May when possible. However, depending on availability, fall planting would occur September-October.

Mulching and Moisture Retention. All regraded and topsoiled areas will be mulched or otherwise treated to promote germination of seeds and to retain moisture. Various moisture-retention products are available and are detailed in the specific reclamation plan in R645-301-340.

Maintenance. Should such procedures prove necessary to the success of the revegetation plan, protection of replanted areas from animals may be carried out. Such procedures however, are

unlikely to be needed because the species to be selected should not require continuous or considerable maintenance beyond replanting.

Vegetation Monitoring Procedures

Qualitative observations of revegetated areas will be made yearly throughout the ten year liability period (See R645-301-250). Quantitative measurements of reclamation will be collected during years 2, 3, 5, 9 and 10 of the same bond liability period. Any areas not achieving success will be re-evaluated and revegetated as needed.

Protection of Fish and Wildlife

Wildlife is present in the mine plan permit area. Due to the size of the total disturbance impacts on the various mammal, amphibian and reptile species should be minimal. In addition, Co-Op is committed to mitigating as much as possible the adverse effects of all new construction and maintaining the natural abundance and diversity of the area.

Projected Impacts of Mining on Fish and Wildlife

Mammals. The Bear Canyon Mine plan area is inhabited by 74 species of mammals, of which 25 species are considered of high interest and 14 of these are protected by state or federal law.

Elk that are thought by the Utah Division of Wildlife Resources (UDWR) to be stable and productive use portions of the mine plan area at various times of the year for such necessary activities as wintering and feeding. This use, however, is marginal and not crucial. The minimal disturbance caused by planned surface facilities will have no significant impact on the herd.

Mule deer utilize the whole permit area, taking advantage of various habitat at different times of the year. Browse in the wintering range within the permit area is in good shape and should facilitate over-wintering of the herd. Projected impact from proposed surface operations is expected to be minimal. The range of cougars in the permit area is determined by the migration patterns of mule deer and by human disturbance. Since the cougar population is low and since their range is far greater than the areas of proposed construction, mining activities will have little impact on the species.

Black bear may inhabit the permit area but the area is small compared to the overall habitat area. Black bears are not numerous, nor are they likely to be disturbed during the most sensitive times of their annual cycle. Impact will be minor at most.

Cottontail rabbits are likely to be affected only by subsidence, which will be limited to relatively small areas thus causing little impact. Disturbance to vegetation resulting in several succession will actually improve the reproduction potential of the rabbits.

Impact on snowshoe hares will be minor since the species habitat in conifer-aspen stands is limited in the permit area.

Furbearers using underground burrows may be affected by subsidence within limited portions of the permit area. However, such effects will be temporary and the species are widespread and adaptable to human activity. Long-term impacts will be minimal. Mining activity will have little effect on the habitat of small mammals. Subsidence damage to burrows could increase mortality and reduce reproductive success temporarily, but the effect would be temporary because of the continued survival of the breeding population in contiguous areas and to the high densities of these species.

Birds. Only one species found in the vicinity of the mine permit area are on the endangered species list: The peregrine falcon is not known to nest within the permit area.

Potential impact on bird species would be limited to the proposed new construction areas. Impacts, however, should be minor since the areas involved are small and since equivalent habitat is readily available close by. (See Raptor Survey UDWR -- Appendix 3-I).

Prior to construction of surface facilities, Co-Op will work with the UDWR in developing a mitigation plan for potential impacts to raptor nest utilization in the vicinity of Wild Horse Ridge.

Amphibians. The three amphibians occurring in the permit area occupy similar habitats throughout the region and are unlikely to be affected in any major way by planned activities.

Reptiles. Reptiles found in the permit area are located in many other similar habitats and their populations will not be seriously impacted by planned activities. UDWR personnel will be notified if any denning sites are discovered during mining or construction.

Aquatic Wildlife. Since there are no high quality streams in the surface operation areas, little impact to aquatic wildlife is expected. Huntington Creek, the closest high qualify stream to the permit boundary, is located a considerable distance from the surface operation, 1.5 miles. This high quality fishery is protected through Co-Op's Sediment Control Structures (R645-301-742.300).

Mitigating Measures to be Employed to Protect Fish and Wildlife

Maximum effort will be made to minimize habitat disturbance and loss. Surface activity will be minimal. Construction will be scheduled to minimize conflict with deer and elk use periods.

The disturbed areas will be reseeded within the next growing season and the resulting seral succession will actually benefit deer and elk. Habitat loss due to construction in limited to the size of the disturbed area and will be small. All water in the permit area is perennial, but of poor quality. Any water sources necessary to wildlife will be provided. in addition, riparian habitat will be enhanced. Structures that pose a barrier of hazard will be provided with passageways, buffers, fences, or other necessary protection, as directed by UDWR (Appendix 3-J). Co-Op is committed to reclaim all disturbed land and remove all support facilities in

accordance with R645-301-540 upon completion of mining to prevent damage to fish, wildlife and related environmental values.

The applicant will inform employees of the vulnerability of local wildlife and will admonish them to avoid all harassment or unnecessary activity. In addition the training film offered by the UDWR "Coal Mining and Wildlife" will be shown annually to all employees.

Any discovered wildlife impact not described here will be mitigated by Co-Op with methods agreed upon by UDWR. Co-Op will also report the presence of all Golden Eagles on the permit area as well as any T&E species.

Since no impacts are expected to surface waters of mine area in the near future, no special mitigation plan concerning Bear Creek is presented here.

Wildlife Monitoring Procedures

Bear Creek does not warrant a biological or habitat monitoring effort in the area of the mine lands. Deer and rodent use of areas planted with tree and shrub species will be observed yearly. If heavy use of the planted trees and shrubs by deer appears probable, appropriate protection measures will be taken. Also, should significant rodent damage become likely, a control program may be developed in conjunction with UDWR and appropriate land management agencies.

R645-301-340 Reclamation Plan

R645-301-341 Revegetation

The following procedures are designed to revegetate and control erosion. They should satisfy the commitments made by Co-Op towards post mining land use while also satisfying State and Federal regulations. A proposed revegetation schedule is given in Table 3-4.

The operator will submit a detailed revegetation plan in the last Five-Year Permit renewal prior to reclamation. The plan will include detailed map(s) of sufficient scale to show exact areas and methods of revegetation (i.e., drill seeding, terraces, netting, etc..) based on the best available technology and final mine site conditions. The operator will notify the division two weeks prior to all seeding work (interim or permanent), to allow the Division to be on site when the work is done.

The actual ground involved in reclamation procedures is identified in R645-301-240, and Table 1-4. The actual procedures involve a four phase program; (1) backfilling and grading, (2) prepare a site which will be stable enough for a period of time to allow vegetation to become established, (3) seed and mulch the entire area to supplement revegetation and control run-off until stabilization is complete, and (4) plant seedlings to further stabilize the soil and to provide necessary wildlife, hydrological and aesthetic commitments as detailed in mine reclamation permit.

Revegetation Timetable

Table 3-4 Revegetation Schedule

Task	MONTH Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Review revegetation Plan	XX	X								
Order Seed		X								
Order Transplants			X							
Regrading					XXX	XXXX				
Spread Topsoil							XXX			
Seedbed Preparation							XX	X		
Apply Fertilizer								XX	X*	
Seeding								XX	X	
Mulching								XX	X	

Task to be done in subsequent years:

Plant Seedlings[1]	XX	X								
Monitor revegetation				XX	XXXX	XXX**		X***		
Submit Monitoring Report	X****									

* May need application of N the spring following seeding.

** Monitor during peak of growing season as per monitoring schedule.

*** For survival of transplants.

[1] Plant transplants the spring within two yrs following seeding.

Seed Mix and Application Rate

All seed obtained will comply with all state and federal seed laws. Copies of certificates for testing and poundage of seed purchased, will be submitted to the division. Any changes in the approved seed mixes will first be cleared with the Division. Costs listed below were gathered from suppliers in Nov. 1990.

It is currently recommended by the State of Utah, Division of Oil, Gas & Mining (DOGM) that riparian areas such as the one in Bear Canyon Mine site not be seeded with a specific Riparian seed mixture. It is often impractical to attempt to seed these narrow corridors in conjunction with the surrounding seeded areas with a separate seed mix. Instead it is recommended that the operator seed the riparian area with the Pinyon Juniper Grass seed mix and augment with woody plant seedlings.

Co-Op proposes to seed the disturbed areas corresponding to all four reference areas with the seed mix shown in Table 3-6.

Table 3-5 Recommended Seed Mix, Riparian-Creek Bottom

Scientific Name	Common Name		Plants/ac
Populus anqustifolia	Cottonwood		150
Prunus virginiana	Chokecherry		150
Rosa woodsii	Wood's Rose		100
Sambucus caerulea	Elderberry		100
Salix spp.	Willow	*	
	TOTAL		750

* Salix should be cut from a source area in close proximity to the mine site and planted in the reclaimed area. In areas of suitable habitat Salix will be planted with at least one cutting every foot.

Table 3-6 Recommended Seed Mix, Pinyon-Junipor-Grass

	Scientific Name	Common Name	PLS lbs/ac*
	SHRUBS		
	Artemisia tridentata	Big sagebrush (Vasey)	0.2
	Artemisia ludoviciana	Prairie sage	0.2
	Cercocarpus ledifolius	Mtn. Mahogany	1.0 ****
	Rhus trilobata	Skunkbush	1.0
	Amelanchier utahensis	Utah serviceberry	1.0
	FORBS		
	Achillea millifolium	Yarrow	0.1
	Aster glaucodes	Blueleaf aster	0.2
	Hedysarum boreale	Northern sweetvetch	1.5
	Linum lewsii	Lewis flax	0.5
	Penstemon eatonii	Firecracker penstemon	.5
	Pentstemon palmeri	Palmer's Pentstemon	0.5
**	Hedysarum Occidentals Var. Canone	Canyon Sweetvetch	See below
	GRASSES		
	Elymus cinereus	Gt. Basin Wildrye	3.0
	Poa secunda	Sandberg's bluegrass	0.4
	Elymus smithii	Western Wheatgrass	3.0
	Elymus spicatus	Bluebunch Wheatgrass	3.0
	Stipa hymenoides	Indian Ricegrass	2.0
***	Elymus salinus	Salina wildrye	2.0
		TOTAL	

* Rates based on broadcast seeding.

** Canyon Sweetvetch will be added, as available, to the seed used on the Wild Horse Ridge.

*** If unavailable no substitution required.

****Also to be transplanted as container grown plants in fall at the rate of 500/acre.

In combination with the seed, the following rates of tackifier will be utilized:

Table 3-7 Suggested Proportions of Tack to Fiber

slope angle (deg)	slope ratio (rise:run)	percent slope	lbs. Tack per ton fiber	ratio tack to fiber
14	1:4	25	60(min)*	1 : 30
26	1:2	50	80	1 : 25
33	1: 1 ½	66	100	1 : 20
45	1: 1	100	120	1 : 16
57	1 ½:1	150	140	1 : 14
64	2:1	200	160(min)	1 : 12

* 60 pounds is suggested as a minimum to insure excellent stabilization; however, in many conditions 40 pounds of Tack per acre has given excellent results on a 1:4 or less slope. (Rates of Tack were developed with respect to velocity and erosive power of water which is proportional to the square root of the slope.) An empirical factor was determined from laboratory and field studies to arrive at the min Tack fiber ratio. Thus, 60 pounds of Tack per ton of fiber is about min for slopes up to 20 pct and the empirical factor is determined as 60 divided 20 pct = For a 100 pct slope (1:1 or 45 degrees) the ratio of Tack to fiber is calculated as: (100 pct) (12) = 120 pounds. Tackifier to be used for Hydroseeding and Hydromulching to Serve as Mulch or Soil Binder.

Planting Methods

The reclaimed areas will be seeded with a hydro-seeder or by hand. Many shrubs and all trees will be planted by hand setting to ensure a permanent plant cover.

All hydroseeded or hand seeded areas, will be lightly raked to insure adequate soil/seed contact. On slopes greater than 2:1, a two step hydroseeding method will be used. One half of the seed amount will be applied and raked and then the remaining seed will be applied.

A min of 120 lbs/acre fiber will be used when hydroseeding.

Seedlings will be planted in Apr - May or Sept - Oct depending on availability and sequence of completion, plants will be grouped to provide wildlife cover. Spacing within the group is defined in Table 3-5 and Table 3-6 and will be correlated to the reference area.

The planting of seedlings will be done within two years of the seeding effort in order to evaluate the number and species of seedlings necessary to insure both composition and stocking of woody species to maximize utilization by wildlife and domestic grazing.

The species and numbers of individual plants are correlated to the reference area which was established during July of 1983.

Planting will be done utilizing a powered auger with a capability of drilling a 3 inch plus diameter hole to a depth of 16 inches or by hand with a shovel. The roots of the seedling will be

arranged in as near natural position as possible paying special attention not to "J" the root tips. (Figure 3-1).

By holding the seedling at the root crown, soil will be compacted back around the roots being careful to leave no air pockets or loose dirt (which would constitute settling). The tree will be firm when light pressure is exerted on the needles and standing in an erect position. Only hands shall be used to pack soil around the tree, the use of a stick or foot is strictly forbidden.

At all times the trees will be protected from direct sun light and special care will be exhibited when lifting the seedling from the planting bag to the prepared hole. The spacing of planted shrubs and trees will be to obtain the desired density and diversity while providing small clumps of cover for wildlife on approximately 100 ft intervals throughout the areas of disturbance that are in excess of 2 acre in size.

Field storage facilities are illustrated in Figure 3-2. In the event snow is not available, a similar cache can be constructed using wet burlap and damp straw.

The mine will have to maintain a sorting, packaging and storing tent at the cache site. A sorting table will need to be set up in one tent. Each seedling must be examined and all that do not have a 2 to 1 crown to root relationship or are damaged must be discarded. The seedlings then need to be dipped in a vermiculite slurry and then rolled in wet burlap and placed in canvas planting bags.

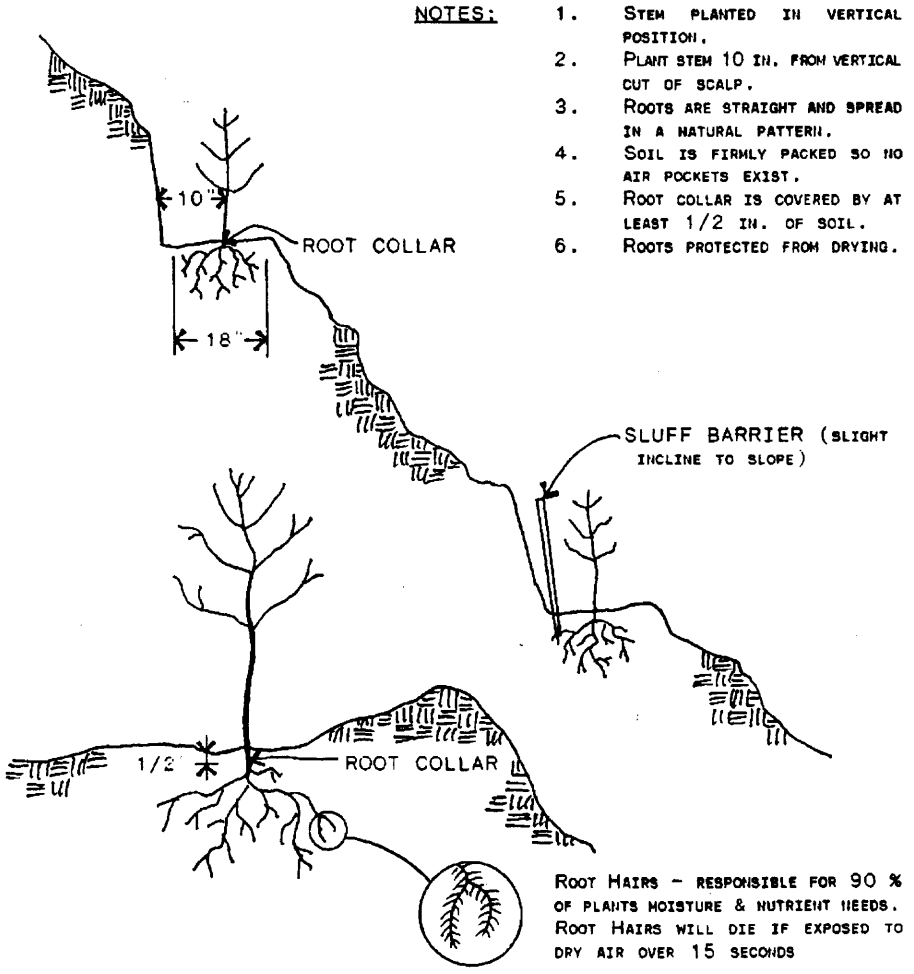
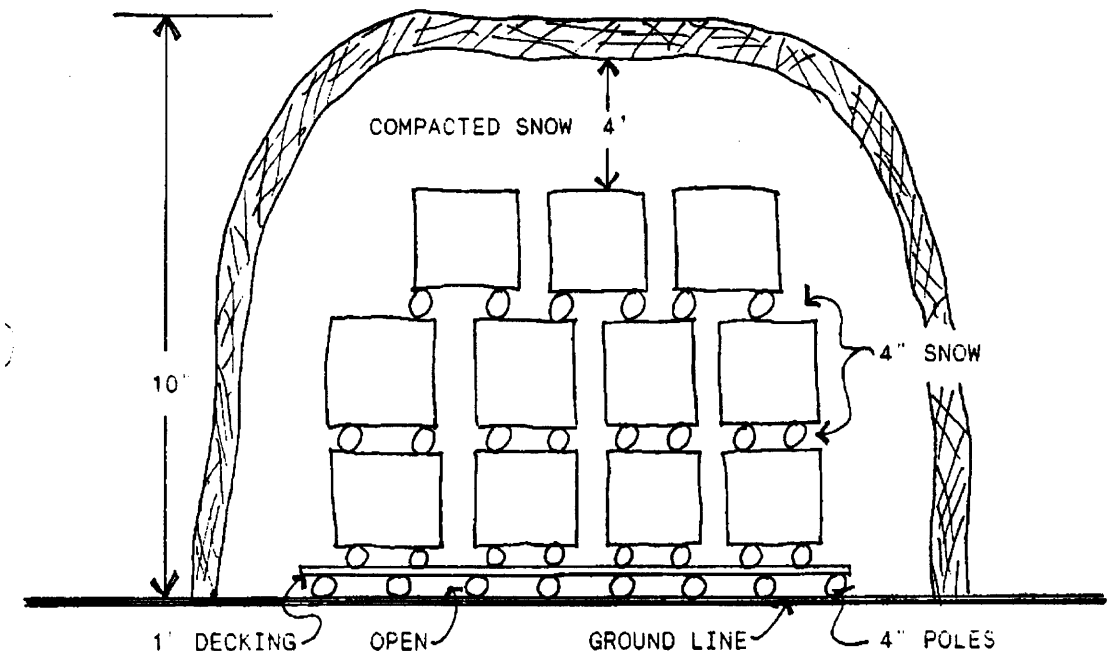


Figure 3-2 Correct Planting Procedures



SNOW CASHE WILL MAINTAIN SEEDLINGS AT 32°F AND RELATIVE HUMIDITY OF 100%. SEEDLINGS SHOULD BE PLACED IN A COOL SHADED AREA 24 HOURS PRIOR TO PLANTING.

Figure3-3 Seedling Storage

The trees can only be left in the bags for twenty-four hour periods and then must be repacked following the same procedures. The field handling of packed trees requires the crowns be kept moist and the bags covered with insulated tarps and stored in shaded areas.

During breaks, lunch, etc., the crews planting bags must be placed in shaded areas. At the end of each operational day all bags must be unpacked and the trees re-dipped in vermiculite and rolled in wet burlap and repackaged to be used first the succeeding day.

341.230 Mulching Techniques

Following the seeding effort all seeded areas with slopes flatter than 2:1 will be hydromulched. The rate of application of the wood fiber mulch is 120 lbs/acre.

The mulch will also be fortified with Tack as previously indicated according to slope. Fertilization and/or neutralizing compounds required according to R645-301-243. will be incorporated in the mulch slurry.

Slopes 2:1 or steeper will be mulched with erosion control matting. The matting will be applied as per manufacturers specifications.

The mulch will be certified as weed free by the county agriculture agent. Copies of this certification, along with weight tickets from a certified scale will be submitted to the Division. All straw or hay mulch will be incorporated into the top 6 in. of topsoil or crimped in order to anchor the mulch to the soil surface.

341.240 Irrigation

N/A

341.250 Determination of Revegetation Success

All reclaimed areas will be monitored to determine when bond release parameters are achieved. Success standards will be based on the reference areas. With the last Five-Year Permit Renewal a map will be submitted with the area partitioned into three to five areas with similar slope and aspect and each of these areas or a weighted average will be used to compare with the reference areas corresponding to that area for bond release.

Qualitative (ocular estimates) monitoring will be completed each year until bond release with the intent of identifying problem areas. Quantitative monitoring will be made during years 2, 3, 5, 9 and 10 until bond releases. Both the final reclaimed area and reference area will be sampled for cover, density (woody plants). Species composition data will be collected and compiled in year 2, 3, 5, 9, and 10 using cover sampling data. Productivity measurements will be collected during years 9 and 10 of the bond liability period.

The success of the reclamation effort will be evaluated by detailed sampling of cover, woody plant density and production of reference and reclaimed areas. The data from the reclaimed areas and the reference area will be collected during the same growing season. If there is no significant difference in cover woody plant density and production between the reclaimed areas and the reference areas when tested at the 90 pct significance level using a one-tailed t-test, then the areas will be judged to adequately reclaimed relative to cover and production.

Wood plant density standards will be sampled for each reference area as well as the reclaimed areas and the success of the reclaimed area based on the results from the reference areas (90 pct pre-mining stock level survival at bond release) cover, woody plant density on reclaimed and reference areas will be measured using the same methods employed during the baseline studies. At the time of bond release, trees and shrubs, used to achieve success, will be healthy and at least 80 pct will have been in place for at least eight growing seasons. No trees and shrubs in place for less than two growing seasons will be counted in determining stocking adequacy. The woody plant density success standard for the Wild Horse Ridge area will be equal to 1,010 trees and shrubs per acre. Although this is less than that of the reference area, it is the density measured in the area prior to disturbance and is considered adequate.

Standard methods will be applied to determine the degree of success for revegetation attempts. Production will be measured using a Harvest methodology. Shrub density data will be collected, using 1 m x 50 m transects.

One of the greatest challenges of revegetation is to create reclaimed areas which have a large number of desirable species. Species diversity on the reclaimed areas will be encouraged by including a variety of grasses, forbs, and shrubs in seeding and planting mixes.

Species diversity will be judged adequate when the relative cover and pct distribution of biomass for the major life form groups approx that which occurs in the reference areas. That is, if the relative cover by perennial grasses is 50 pct in the reference areas, then the relative cover by perennial grasses on the reclaimed areas should also be approx 50 pct. This same relationship should also hold true for productivity. If most of the cover and production were being provided by annual forbs on the reclaimed areas and by perennial grasses on the reference areas, then the reclamation would be judged unsuccessful.

The purpose of the above procedures is to demonstrate that based on cover, production, woody plant density, and species diversity, the disturbed areas have been returned to stable plant communities capable of withstanding the intended post-mining land use.

R645-301-342 Fish and Wildlife Reclamation Plan

The post-mining land use that reclamation will attempt to provide for is wildlife habitat. Revegetation in the mine area will seek to enhance forage values of the reclaimed area sites thus tailoring them to the needs of wildlife and minimizing the undesirable shrubs found in the adjacent area.

R645-301-350 Performance Standards

R645-301-351 General Requirements

All coal mining and reclamation operations will be carried out according to plans provided in R645-301-330 through R645-301-340.

R645-301-352 Contemporaneous Reclamation

Contemporaneous reclamation will be conducted as practicable on disturbed areas of the permit that will not be needed or affected by future operations. The procedures used will be the same as the ones outlined in R645-301-340.

R645-301-353 Revegetation General Requirements

A vegetative cover that is in accordance with the approved permit and reclamation plan or otherwise acceptable, will be established on regarded disturbed areas. The cover will be: diverse, effective and permanent; comprised of native species or desirable introduced species approved by the Division; equal in extent of cover to the natural vegetation of the area; and capable of stabilizing soil.

The reestablished plant species will be compatible with the approved post mining land use; have the same seasonal characteristics of growth as the original vegetation; be capable of plant succession and self-regeneration; be compatible with the plant and animal species of the area; and meet the requirements of applicable Utah and Federal species laws or regulations.

Species having the qualities to meet the above mentioned vegetative cover requirements, as well as rates of application of seeds and transplants are shown in Tables 3-5 and 3-6.

353.250 Noxious Weeds

The following weeds are officially designated as noxious for the State of Utah, as per the authority vested in the Commissioner of Agriculture under Section 4-17-3, Utah Noxious Weed Act, and will be controlled as directed by the Emery County, Extension Agent if found within the permit area:

Bermudagrass	Cynodon dactylon
Bindweed	Convolvulus spp.
Broadleaved Peppergrass (Tall Whitetop)	Lepidium latifolium
Canada Thistle	Cirsium arvense
Diffuse Knapweed	Centaurea diffusa
Dyers Woad	Isatis tinctoria
Johnson Grass	Sorghum halepense
Leafy Spurge	Euohorbia esula
Medusahead	Taeniatherum caput-medusae
Musk Thistle	Carduus nutans
Perennial Sorghum	Sorghum halepense & Sorghum Almum
Purple Loosestrife	Lythrum salicaria
Quackgrass	Agropyron repens
Russian Knapweed	Centaurea repens
Scotch Thistle (Cotton Thistle)	Onopordium acanthium
Whitetop	Cardaria spp.
Yellow starthistle	Centaurea solstitialis

R645-301-354 Revegetation: Timing

Disturbed areas will be planted during the first normal period for favorable planting after replacement of the plant-growth medium.

R645-301-355 Revegetation: Mulching and Other Soil Stabilizing

On all reclaimed areas a wood fiber, straw or hay mulch will be used to enhance moisture retention required for seed germination. Tackifier will be added to the wood fiber mulch to help it adhere to the soil. A min of 60 lbs tackifier/ton fiber will be applied, with steeper sloping areas requiring more as shown in R645-301-341 Table 3-4. Steeply sloped areas will require erosion control matting. These areas will be noted on the detailed revegetation plan and maps to be submitted in the last Five-Year Permit Renewal prior to reclamation. Soil stabilizing practices are outlined in Chapter 2, R645-301-244.

R645-301-356 Revegetation: Standards for Success

All revegetated areas will within at least 80% of the reference areas in density and population.

C.W. Mining Company will assure that for the Tank Seam area there will be at least 1,000 plants per acre after reclamation, and that at least half of the woody plants (by number) will be comprised of Mountain Mahogany, Skunkbrush, and Vasey Big Sagebrush.

R645-301-357 Revegetation: Extended Responsibility Period

The average annual precipitation at Bear Canyon is 12 inches, therefore, the period of responsibility will continue for a period of not less than ten full years.

R645-301-358 Protection of Fish, Wildlife and Related Environmental Values

C. W. Mining Company will to the extent possible be using the best technology currently available, minimize disturbances and adverse impacts on fish, wildlife, and related environmental values and will achieve enhancement of such resources where practicable.

Mitigation of mining impacts on and management of wildlife are usually considered and the plans for implementation prior to any perturbation. These actions often follow one of three general forms:

a. Design of facilities and access or transportation modes to minimize impacts

b. Operation of the mine and associated facilities to minimize impact

c. Enhancement of wildlife habitat both in the vicinity of and away form the mine in order to mitigate losses that may occur.

Since no impact to the perennial waters of the permit area is expected in the foreseeable future due to the stream buffer zones and runoff control measures, no special mitigation plan

concerning Bear Creek is presented here. The creek was monitored for water quality condition with monthly sampling in order to acquire a baseline description of the resource. This baseline provides a solid ground for future impact analysis and mitigation planning if the need arises.

In new mine operations it is easy to suggest, provide and implement mitigative and management measures, but in the case of the Bear Canyon Mine, which is already in operation pre-construction design and associated mitigation and management does not apply. The terrestrial wildlife inhabiting and utilizing the area of concern are accustomed to the present facilities and have adjusted their behavior, including migration patterns, so that change would be of more impact than would retaining the status quo.

Construction and operation of the scale-house, stockpile area and road could potentially disturb wildlife. To minimize habitat disturbance and loss, surface activity will be kept to a minimum.

The mine activities will take into consideration potential conflict with deer and elk reproductive activity and any small acreage involved will be restored as quickly as possible by redistribution of topsoil within the disturbed area, with immediate reseeding and replanting of native seeds and vegetation. Because of the small size of the area, natural reseeding will also occur from the surrounding area. The seral stage habitat created will be beneficial to deer, who readily utilize seral stages of mixed conifer-aspen forest.

Construction of the Mine Site and Haul Road are sources of disturbance. Habitat would be lost temporarily during construction and permanently where the mine is located. Since this is in a wintering area the same community reestablishing and augmenting techniques would be used. The terrain is such that established trails do not exist.

Little riparian habitats exist within the area, there will be little impact by the proposed action. All water is intermittent but since water is such a limiting resource to game animals, care will be taken to prevent disturbance, erosion, or coal deposition in the ephemeral channels. Roads will be routed or acceptable crossings built to avoid disturbance or erosion. Coal will be wetted to prevent blowing if necessary.

As determined in consultation with UDWR, all hazards associated with the expansion and mine operation will be covered, buffered or fenced to prevent damage to wildlife of concern.

Since there are crucial critical periods in the life history of high interest species such as mule deer and elk, the applicant will communicate such to their employees who will be admonished to avoid all unnecessary disturbance and harassment of wildlife species. In addition, all employees will be required to view the film "Coal Mining and Wildlife": as a tool to educate the mine personnel on their role in safeguarding Utah's wildlife.

In any situation not previously mentioned where wildlife habitats are disturbed by this proposed action, reclamation will be implemented by the best available methods and agreeable to

UDWR and the appropriate management agencies. The old road up Bear Creek is an example of mitigation which was completed by October, 1984.

Wildlife Mitigation

Co-Op, in order to mitigate the loss of approximately 10 acres of Mule deer winter range in association with the construction of the Bear Canyon Mine, has agreed to the following course of action with UDWR:

a. The reclamation of a major portion of the abandoned Bear Canyon county road approximately 2 acres (completed Fall 1984).

b. Contemporaneous reclamation of portions of Bear Canyon permit area-topsoil stockpiles, down slopes, power line corridor, etc. Approximately 3.2 acres (started Fall 1983, completion Fall 1985).

c. Enhancement of Bear Creek off permit. This work was accomplished in 1986 and constituted the enhancement of approximately 7 acres of stream channel. The work involved the installation of velocity dissipaters, planting of willows, and compatible wildlife browse species in the stream channel.

In addition, Co-Op has agreed that in the event that escarpment failure due to subsidence impacts any raptor nests within the permit area, that Co-Op will notify UDWR and the U.S. Fish and Wildlife Service and take whatever action is recommended

in order to mitigate such loss. At this time no raptor nest are at risk due to their absence from all areas of potential impact. Raptor nests will be safeguarded from subsidence by maintaining a min of a 100' barrier to the outcrop.

UDWR authorities will be consulted, in the event a need for pesticides becomes necessary to control rodents or insects during reclamation. No control measures will be used without prior approval by all parties concerned.

The Wild Horse Ridge disturbance will require some mitigation for the loss of Big Game Habitat and for the potential loss of raptor nesting during the construction and operation of the facilities. C. W. Mining Company is working with the Division of Wildlife Resources to develop a raptor prey base study and will complete the study in the summer of 2003 for mitigation.

Stream Buffer Zone

Current surface facilities are in the upper reaches of the Bear Creek drainage, which is a tributary of Huntington Creek drainage. Appropriate sedimentation ponds have been constructed. This coupled with coal pile drainage ditches, clear water diversion, water bars, and wind erosion control measures within the permit area disturbed areas, will assure protection from mining impact of aquatic resources far downstream from the mine. Thus, no aquatic biological community determinations have been made relative to surface activities. Stream buffer zones are established along Bear Creek as determined by DOGM to insure protection of the stream channel. Stream buffer zone signs are in place at approximately 200 foot intervals along Bear Creek.

FISH AND WILDLIFE MONITORING

Bear Creek does not warrant a biological or habitat monitoring effort since it is naturally of poor quality. Water quality will be monitored as outlined in R645-301-731.200. Data collected will be correlated with water quality and hydrology measurements discussed in R645-301-731.200. If subsidence should become evident in the drainage area that contributes to Bear Creek, monitoring of aquatic macroinvertebrates and habitat changes will be instated using approved methodology to collect data as the base for impact evaluation.

Co-Op has monitored all existing power transmission lines in order to determine use by raptors. No use was observed, Co-Op will take all necessary measures to ensure the poles and/or structures are safe. All new poles and power transmission facilities will be constructed to be

raptor protected, and will conform with designs shown in both the Avian Power Line Interaction Committee's (APLIC) publications, "Mitigating Bird Collisions with Power Lines: The State of the Art in 1994," and, "Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996". In April 1988 DOGM consented to allow suspension of raptor surveys unless new disturbances warrant a clearance survey (Appendix 3-L).

b. Solid waste generated in the facilities removal will be collected and disposed of as identified in R645-301-541.300. See Appendix 5-D for toxic materials and handling.

In disturbed areas which contain coal fines from current operations and are not proposed to be regarded, the coal fines will be removed to pre-mining levels. Methods of removal will consist of either vacuuming (if justified by large quantities), or by washing down the area by high-pressure water hoses. The wash down procedure is particularly effective on rock and rocky slopes. All other extraneous debris from the operations will also be removed from the areas. Disposal of all materials will be as described in R645-301-529.

It should be noted that the existence of small to moderate amounts of coal fines has not been established as detrimental to either soils or vegetation; therefore, amounts less than the 50 pct figure cited above will not be removed.

c. A backhoe and dozer will work in conjunction to remove the outer edge of the recontoured operational benches and compact it against the cut slopes. This will be accomplished by the backhoe reaching over the edge of the bank approx 20 ft. and pulling the material back. The dozer will then push and compact this material from the cut slope outward to reach a bench slope of approx 1v:3h for drainage purposes and a maximum of 1v:2h on slopes outside of drainage areas. Culverts will be removed by excavating the material over the culvert, extracting the pipe, and backfilling the area.

Chapter 6

R645-301-600 Geology

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R645-301-600 Geology

R645-301-610 Introduction

This chapter describes the general geological conditions of the permit and adjacent areas and identifies whether the conditions are acceptable for recovery of the coal by underground methods.

R645-301-611 General Requirements

Descriptions of the geology within and adjacent to the permit area is given under R645-301-620 through 627.

R645-301-612 Cross-Sections Maps and Plans

All cross-sections, maps, and plans as required by R645-301-622 have been prepared and certified as described under R645-301-512.100

R645-301-620 Environmental Description

Regional and Structural Geology

The mining site lies at the base of an erosional escarpment that forms the eastern face of the Wasatch Plateau, a subdivision of the Colorado Plateau physiographic province. East of the Wasatch Plateau is Castle Valley, a relatively flat area over 80 mi long and 10 mi wide trending northeast-southwest. East of Castle Valley lies the San Rafael Swell, a great upfold marked by rings of hogback hills and intervening valleys.

The Wasatch Plateau is a high, broad, flat area dissected by numerous streams. The high plateaus of Utah, which include the Wasatch Plateau, are thought to be a transition zone containing geologic structures common to both the Colorado Plateau Province and the Basin and Range Province to the west.

The C.W. mining site is located near the east central edge of what is known as the Wasatch Plateau coalfield. The plateau edge is a steep cliff with a maximum relief of about 1,000 ft, coal outcrops appear in the canyon walls and along the cliffs. Rock types at the site are late Cretaceous in age and are generally composed of gray sandstone of fine to medium grain, interbedded with subordinate gray and dark gray carbonaceous shale and coal present with continental and/or transitional sediments. Marine sediments occur below the sequence and are exposed to the east of the escarpment in the Castle Valley.

Table 6-1 gives the generalized stratigraphic sequence and unit description of the Wasatch Plateau. The oldest rocks are of the early upper Cretaceous age. The major commercial coal seams occur in the Black hawk formation and are of Campanian age.

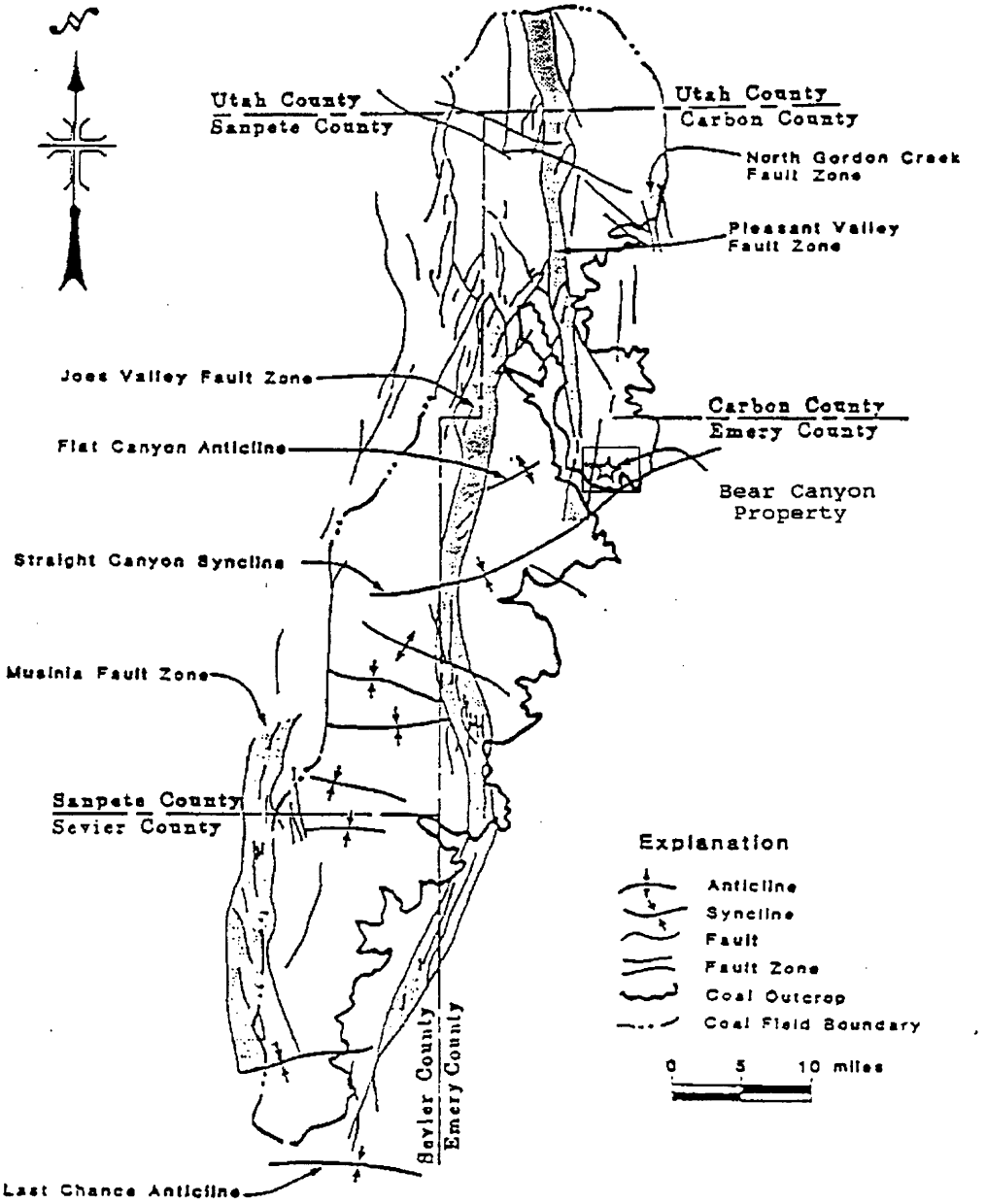
Structurally, strata in the Eastern Wasatch Plateau generally dip southerly (sometimes slightly southeast of southwest) at low angles of 1 to 3 deg. Locally, near faults, the dip increases to about 20 deg. Three major north-south trending fault zones have been defined in the Wasatch Plateau Coal Field (Figure 6-1). Each zone is the product of a high angle block fault with extensive minor fracturing within the graben. The Joes Valley Fault is the largest zone. As shown in Figure 6-1, the zone lies several miles west of the Co-Op permit area. The Pleasant Valley Fault Zone is vertical with between a few ft to 100 ft displacement (Doelling, 1972), although greater displacement occurs locally. The Bear Canyon #1, #2, #3, and #4 Mines operate within this fault zone. The North Gordon Fault Zone, which occurs near the eastern boundary of the Wasatch Plateau field, is the least extensive of the zones. The trends of the faults have a complex pattern. Displacement is generally less than 800 ft (see Plate 6-1 for a larger scale view of faults within the permit area).

TABLE 6-1 Generalized Section of Rock Formations, Wasatch Plateau Coal Field[1]

[1](Doelling, 1972, pg. 68)

System	Series	Stratigraphic Unit		Thickness (feet)	Description
TERTIARY	Eocene	Green River Formation		–	Chiefly greenish lacustrine shale and siltstone.
		Wasatch Group	Colton Formation	300-1,500	Varicolored shale with sandstone and limestone lenses, thickest to the north.
	Paleocene		Flagstaff Limestone	200-1,500	Dark yellow-gray to cream limestone, evenly bedded with minor amounts of sandstone, shale and volcanic ash, ledge former.
			North Horn Formation (Lower Wasatch)	500-2,500	Variegated shales with subordinate sandstone, conglomerate and freshwater limestone, thickens to north, slope former.
CRETACEOUS	?	Mesaverde Group			
	Maestrichthian		Price River Formation	600-1,000	Gray to white gritty sandstone interbedded with subordinate shale and conglomerate, ledge and slope former.
	Campanian		Castlegate Sandstone	150- 500	White to gray, coarse-grained often conglomeratic sandstone, cliff former, weathers to shades of brown.
			Blackhawk Formation *MAJOR COAL SEAMS*	700-1,000	Yellow to gray, fine- to medium-grained sandstone, interbedded with subordinate gray and carbonaceous shale, several thick *coal* seams.
			Star Point Sandstone	90-1,000	Yellow-gray massive cliff-forming sandstone, often in several tongues separated by Masuk Shale, thickens westward.
	Santonian	Mancos Shale	Masuk Shale	300-1,300	Yellow to blue-gray sandy shale, slope former, thick in north and central plateau area, thins southward.
			Emery Sandstone *COAL (?)*	50- 800	Yellow-gray friable sandstone tongue or tongues, cliff former, may contain *coal* (?) in south part of plateau if mapping is correct, thickens to west and south. *Coal* may be present in subsurface to west.
	Coniacian		Blue Gate Member	1,500-2,400	Pale blue-gray, nodular and irregularly bedded marine mudstone and siltstone with several arenaceous beds, weathers into low rolling hills and badlands, thickens northerly.
	Turonian		Ferron Sandstone Member *MAJOR COAL SEAMS*	50- 950	Alternating yellow-gray sandstone, sandy shale and gray shale with important *coal* beds of Emery coal field, resistant cliff former, thickens to the south.
	Cenomanian		Tununk Shale Member	400- 650	Blue-gray to black sandy marine slope forming mudstone.
	Albian	Dakota Sandstone *MINOR COAL*		0- 60	Variable assemblages of yellow-gray sandstone, conglomerate shale and *coal*. Beds lenticular and discontinuous.

Figure 6-1 Principle Structural Features in the Wasatch Plateau



Reference: Davis and Doelling, 1977.

Plate 5-3 shows the topography of the area. The permit area is generally rugged, with elevations varying from 7,000 to about 10,000 ft above sea level. Slopes in the vicinity of the permit area vary from more than 210 pct (65 deg) east of Star Point to less than 4 pct (2 deg) on Gentry Ridge.

Stratigraphy

All of the geologic formations exposed on or adjacent to the permit area are Cretaceous members of the Mesaverde group, with the exception of the North Horn Formation, which is Tertiary (Table 6-1 & Figure 6-1). The minable coal seams are located in the Upper Cretaceous Black hawk Formation.

Mancos Shale

The Mancos Shale, which underlies the Mesa Verde group (Table 6-1), consists of interbedded shale and sandstone members. The uppermost member of the Mancos Shale, directly underlying the Star Point Sandstone, is the Masuk Shale (Doelling, 1972). The Masuk is a dark gray marine shale with thin, discontinuous layers of gray limestone and sandstone (Stokes, 1964).

The Masuk is a soft unit in its exposures but usually forms part of the cliffs rising to the top of the Wasatch Plateau. To the West, it changes faces and joins with the Emery and Star Point sandstones (Doelling, 1972).

Star Point Sandstone

The Star Point Sandstone, the basal formation of the Mesaverde group (Doelling, 1972), is light-colored, fairly well sorted marine sandstone of medium to fine grain (Spieker, 1931). North of the Wattis Canyon area the Star Point Sandstone divides into three tongues.

To the South, the tongues are essentially fused into one massive cliff-forming unit. The Star Point becomes thicker to the southeast, ranging from 400 to 460 ft near the eastern edge of the lease area to 600 ft or more near the central part of Huntington Canyon (Spieker, 1931).

Descriptive core logging of the Star Point Sandstone was conducted in three in-mine drill holes installed in 1992 as part of a hydrogeologic evaluation (EarthFax Engineering, 1993 see Appendix 7-N). During the investigation, it was revealed that the Star Point Sandstone beneath the permit area is comprised of three separate sandstone units (in descending order: the Spring Canyon, Storrs, and Panther Tongues) interbedded with two mudstone units (inferred to be tongues of the Blue Gate member of the Mancos Shale). The core logs from the in-mine drill holes are shown in Appendix A.

Black hawk Formation

Overlying the Star Point Sandstone is the coal bearing Black hawk consisting of alternating sandstone, shale, and coal beds, with thin beds of argillaceous freshwater limestone occurring occasionally. The sequence represents deposition alternations between littoral and

lagoonal sediments. The formation is approximately 1,000 ft thick, with the valuable coal seams located within the lower 400 ft (Doelling, 1972). The sandstone beds are fine to medium-grained (Spieker, 1931). The sands of the Black hawk are generally cemented by calcium carbonate or silica, with the exception of a few localized areas in which the cement is almost entirely clay. Iron is also present in the cement of all but the pure white sandstone (Spieker, 1931).

An exception to above mentioned sandstone is the Aberdeen Sandstone, a coarse-grained, white sand that is traceable from the northern part of the Wasatch Plateau coal field southward to the northwest slopes of Gentry Mountain (Spieker, 1931). The generally discontinuous nature of the Black hawk and apparent low specific water yield (Cordova, 1964) indicates that the water yielding capabilities of the Black hawk is only of local importance.

Three general types of shale, all continental in origin, have been identified in the Black hawk formation (Spieker, 1931): ordinary clay shale, carbonaceous shale, and smoke-gray shale. The ordinary clay shell is gray or green, granular, and normally soft at the outcrop; the carbonaceous shell is brown to black, massive, and laminated; and the smoke-gray shell is tough and leathery, and in its unweathered state is hard and homogeneous (Spieker, 1931). Shale acts as an effective barrier to the vertical movement of water within the Black hawk Formation. Therefore, a significant portion of the water that reaches the Black hawk probably percolates downward until it reaches a shale layer, which causes horizontal movement to the surface or another "drain" (i.e. sandstone finger) within the formation.

Castlegate Sandstone

The Castlegate Sandstone, generally considered the basal member of the Price River Formation (Spieker, 1931) consists of massive, highly resistant medium to coarse-grained sandstone beds containing, in places, conglomerate with a matrix of grit (Doelling, 1972). It is thought to be of marine origin (Paul Wier Company, 1977). Although the Castlegate overlies the Black hawk Formation, it appears barren of coal in the plateau lease area.

Price River Formation

The lithologic characteristics of the Price River Formation and the underlying Castlegate Sandstone are similar; however, the castlegate member is differentiated from the Price River Formation in that it consists of medium to coarse-grained sandstone beds with occasional lenses of shale. Although the unit has a high porosity, its apparent low permeability (Cordova, 1964) reduces its water yielding capabilities except through fractures.

North Horn Formation

The youngest geologic formation within the permit area is the North Horn Formation, which caps Price River Formation on Gentry Mountain (Doelling, 1972). The North Horn, the lowest member of the Wasatch Group, consists of variegated shale's, irregular beds of gray, brown, or cream colored sandstone of various textures, and thin beds of steel-gray and cream colored limestone (Spieker, 1931).

Geology of Coal and Adjacent Units

Multiple coal seams are found in the lower 350 ft of the Black hawk Formation. In ascending order the seams are as follows: Hiawatha, Blind Canyon, Bear Canyon, upper beds, and the Tank Seam (Table 6-2).

Small rider seams also exist interbedded in the black hawk formation. The majority of these seams occur between the Bear Canyon and Tank Seam, which are often referred to as the "Upper beds."

None of the coal lies at depths of more than 1,800 ft. in the study area. Depth should not be a limiting factor in mining.

It was noted in the field that strata situated at elevations consistent with the upper beds structural horizon were badly burned and not of economic importance, with the exception of the Tank Seam, which has an average thickness of 7 feet in the permit area, but disappears to the North.

Table 6-2 Coal Beds, Lower Huntington Canyon

LAYER	FT
TANK SEAM	0-8
Interval	220-250
BLIND CANYON BEDS	0-14
Interval	40-110
HIAWATHA	5-8
Interval	5-8
STAR POINT SANDSTONE	

The Tank seam outcrops locally in the Southern portions of the study area. Drilling in the Bear Canyon Mine indicates minable thickness within the permit area. Drillhole logs are found in Appendix 6-A. The seam, a member of the upper beds of the Black hawk formation, achieves minable thickness only in the Southern portions of Bear Canyon and Fish Creek Canyon. Drillholes North of the study area have shown the Tank Seam to be nonexistent to the North.

The Blind Canyon and Bear Canyon seams were measured and observed at various points in the study area by the author. However, these seams were traceable only locally in Bear Canyon. Limited traceability of these two seams is attributed to the lenticular nature of the seams, the extent of slope debris acting as a cover and/or depositional irregularities. H. H.

Doelling indicates the Bear Canyon seam is present in Left Fork of Fish Creek Canyon (east of Bear Creek Canyon) with a thickness of 6.5 ft. However, this measurement was not verified in the field, possibly because this particular exposure has since been covered by slope debris.

A small adit approximately 50 ft in length and interpreted as penetrating the Bear Canyon seam (measurement M-5), and a longer adit approximately 300 ft in length and interpreted as penetrating the Blind Canyon seam (measurement M-7), were discovered in Bear Creek Canyon, Section 24, Township 16 South, Range 7 East. The full extent and history of these workings is not known. The fact that these two seams are not traceable for any significant area beyond these old workings indicates the subordinate nature of the Bear and Blind Canyon seams.

The Bear Canyon Mine is located in the SW 1/4 of Section 24, Township 16 South, Range 7 East. Two seams were worked there, the upper of which was the Bear Canyon seam (elevation 7,340 ft). This interpretation is based on the seams stratigraphic position above the Star Point Sandstone. The Blind Canyon seam apparently has pinched out or has been replaced in this locality. The mine lies on the west side of the Bear Canyon fault. The presence of the Hiawatha and Bear Canyon seams at the mine lend credence to the author's opinion that these seams are probably present across canyon to the east where they were not traceable nor measurable due to slope cover.

The Hiawatha seam was identified throughout the majority of the study area based on its stratigraphic relationship with the underlying Star Point Sandstone. The Star Point Sandstone is

continuous and conspicuous within the area covered by this report. The Hiawatha seam was also measured in Left Fork of Fish Creek Canyon Doelling states that "extensive mining under Gentry Mountain (a short distance due north of Bear Canyon) reveals that the Hiawatha is continuous in the anticipated thickness". Where identified and measured, the Hiawatha seam achieved minable thickness in all but one instance (3.3 ft-measurement M-2). However, recent drilling has demonstrated that the Hiawatha seam is not continuous through this area. Mining and drilling in the Hiawatha seam has identified several large sandstone channels and scours which have rendered much of the Hiawatha seam unminable in the vicinity of Bear Creek and Fish Creek Canyons. Specific work accomplished is shown on the Hiawatha seam Isopach map (Plate 6-15).

Structure

Structurally the strata in the Wasatch Plateau generally dip southerly (slightly southeast or southwest) at angles of 1 to 3 deg. Three major north-south trending fault zones have been defined in the Wasatch Coal Field. Each zone is the product of a high block fault with extensive minor fracturing within the graben. The Bear Canyon Mine is located in the Pleasant Valley Fault Zone. The vertical displacement varies between a few ft and 200 ft plus. A major fault separates the Bear Canyon Mine from the Trail Canyon Mine. (Note: Geotechnical sections are located in Appendix 2-A and the mine is mapped on Plates 5-1A, 5-1B, and 5-1C). Displacement on this particular fault is estimated to be 220 ft. During the mining of the Blind

Canyon Seam several minor faults were discovered in the Trail Canyon Mine. These faults may affect the mining of other seams.

R645-301-621 General Requirements

All of the geological formation exposed on or adjacent to the permit area are Cretaceous members of the Mesa Verde group, with the exception of the North Horn Formation, which is Tertiary. The minable coal seams are located in the upper Cretaceous Black hawk Formation.

General Stratigraphy

The exposed geologic column, in ascending order, consists of the Mancos Shale, the Star Point Sandstone, coal-bearing Black hawk Formation and the Castlegate Sandstone Member of the Price River Formation. All of these Geologic units are Cretaceous in age. The Star Point Sandstone through the Price River Formation composes the Mesa Verde Group in this locality.

The Mancos Shale forms the initial steep slopes rising from the washes which in turn are overlain by the initial cliff-forming Star Point Sandstone described in R645-301-620.

The Black hawk Formation is composed of alternating sandstones, shales, mudstones and coal representing marine, transitional and terrestrial varieties of sedimentation. Depositional environments of the Black hawk Formation include littoral, lagoonal, estuarine and swamp type environments. The Black hawk outcrops to form a step and slope topography slightly less resistant than the Star Point below and the Castlegate above. Multiple coal seams are found within the lower 350 ft of the Black hawk.

The Castlegate Member of the Price River Formation makes up a massive, resistant cliff-forming unit above the Black hawk.

Structure

The Bear Canyon Fault, which is part of the north-south trending Pleasant Valley Fault Zone, marks the eastern boundary of the permit area. Displacement on this particular fault is estimated by C.W. Mining to be 200 ft+ in the vicinity of Bear Creek Campground on the north side of State Highway 31. The west side of the fault is down relative to the east side. Strata immediately bordering the fault are disturbed and inconsistent in spatial attitude with equivalent strata in the study area east of the Bear Canyon fault. This will no doubt have a limiting effect on the extent to which coal can be mined in the immediate vicinity of the fault. Strata east of the fault are nearly horizontal in attitude providing excellent mining conditions.

The Blind Canyon Fault, also part of the Pleasant Valley Fault Zone, marks the western boundary of the mine area. Displacement on this normal fault is estimated to be 220 feet, west side down.

Coal outcrops slightly lower in elevation in the southern portion of the area than in the northern portion.

Small faults noted in the field along outcrops were interpreted to be largely of non-tectonic origin (e.g. landslide and slump) by C. W. Mining. Other faults observed did not express displacement of sufficient magnitude to prohibit mining.

No geologic conditions exist within the permit area, which will obstruct or inhibit reclamation activities. The affects of the geologic structures on groundwater movement are discussed in Appendix 7-N, Section 2.4.3.

R645-301-622 Cross Sections Maps and Plans

622.100 Elevations and Locations of Core Samples

The elevations and locations of test borings and core samplings are given in Appendix 6-A. Additional drill hole logs can be founding in Appendix 7-A.

622.200 Nature Depth and Thickness of Seam to be Mined

This is shown on Plate 6-3 (Tank Seam), Plate 6-7 (Bear Canyon Seam), Plate 6-11 (Blind Canyon Seam), and Plate 6-15 (Hiawatha Seam).

622.300 Coal Crop Lines and Strike and Dip of Coal Seam

This is shown on Plate 6-4 (Tank Seam), Plate 6-8 (Bear Canyon Seam), Plate 6-12 (Blind Canyon Seam), and Plate 6-16 (Hiawatha Seam).

622.400 Location of Gas and Oil Wells

There are no gas or oil wells within the permit area.

R645-301-623 Geologic Information

623.100 Acid or Toxic Forming Strata

Copies of test results from coal samples taken within the permit area are included in Appendix 6-C. The coal quality is shown on page 6C-2. Analyses for acid- or toxic-forming materials in the coal, roof, and floor rock are shown on pages 6C-7 through 6C-21. Table 2-4a. lists the parameters to be tested for in roof, floor and mid-seam analyses. Coal and rock sample

locations are shown on Plates 5-1. Engineering and material properties of the coal and surrounding rock are discussed on page 6C-22.

623.200 Geologic Information to Determine Reclamation

Geologic information to assist in determining whether reclamation can be accomplished is discussed in R645-301-724.

623.300 Geologic Information Pertaining to Subsidence

Geologic Information to assist in preparing the subsidence control plan is given under R645-301-332 (Anticipated Impacts of Subsidence), 645-301-525 (Subsidence Control Plan).

R645-301-624 Additional Geological Information

624.100 Geology in Permit and Adjacent Areas

This information is given in R645-301-620, R645-301-621, and R645-301-724.

624.110 Cross Sections and Maps and Plans

This is addressed under R645-301-622

624.130 Literature and References

Geologic Literature and references are given in R645-301-620.

624.200 Removal of Strata

Does not apply.

624.300 Test Boring

In 1992, C. W. Mining Company drilled 3 in-mine test holes through the Star Point Sandstone to the top of the Masuk Shale. These holes are shown on Plate 7-4 as DH-1A, DH-2, and DH-3, and were later completed as monitor wells. The test holes, shown in Appendix 6-A, revealed the Star Point Sandstone beneath the permit area to be comprised of three separate sandstone tongues interbedded with two mudstone units inferred to be tongues of the Bule Gate member of the Mancos Shale, referred to as Mancos No. 1 and Mancos No. 2. In 1993, DH-3 was abandoned due to pillaring activities, and was sealed in accordance with R645-301-631. It was replaced by DH-4, shown on Plate 7-4.

Spring Canyon Tongue. The Spring Canyon Tongue of the Star Point Sandstone, the uppermost unit, is 88 feet thick at DH-1, 103 feet thick at DH-2, and 98 feet thick at DH-3. It is generally light gray with minor dark minerals, but varies from dark gray to white. The grains range in size from fine to medium, and are moderately well sorted, subangular to subround, and well cemented with calcium carbonate. The unit is generally moderately- to well indurated. Bedding

is variable through the unit, from massive to laminated, with muddy zones and partings and locally dense bioturbation. The contact with the overlying Hiawatha coal seam of the Black hawk Formation is abrupt; the lower contact with the Mancos No. 1 mudstone tongue is gradational.

Storrs Tongue. The Storrs tongue is 96 feet thick at DH-1A, 105 feet thick at DH-2, and 120 feet thick at DH-3. It is generally light gray to dark gray, with minor dark minerals. The grains range in size from very fine-to-fine, and are moderately well sorted, sub angular to sub round, and well cemented with calcium carbonate. The unit is generally well indurated. Bedding is variable through the unit, from massive to laminated, with muddy zones and partings and locally dense bioturbation, particularly in the lower portion of the unit. The contacts with the overlying Mancos No. 1 and underlying Mancos No. 2 mudstones are gradational. The Storrs Tongue Sandstone is generally finer grained, denser, more highly indurated, and less permeable than the other two Star Point Sandstone tongues.

Panther Tongue. The Panther Tongue is 105 feet thick at DH-1A, 88 feet thick at DH-2, and 97 feet thick at DH-3. It is generally light gray with minor dark minerals, but, like the Spring Canyon and Storrs tongues, varies from dark gray to white. The grains range in size from fine to coarse, and are poorly to moderately well sorted, round to sub round, and poorly cemented with calcium carbonate. The unit is generally poorly to moderately-well indurated, and locally friable. Bedding is variable through the unit, from massive to laminated, with muddy partings

and local bioturbation. The contact with the overlying Mancos No. 2 mudstone is gradational; the lower contact with the Mancos Shale is abrupt. The Panther Tongue sandstone is less dense, coarser-grained, less well cemented, less indurated, and more permeable than the Spring Canyon and Storrs tongues.

Additional drill hole information is given in Appendix 6-A and Appendix 7-A. A chemical analysis of the coal seam is found in Appendix 6-C.

624.340 Properties of Clay

No significant amount of clay was detected in the samples analyzed. (See Appendix 6-C)

R645-301-630 Operation Plan

R645-301-631 Casing and Sealing of Exploration Holes

Drillholes DH-1A, DH-2, and DH-3, were completed as monitor wells in 1992. The completion of these wells are shown and described in Appendix 7-N. DH-3 was abandoned in 1993 due to pillaring in the location of DH-3. It was replaced by DH-4, shown on Plate 3-4A. DH-4 was drilled into the Spring Canyon Member of the Starpoint Sandstone in January of 1994 and was also completed as a monitor well. The drillhole logs and well completion diagrams for these four wells are included in Appendix 7N-G. All exploratory boreholes drilled by C.W. Mining will be sealed as described in R645-301-529. Holes will be closed and sealed in compliance with all applicable state and federal regulations.

R645-301-632 Subsidence Monitoring

A Subsidence Monitoring Plan along with a map showing the location of monitoring points (Plate 5-3) is given in Chapter 5 under R645-301-525.

Reference:

Cordova 1964. Hydrogeologic reconnaissance of part of the headwaters area of the Cordova, Utah Geological and Mineralogical Survey, Salt Lake City.

Doelling H.H 1972. Central Utah Coal Fields Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery. Utah Geological and Mineralogical Survey, Salt Lake City.

Doelling, H.H., Davis, F.D. 1977. Coal drilling at Trail Mountain, North Horn Mountain, and Johns Peak areas, Wasatch Plateau, Utah, Utah Geological and Mineral Survey, Salt Lake City.

Earth fax Engineering 1993. Revised Hydrogeologic Evaluation of the Bear Canyon Mine Permit and Proposed Expansion Areas.(See Appendix 7-N.)

Stokes, William Lee, 1964. Geologic map of Southeastern Utah, Washington D.C., Williams and Heintz Map Corp.

Spieker,Edmund M., 1931 The Wasatch Plateau Coal Field, Utah, U.S. Geological Survey,

Bulletin 819.

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Chapter 7 Hydrology

List of Appendices

within the coal itself. As discussed in the PHC, the estimated volume of water removed in this manner is 22 acre-feet per year.

The affects of subsidence in the permit area, on regional or local groundwater flow, are expected to be minor and of short duration. Localized diversions or interceptions of short duration only are expected due to the plastic flow of shaley units and to both development and tightening of existing fractures which occur due to unbalanced compressive-tensile forces associated with subsidence. The reclamation plan proposes to control post-mining subsidence which is expected to be a maximum of 5.5 feet assuming all three seams are mined, with no subsidence to occur in a varying 100 to 200 ft wide corridor from outcrop areas and permit boundary areas, as well as under escarpments.

In the portion of Federal Lease U-024316 to be permitted, mining will take place in the Tank Seam only, which will limit any subsidence to a maximum of 1.9 feet. In the event mining reaches far enough North to mine at an elevation below Bear Creek, an adequate barrier will be left to completely prevent any impact on Bear Creek. This barrier is shown on Plate 5-3 and described in Appendix 5-C.

Quality

The potential impacts to water quality include contamination of water due to rock dust usage, abandoned equipment the usage of hydrocarbons, and contamination from road salting. These potential water quality impacts are discussed in detail in Appendix 7-J, Section 9.0 (PHC).

Rock dust which is used for the suppression of coal dust may potentially impact the groundwater flowing through the mine by the dissolution of the rock dust constituents into the water. This could result in increase concentrations of TDS or sulfates. Gypsum rock dust has been known to result in high TDS concentrations; therefore Co-Op has implemented the use of limestone rock dust. Mine water discharged into Bear Creek is monitored for TDS, as well as the in-mine water monitoring wells, to ensure increased concentrations do not result for the mining activities.

Hydrocarbons (in the form of fuels, greases, and oils) are stored and used on-site for the mining equipment. Spillage of these materials could potentially contaminate the groundwater in the permit area. Section 9.0 of the PHC (Appendix 7-J) discusses in detail the program, which C. W. Mining has implemented to prevent contamination of the groundwater from these sources. Road salting is also discussed. Abandoned equipment is discussed in Appendix 7-Q.

Mitigation and Control Plans

No treatment of groundwater occurrence or other control measures in the present mine have been required. Interference of the groundwater regime has consisted of interception of local perched zones within the Blackhawk formation, with the significant portion of the flow coming from a sandstone channel located at the North end of the Blind Canyon Seam workings.

No treatment of groundwater occurrence or other control measures have been required or are expected to be required for the permit area. See the discussion on potential impacts in Appendix 7-J.

Table 7-14 Water Monitoring Matrix: Operational Phase of Mining

Location	Jan	Feb	Mar	Apr	May	June	July	Aug[3]	Sept	Oct	Nov	Dec
Streams												
BC-1 (Upper Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-2 (Lower Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-3 (Lower Rt Fork Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-4 (Upper Rt Fk. Bear Creek)		oper			oper.	field	field	oper.	field	oper		
MH-1 (McCadden Hollow Creek)					field [5]		field	field		field		
FC-1 (Left Fork Fish Creek)					field [5]		field	field		field		
Springs												
SBC-3 (Creek Well)		oper			oper			oper.		oper		
SBC-4 (Big Bear Springs) [4]		oper			oper			oper.		oper		
SBC-5 (Birch Spring) [4]		oper			oper.			oper.		oper		
SBC-9A (Hiawatha Seam portal)		oper			oper			oper		oper		
SBC-12 (16-7-13-1)					field. [5]		field	field		field		
SBC-14 (WHR-6)		oper			oper.			oper.		oper		
SBC-15 (WHR-5)					field[5]		field	field		field		
SBC-16 (WHR-4)					field[5]		field	field		field		
SBC-17 (16-7-24-4)		oper			oper.			oper.		oper		
SMH-1 (FBC-6)					field. [5]		field	field		field		
SMH-2 (FBC-5)					field [5]		field	field		field		
SMH-3 (FBC-13)					field. [5]		field	field		field		
SMH-4 (FBC-4)					field [5]		field	field		field		
Wells												
SDH-2 (Well, Sec. 11, T16S, R7E)					level [5]		level	level	level	level		
SDH-3 (Well, Sec. 10, T16S, R7E)					level [5]		level	level	level	level		
MW-114 (Well, Sec 18, T16S, R8E)					level [5]		level	level	level	level		
MW-117 (Well, Sec 12, T16S, R8E)					level [5]		level	level	level	level		

Notes: 1. See Tables 7-13 and 7-17 for listing of water quality monitoring parameters.
2. oper. = operational base. = baseline
3. Baseline parameters taken in August of year 5 prior to each permit renewal.
4. SBC-4 and SBC-5 shall also be tested for oil and grease.
5. First sample to be taken in May or June, when Gentry Mountain is accessible.

Reclamation activities for the channels will involve excavating the channel back to the pre-mining configuration. The majority of the boulders in the pre-mining channels will remain as markers, which can be excavated back to. Photographs of the pre-mining channels are contained in Appendix 7-H, and the profiles on Plate 7-8C reflect the pre-mining profiles and descriptions.

Wild Horse Ridge Access

The portal pad for the Bear Canyon No. 3 Mine will drain into Sediment Pond "D". For the remaining disturbed areas associated with the Wild Horse Ridge access road and conveyor belt, runoff will be controlled using alternate (ASCA) treatments. See Plates 7-1F and 7-1G for division structures and ASCA areas (BTCA Area "V", "W", "X" and "Y").

Runoff control for these ASCA areas are described in Appendix 7-K, and will consist of silt fences, erosion control matting and/or catch basins as described in Appendix 7-K and shown on Plates 7-1F and 7-1G. ASCA areas under the conveyor belt will be protected by a pan structure on the conveyor belt is described in Appendix 7-K.

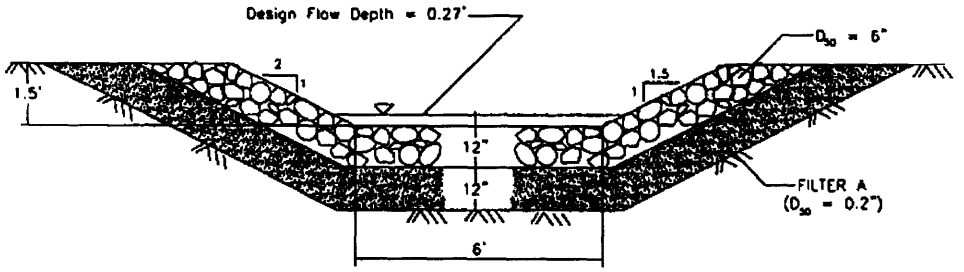
Designs for the ditches and culverts associated with this area are included in Appendix 7-G and summarized in Tables 7-24 and 7-28.

The reclaimed channel designs for the Wild Horse Ridge Area are described in Appendix 7-H and R645-301-760.

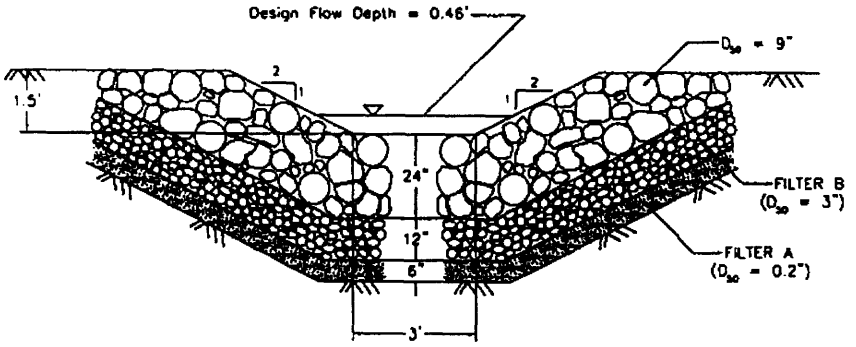
Table 7-27 Summary of Post-mining Drainage Ditches

Channel	Bottom Width (ft)	Top Width (ft)	Side Slopes	Depth (ft)	Lining
RC-RD1	0.0	6	2:1	1.5	Soil
RC-RD2	0.0	8	2:1	2.0	D50 = 6"
RC-RD3	0.0	6	2:1	1.5	Soil
RC-RD4	0.0	8	2:1	2.0	D50 = 6"
RC-RD5	5.0	14	3:1	1.5	Soil
RC-RD6	0.0	6	2:1	1.5	Soil
RC-RD7	0.0	6	2:1	1.5	Soil
RC-RD8	0.0	7	2:1	1.75	D50 = 6"
RC-RD9	0.0	12	3:1	2.0	D50 = 6"
RC-RD10	0.0	6	2:1	1.5	Soil
RC-RD11	0.0	5	2:1	1.25	Soil
RC-RD12	0.0	6	2:1	1.5	D50 = 3"
RC-RD13	0.0	6	2:1	1.5	D50 = 3"
RC-RD14	0.0	8	2:1	2.0	Bedrock
RC-RD15	0.0	5	2:1	1.25	Soil
RC-RD16	2.0	7	2:1	1.25	Soil
RC-BP1	0	5	3:1, 1:1	1.24	Soil

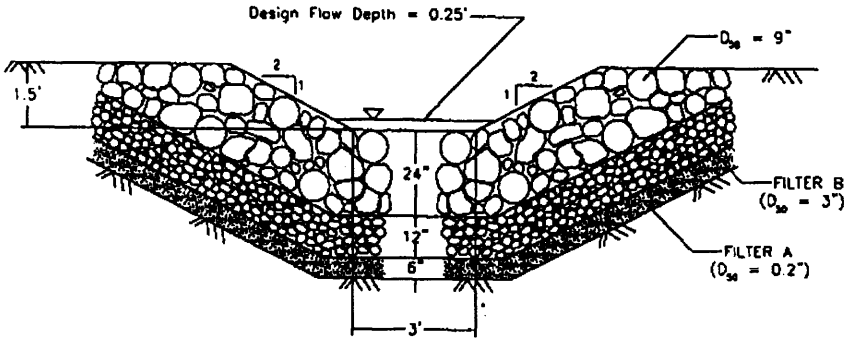
Note: See Appendix 7-H, pg. 130 for a discussion on channel RC-BP1.



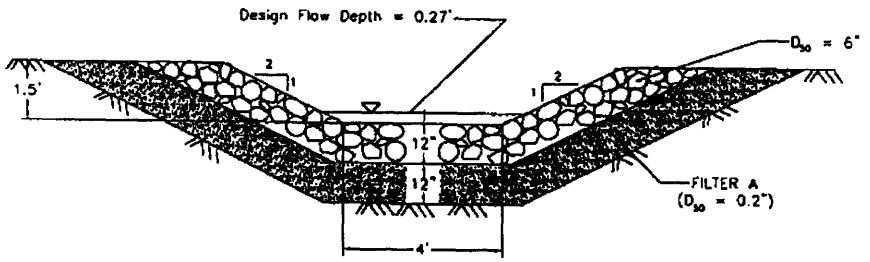
Minimum Cross Section
Channel RC-1
Scale: 1" = 4'



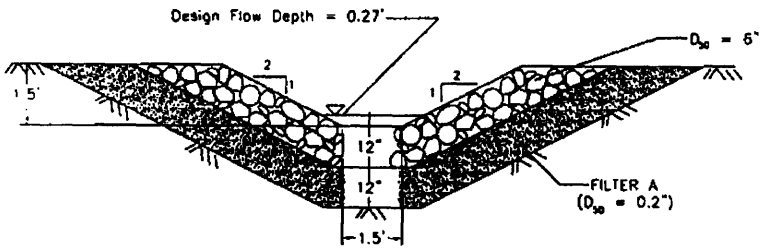
Minimum Cross Section
Channel RC-2
Scale: 1" = 4'



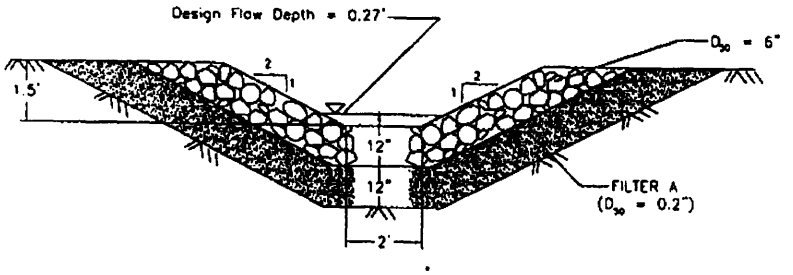
Minimum Cross Section
Channel RC-3
1" = 4'



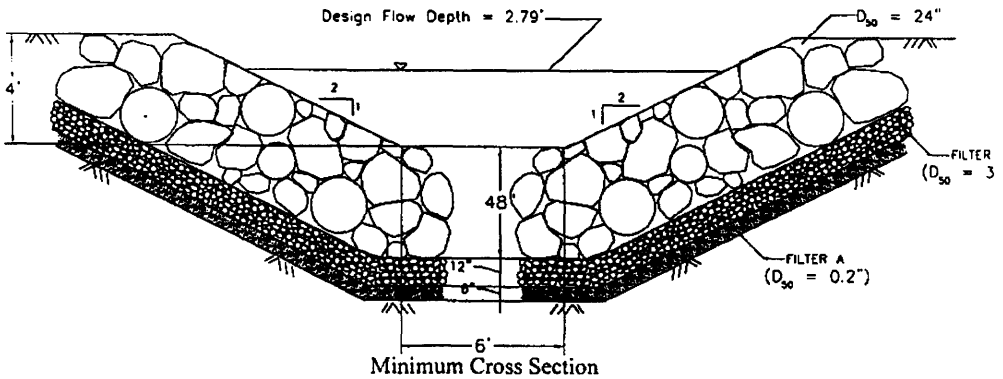
Minimum Cross Section
Channel RC-4
Scale: 1" = 4'



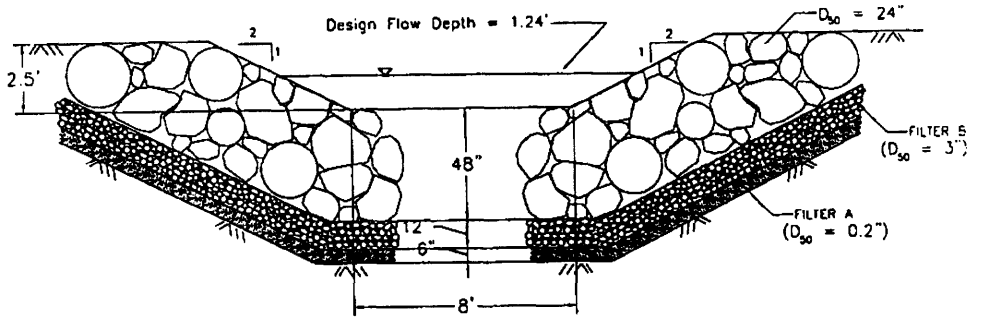
Minimum Cross Section
Channel RC-5
Scale: 1" = 4'



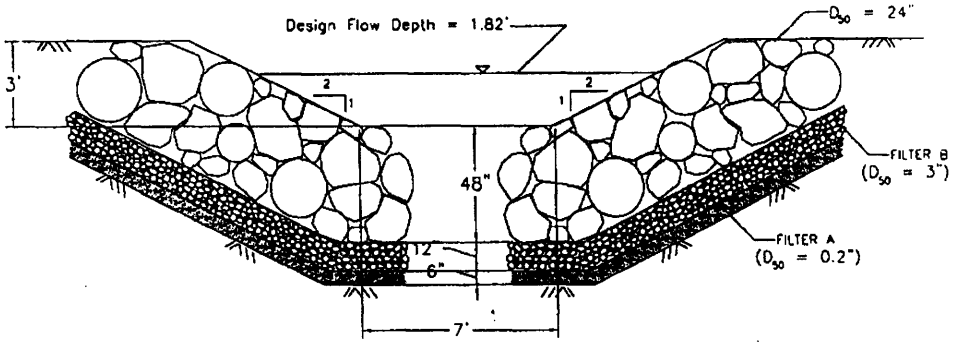
Minimum Cross Section
Channel RC-6
1" = 4'



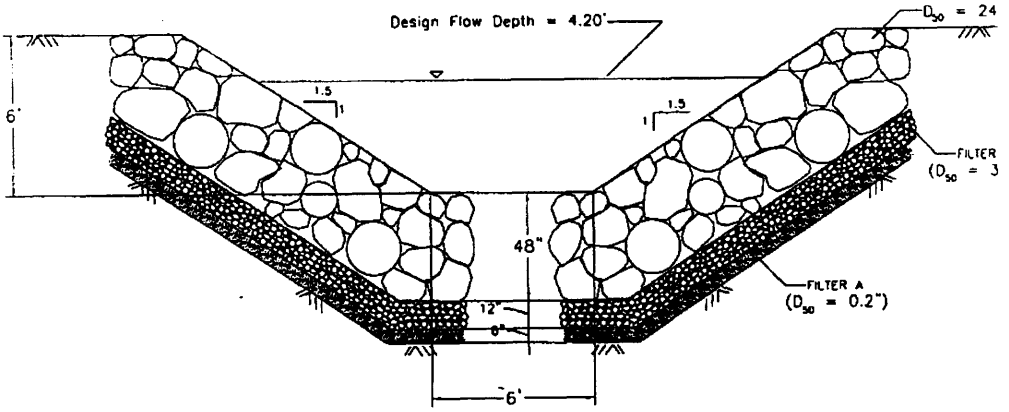
Minimum Cross Section
Channel RC-7
Scale: 1" = 5'



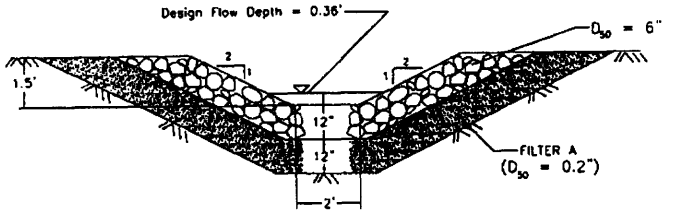
Minimum Cross Section
Channel RC-8
Scale: 1" = 5'



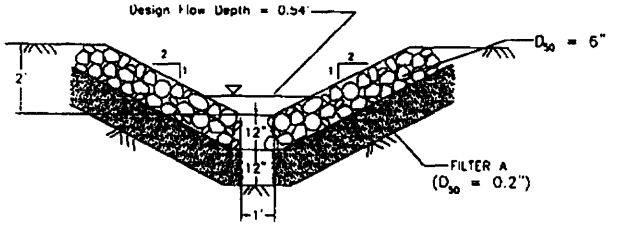
Minimum Cross Section
Channel RC-9
1" = 5'



Minimum Cross Section
Channel RC-10
Scale: 1" = 5'



Minimum Cross Section
Channel RC-11
Scale: 1" = 4'



Minimum Cross Section
Channel RC-12
1" = 4'

A Q T E S O L V R E S U L T S
Version 1.10

05/12/92 01:41:47

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TEST DESCRIPTION

Data set..... DH1PANB1.AQT
Data set title..... DH-1A PANTHER SLUG WITHDRAWAL TEST #1
Company..... EarthFax Engineering
Project..... UC-192-06
Client..... CO-OP Mine
Location..... Huntington Canyon
Test date..... 9-25-91
Test well..... DH-1A

Knowns and Constants:
No. of data points..... 1183
Radius of well casing..... 0.1
Radius of well..... 0.1
Aquifer saturated thickness..... 70
Well screen length..... 60
Static height of water in well..... 70
Log(Re/Rw)..... 5.36
A, B, C..... 0.000, 0.000, 11.189

==========

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==========

RESULTS FROM STATISTICAL CURVE MATCHING

STATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
K =	5.0803E-004	+/-	1.9809E-004
y0 =	2.5218E+000	+/-	6.3316E-002

ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
Number of residuals..... 7
Number of estimated parameters.... 2
Degrees of freedom..... 5
Residual mean..... 1.909E-005
Residual standard deviation..... 0.06857
Residual variance..... 0.004702

Model Residuals:

Time	Observed	Calculated	Residual	Weight
0.0083333	2.5909	2.498	0.092898	1
0.033333	2.3412	2.428	-0.086775	1
0.041667	2.3412	2.4051	-0.063872	1
0.058333	2.3412	2.3599	-0.018712	1
0.066667	2.3412	2.3377	0.0035497	1
0.075	2.3412	2.3156	0.025601	1
0.083333	2.3412	2.2938	0.047444	1

==

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	5.0803E-004
y0 =	2.5218E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

A Q T E S O L V R E S U L T S
Version 1.10

04/25/94 11:35:16

TEST DESCRIPTION

Data set..... dh4slu#2.aqt
Data set title..... DH-4 SLUG TEST #2
Company..... EARTHFAX ENGINEERING, INC.
Project..... UC-192-09
Client..... CO-OP MINING COMPANY
Location..... BEAR CANYON MINE
Test date..... 3-14-94
Test well..... DH-4

Knowns and Constants:

No. of data points	2000
Radius of well casing	0.0625
Radius of well	0.099
Aquifer saturated thickness	177.7
Well screen length	20
Static height of water in well	177.7
Log(Re/Rw)	5.519
A, B, C	0.000, 0.000, 6.946

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM STATISTICAL CURVE MATCHING

STATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
K =	1.1330E-004	+/-	5.0615E-007
y0 =	1.9690E-001	+/-	6.1032E-004

ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

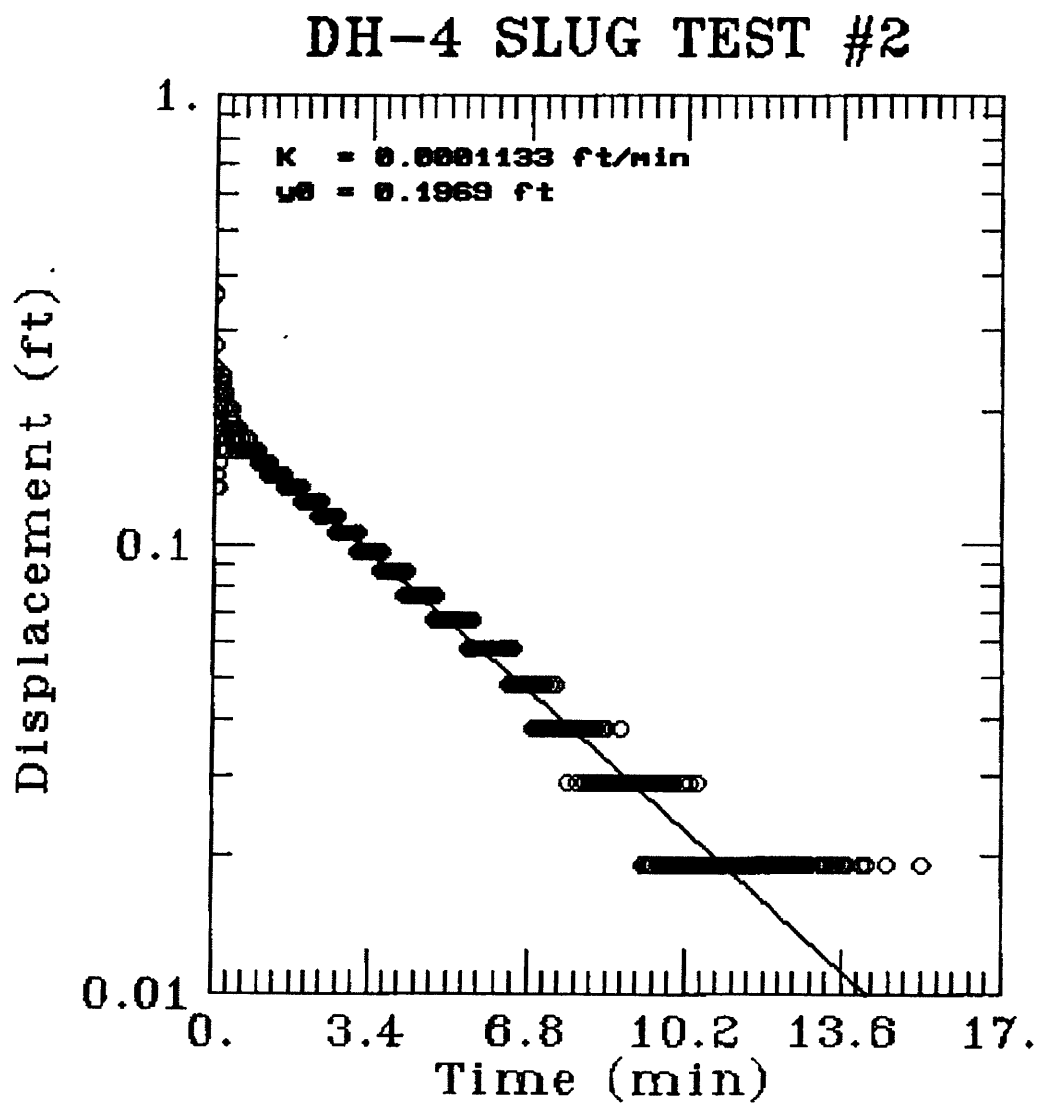
Weighted Residual Statistics:

Number of residuals	2000
Number of estimated parameters	2
Degrees of freedom	1998
Residual mean	0.00022
Residual standard deviation	0.007172
Residual variance	5.144E-005

Model Residuals:

Time	Observed	Calculated	Residual	Weight
0.025	0.27845	0.19587	0.08258	1
0.041667	0.24004	0.19519	0.044855	1
0.058333	0.19203	0.1945	-0.0024723	1
0.075	0.14403	0.19382	-0.049792	1
0.091667	0.13442	0.19314	-0.058724	1
0.10833	0.13442	0.19247	-0.058049	1
0.125	0.16323	0.1918	-0.028565	1
0.14167	0.19203	0.19112	0.00090539	1
0.15833	0.22084	0.19046	0.030384	1
0.175	0.24004	0.18979	0.05025	1
0.19167	0.24004	0.18913	0.050914	1
0.20833	0.23044	0.18846	0.041975	1
0.225	0.21124	0.18781	0.023434	1
0.24167	0.18243	0.18715	-0.0047187	1
0.25833	0.16323	0.18649	-0.023264	1
0.275	0.16323	0.18584	-0.022612	1
0.29167	0.16323	0.18519	-0.021962	1
0.30833	0.17283	0.18454	-0.011714	1
0.325	0.18243	0.1839	-0.0014686	1
0.34167	0.19203	0.18326	0.0087746	1
0.35833	0.20164	0.18261	0.019026	1
0.375	0.20164	0.18198	0.019664	1
0.39167	0.20164	0.18134	0.020301	1
0.40833	0.19203	0.18071	0.011325	1
0.425	0.18243	0.18007	0.002357	1
0.44167	0.17283	0.17944	-0.0066132	1
0.45833	0.16323	0.17882	-0.015586	1
0.475	0.16323	0.17819	-0.01496	1
0.49167	0.17283	0.17757	-0.0047369	1
0.50833	0.17283	0.17695	-0.0041159	1

0.525	0.18243	0.17633	0.006103	1
0.54167	0.18243	0.17571	0.0067197	1
0.55833	0.18243	0.1751	0.0073343	1
0.575	0.18243	0.17448	0.0079467	1
0.59167	0.17283	0.17387	-0.001043	1
0.60833	0.17283	0.17326	-0.00043489	1
0.625	0.16323	0.17266	-0.0094289	1
0.64167	0.16323	0.17205	-0.008825	1
0.65833	0.16323	0.17145	-0.0082232	1
0.675	0.16323	0.17085	-0.0076235	1
0.69167	0.16323	0.17026	-0.007026	1
0.70833	0.17283	0.16966	0.0031695	1
0.725	0.17283	0.16907	0.0037629	1
0.74167	0.17283	0.16848	0.0043542	1
0.75833	0.17283	0.16789	0.0049435	1
0.775	0.16323	0.1673	-0.0040693	1
0.79167	0.16323	0.16671	-0.0034842	1
0.80833	0.16323	0.16613	-0.0029011	1
0.825	0.16323	0.16555	-0.00232	1
0.84167	0.16323	0.16497	-0.001741	1
0.85833	0.16323	0.16439	-0.001164	1
0.875	0.16323	0.16382	-0.00058899	1
0.89167	0.16323	0.16325	-1.6019E-005	1
0.90833	0.16323	0.16268	0.00055495	1
0.925	0.16323	0.16211	0.0011239	1
0.94167	0.16323	0.16154	0.0016909	1
0.95833	0.16323	0.16097	0.0022559	1
0.975	0.15363	0.16041	-0.0067811	1
0.99167	0.15363	0.15985	-0.00622	1
1.0083	0.15363	0.15929	-0.005661	1
1.025	0.15363	0.15873	-0.0051038	1
1.0417	0.15363	0.15818	-0.0045486	1
1.0583	0.15363	0.15763	-0.0039954	1
1.075	0.15363	0.15707	-0.0034441	1
1.0917	0.15363	0.15652	-0.0028947	1
1.1083	0.15363	0.15598	-0.0023472	1
1.125	0.15363	0.15543	-0.0018017	1
1.1417	0.15363	0.15489	-0.001258	1
1.1583	0.15363	0.15435	-0.00071633	1
1.175	0.15363	0.15381	-0.00017648	1
1.1917	0.15363	0.15327	0.00036148	1
1.2083	0.15363	0.15273	0.00089753	1
1.225	0.15363	0.1522	0.0014317	1
1.2417	0.14403	0.15167	-0.0076359	1
1.2583	0.14403	0.15114	-0.0071055	1
1.275	0.14403	0.15061	-0.0065769	1
1.2917	0.14403	0.15008	-0.0060501	1
1.3083	0.14403	0.14956	-0.0055252	1


DH-4 SLUG TEST #2
K = 0.0001133 ft/min
y0 = 0.1969 ft
1.
0.1
0.01
Displacement (ft)
0.
3.4
6.8
10.2
13.6
17.
Time (min)

7NF-127

DH-4 BAIL TEST #2