Volume 3

Mining and Reclamation Plan

Rilda Canyon Mine

Prepared for
West Appa Coal Company
Price, Utah

April 1983

Ford, Bacon & Davis Incorporated

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CHAPTER IX

VEGETATION RESOURCES

Prepared for

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CHAPTER IX

VEGETATION RESOURCES

9.1 SCOPE

This chapter presents quantitative information on the vegetation inside the boundaries of the West Appa Coal Company lease area. In addition, two communities outside the lease boundary are described. A species presence list is presented for both, and quantitive tree and shrub data are presented for one of them.

The leasehold boundaries enclose all of Section 36 of T16S, R6E; all of Sections 31 and 32 of T16S, R7E; and one-eighth-section corners of Sections 28, 29, and 33 of T16S, R7E plus an additional 1/16 of Section 33. The total acreage is 1971.6 acres "more or less," as the legal description puts it, since the area is mountainous with high relief and the acreage is estimated from the flat map.

A vegetation map is provided, showing the entire leasehold area (Plate 9-1), with the major plant communities delineated. The mine entrance and operations area (permit area) are to be located at the northeast extreme corner of the leasehold, extending outside it, and a second map at a larger scale is provided showing the existing vegetation in the mining operations area before construction (Plate 9-2). Map measurements are provided for both maps, the main set estimating acreage of each dominant plant community and the second set estimating the acreage of existing vegetation that may be disturbed during mine construction.

In the permit area, there are four plant communities that may be disturbed during construction and mining activities, plus a fifth sensitive spring area that will not be intentionally disturbed, but which is adjacent to projected disturbance areas. The four potentially disturbed communities were sampled quantitatively by standard ecological methods to provide complete descriptions of the vegetation. These data collections were done according to DOGM guidelines and with advance approval of the methods and communities to be sampled. The "baseline" method was used.

In the data collection, complete descriptive data were obtained for each species of living plant and the data were combined by life-form categories of trees, shrubs (over and under 1-meter tall separately), grasses, forbs (herbaceous non-grass plants), and cryptogams (mosses and lichens combined). Non-living cover data were gathered for rock, litter, and bare soil. Data were collected by strictly random sampling methods in a manner that would permit determining the percent cover, percent frequency, density, relative importance, and standing biomass (productivity) of each species (or group for productivity) that fell within a sampling unit. Since there were often additional species that did not happen to fall within a sampling unit, a careful survey was taken by searching for these species and a species presence list was complied. This type of presence list was also prepared for the adjacent spring area and for the riparian (streamside) community located at the confluence of Rilda Creek and Huntington Creek about 2 miles down canyon. This latter area may have to support additional road construction to provide for a safe approach to the main highway in Huntington Canyon. In addition to the species list, a complete set of tree, sapling, and shrub (over 1-meter tall) measurements were taken, which served as the basis for describing the dominant plant community (woody trees and shrubs).

These data were gathered to assist in estimating the impacts of mining operations on the vegetation in the area and to provide a baseline against which future reclamation efforts can be compared.

The material is presented below according to the format provided in the DOGM General Guideline for Organizational Format and Content (revision of November 3, 1980) except for slight changes in the sequencing of material under Section 9.3 (Existing Resources). These changes consisted of moving the map discussion forward into the section titled 9.3.1 (General Site Description), and moving the species lists to the front of each of the community descriptions instead of presenting them at the ends. This was done to facilitate the general descriptive section for each community and to provide a reference to the standardized species name codes (SCS, 1978), which were used rather than the full species names in the quantitative data tables to follow. In this manner the species codes are presented with their full Latin and common names before they are used alone in other places.

9.2 METHODOLOGY

9.2.1 Species Presence

During the course of quantitative data collection, the name of each new species encountered was entered into a list kept for that purpose. Searches were made to extend the list until we were confident most had been found. Many species were recognized immediately from past experience. Those requiring identification were keyed out immediately using Welsh and Moore (1973), Utah Plants: Tracheophyta, with occasional assistance from other sources such as Arnow et al (2nd ed., 1980), Flora of the Central Wasatch Front, Utah, which provides useful descriptions in addition to keys. Occasionally Harrington (1954), Manual of the Plants of Colorado was consulted. In a few cases when plants could not be identified in the field, a specimen was collected in a plant press and an identifying code was used in the plant lists until a positive identification could be obtained. These plants were often successfully keyed out later, but in a few cases assistance was obtained from Lois Arnow and Beverly Albee at the University of Utah Herbarium, where comparison specimens were also available, and from Dr. Stanley Welsh, Brigham Young University. We wish to acknowledge with gratitude the help received from these sources.

The species names were collected for each community and an attempt was made to determine the best currently accepted nomenclature for each. Each name was checked in the National List of Scientific Plant Names (SCS, 1982, in two volumes) and in the List of Scientific and Common Plant Names for Utah (SCS, 1978). This latter reference provided the "plant symbols" or species name codes shown for each entry in our lists. The "plant character" information was also copied out of this source for each species. Plant character is a term used to describe life forms and growth habits for plants. Examples are NT (native tree), NPG (native perennial grass), IAF (introduced annual forb), and so on. A complete list of the plant character codes used appears with each species list.

In addition to the taxonomic literature already described, the following resource material was also consulted: Checklist of the Vascular Plants of the Intermountain Region (Holmgren and Reveal, 1966) and Preliminary Index of Utah Vascular Plant Names (S.L. Welsh, et al, 1981).

Threatened and endangered plants of Utah, although none were found in the study area, are described in the Illustrated Manual of Proposed Endangered and Threatened Plants of Utah (Welsh and Thorne, 1979). Bob Thompson of the U.S. Forest Service provided information about a possible candidate for T&E status in the Huntington Canyon area. This species (*Hedysarum boreale* var. *canone*) was diligently sought in our field work but was not found.

After obtaining the name codes, Latin names, common names, and growth habit codes, the species lists were divided into trees, shrubs, grasses, and forbs, and the lists were alphabetized in each category. This was done for the species lists in all six communities sampled and they are presented in that form in this report.

The species presence lists contain more entries than appear in the data tables presented further on. This is because not all species fell within the sampling quadrats that provide the quantitative data framework.

9.2.2 Trees, Saplings, and Shrubs Over 1 Meter Tall

The point-quarter method was used to determine the density, dominance, and frequency of trees (over 4 inches diameter), saplings (less than 4 inches diameter), and tall shrubs (over 1 meter tall). Cover of tree species and tall shrubs was obtained by the line-intercept method with "in-out" measurements having a 6-inch resolution. The point-quarters and line intercept paths were located along 50-foot transects whose locations were determined randomly by using a random number table and a grid system.

In the point-quarter method, the four nearest trees to each point (one in each of four quadrants) were measured for diameter and distance from the point. Four saplings were similarly measured and four tall shrubs were measured for distance and height. Pinyon and juniper trees were measured for diameter at one foot height above the ground. All other trees were measured at breast height. The term DBH, used in the tables and discussion, means "diameter-breast-height." These point-quarter measurements yielded density and frequency values for trees, saplings, and shrubs. Tree dominance in terms of basal area was obtained from DBH. Sapling data provided estimates of tree reproductive success and also mortality estimates by comparison of sapling density with mature tree density.

The importance value (IV) was obtained by the method of relative density plus relative dominance plus relative frequency, which yields a possible IV index of 300. Relative abundance was obtained for each species by taking its IV value as a percentage of the total IV value of 300 for the group (trees and saplings). Relative abundance for shrubs was determined by the C x F Index (% cover x % frequency) because no dominance value exists for the shrubs in the absence of a DBH or basal area measurement.

Absolute density of trees, saplings, and shrubs was obtained individually by summing all the distances measured to trees (disregarding species) and dividing by 4 times the number of points sampled (i.e., dividing by the total number of trees in the sample) to obtain average distance per tree from the sample point. This number is equal to the square root of the mean area of the plants under consideration, disregarding species. The mean area was then divided into 43,560 square feet per acre to obtain the total number of individuals per acre. This total density was then multiplied by the relative densities of each species to get the absolute density of each species per acre. The relative density of a species is the number of trees of that species divided by the total number of trees in the whole sample. Thus if there were 12 individuals of a given tree species out of 40 trees in the entire set, the relative density would be 12/40 = 0.30. If the absolute density of all trees, disregarding species, was 250 trees per acre, then the example species would have an absolute density of 0.30 x 250 = 75 trees per acre. The same method is used for saplings and shrubs.

In the tree and shrub tables for each of the five communities sampled, the field data from the point-quarter distances and DBH measurements are summarized as "data" showing (per species) the number of points of occurrence, the number of individuals, the total distance; and the total basal area. From these data are calculated (and shown) the density (number per acre and relative density); dominance (average basal area per tree, basal area per acre, and relative dominance as a percent per species of the total basal area per acre); frequency (number of points of occurrence as a percent of the total number of points); importance value (density + dominance + frequency); and the relative importance (IV % of 300 for each species).

9.2.3 Understory Vegetation

Cover, density, and frequency of understory plants, plus non-living cover of rock, soil, and litter were measured by the quadrat method. The quadrat size was 1.0 by 1.0 meter = 1.0 m^2 for all communities except the upper spring grassland area where 0.5 by 0.5 meter = 0.25 m^2 quadrats were used. The quadrats were located by means of a random number table in which the numbers selected represented distances along the transect and distances to the right or left of the transect. The right-or-left decision was made by tossing a coin for each quadrat. The transects were also located by a random number table which selected grid coordinates for one end of the transect. The locations of all transects and quadrats were thus entirely random and not subject to observer bias in any way. Moreover, any transect or quadrat location had an equal chance of being selected each time a choice was made. This is a feature of truly radom sampling.

The Mixed Aspen-Conifer Community was sampled with 60 quadrats, the Conifer-Shrub Community sampled with 60, the Mountain Grass-Shrub Community was sampled with 50, and the Grass-Spring Area was sampled with 50 quadrats. The Lower Spring Area was not sampled quantitatively and the Riparian Community for which tree data were taken was not sampled for understory vegetation except for compilation of a species presence list.

Living plants falling within quadrats were determined to species and the percent of total area in each quadrat (cover) was estimated to the nearest percent. The number of separate plants of each species was also counted (density) in each quadrat. These data were grouped by life form (tree seedlings, shrubs, grasses and grasslike plants, forbs, and cryptogams). In addition, the non-living cover for rock, soil, and litter was estimated. The total percent cover for living plus non-living cover was 100%, that is, actual cover was determined rather than relative cover.

At the conclusion of field work, the data were tabled out and summed. Average and relative percent cover and percent frequency were determined for each species, as well as absolute and relative density.

9.2.4 Productivity

Productivity, or more accurately, standing biomass, was measured by clipping vegetation from quadrats in each of four communities. The clipped quadrat data were supplemented by estimating the quantity of vegetation in four unclipped quadrats near each clipped one. The total number of quadrats sampled for productivity was 75 in each community, which consisted of 15 "clusters" of one clipped plus four estimated quadrats. The Lower grassy spring area and the riparian community at the confluence of Rilda Creek and Huntington Creek, which were outside the lease boundary, were not sampled for productivity in the understory.

The vegetation clippings were separated into shrubs, grasses, and forbs (no tree clippings were collected) and placed in individual bags marked with quadrat identification codes, the date, and vegetation type. These samples were weighed at the end of the collection period to obtain fresh weights, and then they were transported to the laboratory where they were oven-dried at 105^{o} C for 24 hours and weighed again to the nearest 0.1 gram. The fresh and oven-dry weights were recorded. The average weight of all the samples in a community was then related to the respective quadrat sizes (1/4 x 1/4 or 1/2 x 1/4 meter) to obtain grams per square meter. This value was then converted to a pounds per acre and kilograms per hectare by the application of simple scaling factors (1 hectare = 10,000 m^2 = 2.471 acre, 1 kilogram = 2.2046 pounds).

9.2.5 Sampling Precision, Confidence, and Adequacy

As described above, several methods were used to obtain estimates of vegetation growth in the vicinity of the West Appa Coal Company mining operations area. These methods all involved sampling and using the results to estimate the true population values. Adequate sampling ensures that the true population mean will be estimated with acceptable precision. Any degree of precision can be obtained by increasing the sample size. Perfection can be achieved by measuring every member of the population. This is, of course, impractical. A compromise is always struck between the level of precision desired and the expense and time required to attain it.

The DOGM guideline for the baseline data method asks for grass- and forb-dominated communities to be sampled to a precision of 10% for cover, density, and productivity at a statistical confidence level of 90%. This means that the true population mean has to be estimated to within 10% or better, and that if we sampled the community in the same way again, we would get the same answer (within the $\pm$ 10% precision range) 9 times out of 10 times the sample was repeated. Shrub- and tree-dominated communities are to be sampled to a precision of $\pm$ 10% at a statistical confidence level of 80% (cover, density, and productivity). When the above precision and accuracy guidelines cannot be met with a reasonable number of samples, DOGM guidelines specify acceptable sample sizes of 40 understory quadrats, 50 line-intercept transects, 40 point-quarter points, and 40 productivity quadrats. All understory data in this report were based on either 50 or 60 quadrats per community and thus exceed the sampling adequacy test of 40 quadrats. The tree and shrub density data are based on 10 to 15 point-quarters, and the productivity data are based on 15 clusters of 5 quadrats in each community.

In the present study three of the five sampled communities are dominated by trees and shrubs. Only the grassy spring area and the grass-shrub community are dominated by grass. Thus the 10% precision-80% confidence test should apply to three of the communities discussed here, and the 10%-90% test should apply to the remaining two.

The test used to estimated sampling adequacy is shown in equation (1).

$$N = \left[\frac{t\ s}{p\ x}\right]^2 \qquad (1)$$

in which N = the number of sampling units necessary to sample within the precision and confidence limits defined by the right-hand side of the equation (note: DOGM guidelines use the symbol d in place of the p used here, but the tests are identical in every way).

t = In a strict test, Students' t-value for a two-tailed test and N-1 degrees of freedom should be used here. For the 90% confidence test the value of t = 1.645 and for the 80% confidence test it is t = 1.282 is used.

s = the standard deviation of the data set.

$\bar{x}$ = the mean (average) of the data set.

p = sampling precision, entered as a decimal but representing the percent variability around the true population mean. DOGM guidelines ask for p = 0.1 (±10% precision implied) in all communities for all sampled variables.

The actual precision obtained in any sampling program can be obtained from the same formula by transformation, isolating p on the left and entering for N the actual number of samples taken. The precision-achieved formula is shown in equation (2):

$$p = \frac{t\ s}{\sqrt{N}\ \bar{x}} \qquad (2)$$

The interpretation of the adequacy and precision tests given in equations (1) and (2) is given in the following example. If N is to be calculated by equation (1) using the results of 30 samples, the 30 measurements must be summed to obtain the mean ($\bar{x}$) and standard deviation (s). The value of t = 1.645 for a 90% confidence level or t = 1.282 for an 80% confidence level test is selected. Assume t = 1.282 for this example. The desired value for p is selected; in this case it will be p = 0.1, which means the true population is to be estimated to within ±10% precision. Assuming the example yielded an answer of N = 26, we could say that the 30 actual measurements constituted an adequate sample since only 26 were required to meet the criteria of ±10% precision with an 80% confidence level. If we then said that our $\bar{x}$ was the mean for the population, we would be within ±10% of the true mean in 80 out of 100 times that we sampled the population in the same way. Another way of explaining the confidence level is to say that if we assumed $\bar{x}$ was within ±10% of the true mean, we would be wrong only 20 times out of 100 for random causes alone. The true precision for our 30 samples in this example can be calculated from equation (2). In this example it would be less than 0.10 (±10% precision) because only 26 samples were needed to obtain p = 0.10; in fact, it would be 0.09 (±9% precision).

Vegetation sampling should be done to various precision levels and within various confidence limits to suit different requirements. Greater precision and increased confidence can be had for increased costs in time and money. However, some plant communities do not require high precision sampling to achieve data useful for decision-making. There is usually a level of sampling at which any further sampling is counterproductive--it may refine the estimate of the population mean in the most hair-splitting way but the cost to accomplish this rises out of proportion to the added precision attained by the enlarged sample.

9.2.6 Vegetation Maps

Three maps were compiled with the aid of aerial photographs and ground-truthing surveys. The first, printed to a scale of 528 feet to the inch (1:6,336) (Plate 9-1), shows the dominant vegetative cover for the entire lease area. The second, printed to a scale of 50 feet to the inch (1:600) (Plate 9-2), shows the existing vegetation in the vicinity of the proposed mining operations area. The third vegetation map (Plate 9-3), overlapping part of the 1:600 map, is an extension of it showing the existing vegetation in the proposed soil stockpile area.

All three maps are printed on base maps scaled up from U.S.G.S. topographic quadrangle maps. The 1:600 mining operations area maps are provided with additional contours from a special survey to show elevation intervals of two feet.

Dominant vegetation in both mapped areas was determined by walking the areas involved and recording the larger plant communities directly on the aerial photographs. Later, in the laboratory, community boundary lines were drawn in and the mapped area was rectified by a 360-unit grid transfer to the desired topographic contour map. Community boundaries were then inked, suitable texture overlays were applied to each community type, and legend codes were added. The maps were prepared on mylar and printed by blue-line.

Area measurements were made for each community by the method of weighing relative areas cut from the map. A triple-beam balance accurate to 0.01 gram was used. This method provided for an area precision of about one part in 1,000, which exceeds the precision with which the community boundaries could be determined from the aerial photographs. The combined weight of map areas for each community type was taken as a percent of the entire map area. These values were each multiplied by the total permit area in acres (1,971.6 acres) to obtain the acreage for each community.

9.3 EXISTING RESOURCES

9.3.1 General Site Description

The West Appa Coal Company lease area boundaries are given elsewhere, but the total area is 1,971.6 acres "more or less," as the legal description has it, which is the best approximation that can be made in terrain with such high relief. The elevation extends from about 7,800 feet at the proposed mining operations area in Rilda Canyon to over 10,000 feet in Section 36 at the west end of the lease area. This region is part of the Wasatch Plateau; floristically it is dominated by extensive areas of the Rocky Mountain Montane and Subalpine Forest systems.

9.3.1.1 Permit Area Vegetation Map

There are six main vegetation types within the lease area, which are shown on Plate 9-1, titled "Existing Vegetation Within Lease Area." These six are also listed in Table 9-1 with their relative areas. The lease area is dominated by coniferous forest, some 724 acres, plus an additional 394 acres of mixed aspen-conifer forest that is probably in a seral stage trending toward uniform coniferous forest. The pure coniferous forest thus occupies about 37% of the land surface area and the mixed aspen-conifer vegetation occupies another 20%. The remaining area is divided between aspen forest (19%), grasslands (10%) and shrub-dominated communities (14%). Rocky cliffs, a minor amount

TABLE 9-1

ACREAGE OF DOMINANT VEGETATION TYPES
WITHIN WEST APPA COAL COMPANY PERMIT AREA:
MEASUREMENTS FROM PLATE 9-1

Map Symbol	Type of Surface	Approximate Land Surface Area[a] (Acres)	(%)
A	Aspen Woods	364.6	18.5
AC	Mixed Aspen-Conifer Forest	391.6	19.9
CL	Limber Pine Coniferous Forest	74.3	3.8
CS	Spruce-Fir Coniferous Forest	649.6	32.9
G	Grasslands	201.3	10.2
R	Rocky Cliff Areas	13.4	0.7
S	Mountain Shrub Communities	276.8	14.0
	TOTAL	1971.6	100.0

(a) The acreage and relative percent of each type are shown to one decimal; however, the map is not prepared to this level of precision. It is shown this way to account for the total acreage listed in the legal description, 1971.6 acres. The values should be thought of as approximate to about ± 10% or so.

of talus, and some bare areas comprise about 1% of the total permit area. Each of the main vegetation communities will now be described.

9.3.1.1.1 Aspen Forest and Mixed Aspen-Conifer Forest

About 365 acres of aspen forest are found within the lease area in parklike stands dominated almost entirely by aspen trees (*Populus tremuloides*, map symbol A). These aspen stands are often interspersed with open grassy areas of less than 1 to a maximum of about 10 acres in extent. All of the smaller grassy openings are highly influenced by the surrounding aspen forest but openings larger than about 10 acres have been included in the grassland vegetation type to be described separately. In addition to those in pure aspen stands, aspen trees account for about half of the total tree count in the mixed aspen-conifer forest type, (map symbol AC), of which some 390 acres are found in the lease area. The pure aspen stands and the mixed aspen-conifer stands together occupy about 40% of the lease area.

The aspen forest is an important plant community in this region. Aspen is the most abundant deciduous tree species in Utah, as it is in this lease area. It has a rich understory vegetation of forbs and grasses, which makes it ideal for use as summer range by grazing cattle, sheep, and wildlife such as deer and elk. Understory shrubs such as mountain lover (*Pachystima myrsinites*) are abundant in the aspen and mixed aspen-conifer forests, and this shrub, as well as others, is a favorite browse plant of deer.

Aspen trees often appear in areas disturbed by fire even though the original forest trees may have been conifers. Aspens, however, do not reproduce well in their own shade whereas many coniferous species require shade. For that reason many aspen stands slowly revert to coniferous forest in the absence of further fire. This process appears to be in operation in the mixed aspen-conifer forest that dominates about 20% of the lease area. The conifers in this mixed community consist mainly of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). At lower elevation sites and in canyon bottoms the conifers are mainly white fir (*Abies concolor*) and Douglas fir (*Pseudotsuga menziesii*). Aspen trees also form an important part of the vegetation along stream courses and in canyon bottoms in the permit area. In the vicinity of the West Appa Coal Company mining operations area at the northeast corner of Plate 9-1, for example, the riparian community is richly supplied with aspen trees, which are more abundant at this elevation (about 7,800 feet) than are the narrowleaf cottonwoods (*Populus angustifolia*) that dominate riparian areas at lower elevations.

At the higher elevations between 9,000 and 10,000 feet in the main extent of the lease area, the aspen forests tend to favor south-facing and west-facing slopes, while the spruce-fir coniferous forest occupies the more northerly-facing slopes, where it is considered to be the climax vegetation type. The mixed aspen-conifer communities generally are found between the pure aspen stands and the spruce-fir coniferous forest.

9.3.1.1.2 Spruce-Fir Coniferous Forest

About 33%, or 650 acres, of the lease area is occupied by coniferous forest consisting mainly of Engelmann spruce and subalpine fir (Map symbol CS). These are the coniferous species of the higher elevations. At lower elevations and in the drainages especially at the northeast portion of the permit area, the conifers consist mainly of white fir and Douglas fir, plus a few blue spruce (Picea pungens) and Utah junipers (Juniperus osteosperma).

The subalpine spruce-fir forest is not richly supplied with understory forbs and grasses, and for that reason is not as heavily utilized as the aspen forests are by cattle and sheep for grazing. The ground in these forests is covered almost entirely by fallen conifer needles, twigs, and small branches. Frequent fallen trees are encountered as well. Although the understory plant cover of the spruce-fir forest is sparse, there is a rich shrubby and herbaceous development around the edges of the community, and in openings. The tree density, generally steeply sloped topography, and relative inaccessibility of this forest type in the lease area provide for cover and protection to wildlife. It is also important as a source of summer forage to deer.

9.3.1.1.3 Limber Pine Community

About 74 acres (4%) of the lease area is occupied by scattered limber pines (Pinus flexilis), some Douglas fir (Pseudotsuga menziesii), and a few other conifers (Map symbol CL). The habitat is typically dry, rocky ridge tops; steep, windward exposures, and south-facing slopes. The understory vegetation is sparse, averaging perhaps only about 5% cover, and even the organic ground litter of the spruce-fir forest floor is missing. The ground surface is typically bare, gravelly, or rocky in this community. A long band of this vegetation type is located at the west end of the lease area at an elevation of 10,000 feet overlooking a steep drop to lower elevations further west. This community merges with the spruce-fir forest on either side and with aspen-dominated communities in a few areas. Smaller stands of limber pine are also found on exposed ridgetops in the eastern portion of the permit area.

9.3.1.1.4 Grass-dominated Communities

About 200 acres (10%) of surface area in the permit area are covered with almost-pure stands of grass, or with grass and scattered shrubs (Map symbol G). Some of these are open parklands on exposed ridges in similar situations to those in which limber pine are found, but in areas of soil development instead of bare rocky substrate. These areas have an abundant cover of Agropyron trachycaulum, Hesperochloa kingii, and other grass species, some of which form bunches with bare ground between, and others of which form a solid mat or even stand of knee-high grass. Scattered shrubs of big sage (Artemisia tridentata) and occasional serviceberry (Amelanchier alnifolia) or other species are found.

Other grassy communities are found in more mesic situations, including open meadows in aspen stands and wet seeps or catch-basins along drainages. These grassy areas are dominated mainly by Kentucky blue grass (Poa pratensis), ravine fescue (Festuca sororia), and others. Herbaceous forbs such as dandelion (Taraxacum officinale) are common too.

9.3.1.1.5 Shrub-dominated Communities

About 275 acres (14%) of the lease area consists of mountain shrub-grassland communities (Map symbol S) in which shrubs are more conspicuous than grasses. The shrubs in most of these areas are big sage (Artemisia tridentata). On some steep slopes and north-facing exposures, however, other shrubs predominate such as birchleaf and curlleaf mountain mahogany (Cercocarpus montanus and C. ledifolius), serviceberries (Amelanchier utahensis and A. alnifolia), bush oceanspray (Holodiscus dumosus), and corymbed buckwheat (Eriogonum corymbosum). These shrub communities usually have an abundant cover of grass between and among the branches of the shrubs but trees are absent and forbs are scarce.

9.3.1.1.6 Rocky Cliff Areas

A small part of the lease area (13 acres, 0.7%) consists of rocky cliffs, talus, or bare exposed outcrops of rock. These regions support pioneering communities of lichens and mosses, and provide habitat for some smaller forms of wildlife. The most extensive of these areas is along the northeast side of the long ridge found in the westernmost section (36) of the lease area at the head of the Left Fork of Rilda Canyon. This entire area is remote, difficult of access, thickly covered with spruce-fir forest, and steeply sloped toward the north and northeast. It appears to be good habitat for deer and possibly elk.

9.3.1.2 Mine Portal and Mining Operations Area Map

The mining operations area in the vicinity of the planned mine portal, where coal-handling facilities will be constructed and operated is located in Rilda Canyon at an elevation of about 7,800 feet. This area is shown on Plate 9-1 at the upper right corner (northeast corner). Two enlarged maps, each showing about 45 acres of land, were prepared of this area to show existing vegetation before construction begins. Plate 9-2 is of the coal handling area proper, and Plate 9-3 shows an area slightly down-canyon (east) where soils are proposed to be stockpiled for later reclamation purposes.

Ten major plant communities exist in the vicinity of the mining permit area, six of which are found within the lease boundaries. Quantitative and qualitative data for four of the communities inside the lease area and for two outside were gathered during early September, 1982 to support this permit application. These areas were the ones for which some disturbance is anticipated when construction activities begin.

The detailed quantitative data are presented in other sections of this chapter, but brief general descriptions of the ten plant communities of Plate 9-2 will be presented below. These descriptions will also serve for all communities on Plate 9-3 that have the same map symbols. Plate 9-3 is contiguous with, and overlaps a portion of Plate 9-2 on the east side, down-canyon from the mining operations area.

Acreages of each plant community, both inside and outside the lease boundaries to the edge of the map are shown in Table 9-2. Acreages from the soil stockpile area of Plate 9-3 are shown in Table 9-3. Finally, estimates of the areas where anticipated construction disturbances will occur, and the acreages of any affected plant communities, will be discussed in Section 9.5 near the end of this report.

9.3.1.2.1 Already-Disturbed Areas (Map Symbol D)

The West Appa Coal Company mine and mining operations area is located on the site of a pre-existing mine that operated in years past but is now abandoned. The existing mine area is located at the juncture of the Left and Right Forks of Rilda Canyon, near the left (south) side. It is reached by a 2-mile dirt road in Rilda Canyon that follows the stream course up from Huntington Canyon. At the old mine site there is an abandoned scale house foundation, a remnant of an old coal pile, and a service road that winds around the base of the mountain slope to the old mine entrances. All of these areas are previously disturbed, and remain so today. The total acreage shown on Plate 9-2 is 4.0 acres, and the portion inside the lease boundary, which runs through the middle of the old coal handling area, is 2.0 acres.

These disturbed roads, roadsides, construction sites, coal piles, road cuts, and associated areas contain bare ground or ground with sparse cover of weedy and noxious vegetation consisting of smotherweed (*Bassia hyssopifolia*), poverty weed (*Iva axillaris*), houndstongue (*Cynoglossum officinale*), Russian thistle (*Salsola kali*), various true thistles (*Cirsium* spp.), and other ruderal species.

TABLE 9-2

EXISTING VEGETATION IN THE VICINITY OF THE PROPOSED WEST APPA MINING PERMIT AREA BEFORE CONSTRUCTION: MEASUREMENTS FROM PLATE 9-2[a]

Plant Community	Map Symbol	Inside Lease Boundary (Acres)	Inside Lease Boundary (%)	Outside Lease Boundary (Acres)	Outside Lease Boundary (%)	Total Area Shown On Map 9-2 (Acres)	Total Area Shown On Map 9-2 (%)	Within Permit Area (Acres)	Within Permit Area (%)
Aspen-Conifer[b]	AC	5.1	18.6	0.4	2.1	5.5	12.2	4.9	18.8
Coniferous	C	2.4	8.9	0.5	3.0	2.9	6.4	1.3	5.0
Conifer-Shrub[b]	CS	9.3	34.2	3.9	21.6	13.2	29.3	4.3	16.5
Disturbed	D	2.0	7.5	2.0	11.4	4.0	8.9	3.8	14.6
Desert Shrub	DS	0	0	3.3	18.6	3.3	7.3	0.7	2.7
Grassland[b,c]	G	0.3	1.1	1.1	6.4	1.4	3.1	2.4	9.3
Grass-Shrub	GS	1.3	4.9	0	0	1.3	2.9	1.4	5.4
Mountain Shrub	MS	6.8	24.8	0.1	0.7	6.9	15.3	3.5	13.4
Pinyon-Juniper	PJ	0	0	3.5	19.4	3.5	7.8	0	0
Riparian[c]	R	0	0	3.0	16.8	3.0	6.7	3.7	14.2

[a]Area is measured to edge of map at frame line. Map scale is 50 feet to the inch and the 23x34 inch map area represents about 45 acres, more or less.

[b]Communities that may be impacted by mining activities and for which extensive quantitative data were gathered.

[c]Communities for which a species list and/or some quantitative data were gathered.

TABLE 9-3

EXISTING VEGETATION IN THE VICINITY OF THE
PROPOSED SOIL STOCKPILE AREA FOR THE WEST APPA COAL MINE

Plant Community	Map Symbol	Area To Be Disturbed (Acres)
Grassland	G	0.7
Coniferous	C	0.3
Riparian	R	0.2
TOTAL		1.2

9.3.1.2.2 Mixed Aspen-Conifer Woodland (Map Symbol AC)

Evidence of early disturbance caused by mining activities is also apparent in the mixed aspen-conifer woodland adjacent to the coal pile and around which the old mine service road passed on its way to the mine entrances. For example, within the aspen-conifer woodland are old road cuts now grown over with grass (hence included with the grass communities in the acreage measurements). Other disturances, such as ditch embankments, bulldozer scraping piles, talus from the road cut leading to the mine entrance, and slash areas where vegetation was once cleared away are all evident. Nevertheless, this 5.5-acre area now supports a stand of mixed aspen-conifer trees with a rich understory mainly of shrubs. The main tree species include the deciduous aspen (Populus tremuloides); and bigtooth maple (Acer grandidentatum); and the coniferous white fir (Abies concolor), blue spruce (Picea pungeus), Douglas fir (Pseudotsuga menziesii), and Rocky Mountain juniper (Juniperus scopulorum). This community was sampled quantitatively and a full description is presented in another section of this chapter. Moreover, it is the community likely to receive the most disturbance in the proposed new mining operations. Since it is already a previously disturbed area, it should not be considered as new disturbance when new construction begins.

9.3.1.2.3 Mountain Conifer-Shrub Community (Map Symbol CS)

On the steep north-facing slopes immediately above the old mine entrance a mixed coniferous tree and mountain shrub community exists. The area shown on Plate 9-2 is 13.2 acres but of course it is much larger as it extends beyond the map edges. The dominant trees here are white fir (Abies concolor) and Douglas fir (Pseudotsuga menziesii) with a thick understory of shrubs including birchleaf and curlleaf mountain mahogany (Cercocarpus montanus and C. ledifolius), some shrub juniper (Juniperus communis), and two species of serviceberry (Amelanchier alnfolia and A. utahensis). This community was sampled quantitatively and a full description is presented in another section of this chapter.

9.3.1.2.4 Mountain Shrubs (Map Symbol MS)

Further up the mountain slope, above the old mining service road, and beyond any anticipated disturbance to be caused by the new mining activities is a 6.9-acre mountain shrub community consisting mainly of birchleaf and curlleaf mountain mahoganies. A rich cover of grasses, but few forbs, grows in the understory. A similar area is found across the drainage to the west, which is also considered to be outside any proposed disturbance areas. A few pinyon pine (Pinus edulis) and junipers (Juniperus osteosperma and J. scopulorum) grow among the shrubs on this east-facing slope.

9.3.1.2.5 Mountain Grass-Shrub Community (Map Symbol GS)

Adjacent to the just-described shrub zone, and immediately above the old mining service road is a 1.3-acre area of mixed grasses and shrubs, different in character from the shrub zone above it. Instead of all mountain mahogany, the shrubs consist of the corymbed buckwheat (Eriogonum corymbosum), bush oceanspray (Holodiscus dumosus), and birchleaf mountain mahogany. The grass is even more abundant and consists mainly of the slender wheatgrass (Agropyron trachycaulum). No trees and few forbs are found in this area. A small amount of this community may be disturbed in future mining activities and therefore it was sampled quantitatively and a full description appears in another section of this chapter.

9.3.1.2.6 Coniferous Forest (Map Symbol C)

Small areas of montane coniferous forest extend into the area shown on Plate 9-2. The total is about 2.9 acres. In this area the trees are mainly white fir (Abies concolor) and Douglas fir (Pseudotsuga menziesii). This is the same community type shown on Plate 9-1 as Map Symbol CS, which consists of two other coniferous species that commonly inhabit higher elevations than those in the mining operations area under discussion here.

9.3.1.2.7 Grass-Dominated Communities (Map Symbol G)

Two grassy spring areas totalling about 1.4 acres in extent exist in the proposed mining operations area. The upper one, shown at the lower left side of Plate 9-2, is very small, and is entirely dominated by grasses (some 11 species, especially orchard grass, Dactylis glomerata) and a few shrubs such as wax current (Ribes cereum), wild rose (Rosa woodsii), and wild raspberry (Rubus strigosus). No trees and few forbs are found here.

The second, lower main spring area, is located just outside the lease boundary slightly to the west-northwest of the old coal pile, across the forest road. This area supports a complex plant community of at least 100 species including some trees (birch and conifers), shrubs (willows, dogwood, rose, elderberry, and others), and numerous grasses and forbs. Its character is essentially riparian but on Plate 9-2, because it is mostly open and grassy, it is shown partly as a grass-dominated community. This area was not sampled quantitatively but a species list was compiled, which is presented in another section of this chapter.

9.3.1.2.8 Riparian (Streamside) Community (Map Symbol R)

The Rilda Canyon Creek arises up-canyon from and in the spring area described above. It flows down canyon to the east, gathering volume as it goes. A riparian plant community has grown up along this stream to a short distance on either side.

On Plate 9-2 this community totals 3.5 acres. At the mining operations area the deciduous trees in the riparian area are mainly aspen trees plus a few narrowleaf cottonwoods (Populus angustifolia). Down-canyon, the number of narrowleaf cottonwoods increases dramatically and the aspens decrease. Also, conifers such as blue spruce (Picea pungens) and Douglas fir (Pseudotsuga menziesii) grow near the stream. Willows (Salix spp.), redosier dogwood (Cornus stolonifera), wild rose (Rosa woodsii), and western water birch (Betula occidentalis) are among the shrubby forms in this community, the willows and birch sometimes reaching tree size.

Understory vegetation contains water-loving species such as joint-grass (Equisetum spp.), Richardson's geranium (Geranium richardsonii), baltic rush (Juncus balticus), and many others.

This community was not sampled quantitatively in the vicinity of the mining operations area, but the trees, saplings, and shrubs were sampled further down-canyon at the confluence of Rilda Canyon with Huntington Canyon, and a species presence list was prepared. These data are presented in another section of this chapter.

9.3.1.2.9 Desert Shrub Community (Map Symbol DS)

Across the stream, lining both sides of the canyon road and totalling 6.9 acres on Plate 9-2, there is a shrub community on previously disturbed land consisting mainly of rabbitbrush (Chrysothamnus nauseosus) and big sage (Artemisia tridentata) among which grow numerous houndstongue (Cynoglossum officinale) and other weedy species. Scattered at wide intervals in this area, as shown on Plate 9-2, are single large conifer trees. These are mostly ponderosa pines (Pinus ponderosa). These areas are outside of any proposed new disturbance.

9.3.1.2.10 Pinyon-Juniper Community (Map Symbol PJ)

On the south-facing steep slopes of the opposite wall of Rilda Canyon to the north, there is an extensive pinyon-juniper woodland that runs the length of Rilda Canyon. Only 3.5 acres are shown on Plate 9-2. No disturbance of this area will occur in the proposed mine construction and operation.

9.3.2 Quantitative Analysis of Six Vegetation Communities

Of the nine plant communities (plus the already-disturbed road, coal pile, etc.) shown on Plate 9-2, four that are located inside the lease boundary and two outside the boundary will now be described in detail. These areas were chosen for intensive analysis to provide baseline data for evaluating later reclamation efforts. The four communities inside the lease boundary will probably be disturbed during the new mining activities. One of the communities outside the lease boundary, and located two miles down-canyon, may be disturbed to provide for an adequate and safe road junction with Huntington Canyon. The other community outside the lease boundary is a spring area that is to be protected. It is very near the proposed mining operations area, however, and a species presence list was prepared to assist in evaluating the vegetation growing there.

In the sections to follow, each plant community will be described with the aid of tabled data. These tables consist, in order, of a species presence list; tree, sapling, and shrub data; understory vegetation data; and finally productivity data. Only a species presence list is given for the spring area, however, as no other quantitative measurements were taken there. Similarly, for the riparian community at the confluence of Rilda and Huntington Creeks, only a species presence list plus tree, sapling, and shrub data are given since no understory vegetation or productivity measurements were taken there. A summary of data precision and sampling adequacy is given in Table 9-4.

9.3.2.1 Mixed Aspen-Conifer Community (Map Symbol AC)

9.3.2.1.1 General Description and Species Presence List

This plant community is located in a drainage area immediately west of the slope where the old coal mine entrance and service road are located. The coal pile area, which would normally have supported the same vegetation as the remainder of the area, was excluded from the quantitative sampling area. Construction of the service road to the mine entrance created a talus slope of broken rock; this was also excluded from sampling.

The sampled area itself has sustained past disturbance from the mining and road-building activities that surrounded it on all sides. Ditches were dug through the area, for example, between the small spring area at the upper end and the main coal handling area below.

The vegetation type extends beyond the central, triangular area where sampling was done, which occupies about 2.5 acres. Within the lease boundary shown on Plate 9-2, however, there are 5.1 acres of this vegetation type.

The vegetation in the area is comparatively dense, being dominated by trees, including aspen (Populus tremuloides), blue spruce (Picea pungens), white fir (Abies concolor), and big tooth maple (Acer grandidentatum). The understory is rich in shrubs. The total number of plant species observed was 71. These are listed in Table 9-5 by life form (trees, shrubs, grasses, and forbs), with scientific and common names, a standard name code, and an abbreviated growth habit code.

The greatest species diversity occurred among the forbs, of which 39 species were found. Shrubs were represented by 13 species, grasses and sedges by 12, and trees by 7.

TABLE 9-4. SAMPLING ADEQUACY RESULTS

	Maximum Number of Samples Required	Number of Samples Needed for Required Statistical Confidence and Precision	Number of Samples Obtained (N)	Actual Precision Obtained (%)	Population Mean ($\bar{x}$)	Standard Deviation (s)
	ASPEN-CONIFER COMMUNITY (AC) (Tested at 80% confidence, ±10% Precision)					
Tree Density[(a)]	10-40	35	12	17	19.54	9.05
Canopy Cover[(b)]	15-50	66	12	23	53.42	33.78
Understory Total Living Cover[(c)]	15-40	55	60	10	47.92	27.68
Productivity[(d)]	10-40	44	15	17	30.06	15.59
	CONIFER-SHRUB COMMUNITY (CS) (Tested at 80% confidence, ±10% Precision)					
Tree Density	10-40	19	10	14	18.37	6.31
Canopy Cover	15-50	56	10	24	43.50	25.44
Understory Total Living Cover	15-40	38	50	9	38.72	18.63
Productivity	10-40	51	15	18	14.31	7.99
	GRASS-SHRUB COMMUNITY (GS) (Tested at 90% confidence, ±10% Precision)					
Understory Total Living Cover	15-40	43	50	9	44.75	17.83
Productivity	10-40	16	15	10	26.28	6.33

NOTE: No trees are found in this community, hence no tree sample adequacy test is needed.

	Maximum Number of Samples Required	Number of Samples Needed for Required Statistical Confidence and Precision	Number of Samples Obtained (N)	Actual Precision Obtained (%)	Population Mean ($\bar{x}$)	Standard Deviation (s)
	UPPER SPRING GRASSLAND COMMUNITY (Tested at 90% confidence, ±10% Precision)					
Understory Total Living Cover	15-40	42	50	9	54.00	21.35
Understory Total Living Cover	10-40	48	15	18	23.22	9.73

NOTE: No trees are found in this community, hence no tree sample adequacy test is needed.

	Maximum Number of Samples Required	Number of Samples Needed for Required Statistical Confidence and Precision	Number of Samples Obtained (N)	Actual Precision Obtained (%)	Population Mean ($\bar{x}$)	Standard Deviation (s)
	RIPARIAN COMMUNITY (Tested at 80% confidence, ±10% Precision)					
Tree Density	10-40	8	10	9	18.97	4.06
Tree Cover	15-50	13	10	11	59.60	16.54

NOTE: No understory quadrat data were taken in this community, hence no understory sample adequacy tests are needed.

(a) Tree density data are from point quarter data. N is the number of point quarters and $\bar{x}$ is in feet (average distance for 4 trees per point).

(b) Canopy cover is from line intercept data. N is the number of 50-foot transects and $\bar{x}$ is in percent cover adding to 100% per transect.

(c) Understory cover data are from quadrat data. N is the number of quadrats and $\bar{x}$ is in percent cover adding to 100% per quadrat.

(d) Productivity data are from clusters of clipped and estimated quadrats. N is the number of clusters of 5 such clipped and estimated quadrats and $\bar{x}$ is in grams oven-dry weight per clipped quadrat. The quadrat sizes were different in different communities.

TABLE 9-5

SPECIES PRESENCE LIST: Mixed Aspen-Conifer Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
		TREES (7)	
ABCO	*Abies concolor*	White fir	NT
ACGR3	*Acer grandidentatum*	Bigtooth maple	NT
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper	NT
PIPU	*Picea pungens*	Blue spruce	NT
POTR5	*Populus tremuloides*	Quaking aspen	NT
PRVI	*Prunus virginiana*	Common chokecherry	NT
PSME	*Pseudotsuga menziesii*	Douglas fir	NT
		SHRUBS AND VINES (13)	
ACGL	*Acer glabrum*	Rock Mountain maple, Smooth maple	NT, NS
AMAL2	*Amelanchier alnifolia*	Saskatoon serviceberry	NS
BERE	*Berberis repens*	Oregon grape	NS
CELE3	*Cercocarpus ledifolius*	Curlleaf mountain mahogany	NS
CHNA2	*Chrysothamnus nauseosus*	Rubber rabbit-brush	NS
CHVI8	*Chrysothamnus viscidiflorus*	Douglas rabbit-brush	NS
COST4	*Cornus stolonifera*	Redosier dogwood	NS
JUCO6	*Juniperus communis*	Common juniper, Prostrate juniper	NS

TABLE 9-5 (Cont.)

SPECIES PRESENCE LIST: Mixed Aspen-Conifer Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	SHRUBS AND VINES (13) (Cont.)		
PAMY	Pachystima myrsinites	Mountain lover	NS
RICE	Ribes cereum	Wax current	NS
ROWO	Rosa woodsii	Wood's rose	NS
SACA10	Sambucus caerulea	Blue elderberry	NS
SYOR2	Symphoricarpos oreophilus	Mountain snowberry	NS
	GRASSES, SEDGES, AND RUSHES (12)		
AGCR	Agropyron cristatum	Crested wheatgrass	IPG
AGDA	Agropyron dasystachyum	Thickspike wheatgrass	NPG
AGAL3	Agrostis alba	Redtop bentgrass	IPG
BRCI2	Bromus cilatus	Fringed brome	NPG
BRTE	Bromus tectorum	Cheatgrass	IAG
CAGE2	Carex geyeri	Elk sedge	NPGL
CARO5	Carex rossii	Ross sedge	IPG
DAGL	Dactylis glomerata	Orchard grass	IPG
FESO	Festuca sororia	Ravine fescue	NPG
POPR	Poa pratensis	Kentucky bluegrass	NPG
POSE	Poa secunda	Sandberg bluegrass	NPG
STCO3	Stipa columbiana	Columbia needlegrass	NPG

TABLE 9-5 (Cont.)

SPECIES PRESENCE LIST: Mixed Aspen-Conifer Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (39)		
ACMI2	*Achillea millefolium*	Yarrow	NPF
ANAR	*Anagallis arvensis*	Scarlet pimpernel	IAF
ANGEL	*Angelica* sp.	Angelica	NPF
APME	*Apocynum medium*	Intermediate dogbane	NPF
ARMI2	*Arctium minus*	Small burdock	IBF
ARLV	*Artemisia ludoviciana*	Lauisiana sagewort	NPF
ARMO4	*Arnica mollis*	Hairy arnica	NPF
ASCH2	*Aster chilensis*	Pacific aster	NPF
BAHY	*Bassia hyssopifolia*	Firehook bassia, Smotherweed	IAF
CABU2	*Capsella bursa-pastoris*	Shepherd's purse	IAF
CIUT	*Cirsium utahense*	Utah thistle	NBF
CIVU	*Cirsium vulgare*	Bull thistle	IBF
CYOF	*Cynoglossum officinale*	Hound's tongue	IBF
DERI2	*Descurainia richardsonii*	Richardson's tansy mustard	NBF
DITR2	*Disporum trachycarpum*	Wartberry fairybell	NPF
FRSP	*Frasera speciosa*	Showy elkweed	NPF
GABO2	*Galium boreale*	Northern bedstraw	NPF
GERI	*Geranium richardsonii*	Richardson's geranium	NPF
HAPA	*Hackelia patens*	Common stickseed	NPF

TABLE 9-5 (Cont.)

SPECIES PRESENCE LIST: Mixed Aspen-Conifer Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (39) (Cont.)		
HYRI	Hymenoxys richardsonii	Pingue hymenoxys, Rubberweed	NPF
IVAS	Iva axillaris	Povertyweed	NPF
LALA3	Lathyrus lanszwertii	Thickleaf peavine	NPF
LIPE2	Linum perenne	Blue flax	NPF
MACA2	Machaeranthera canescens	Hoary machaeranthera	NBF
MEAL2	Melilotus alba	White sweetclover	IBF
MEOF	Melilotus officinalis	Yellow sweetclover	IBF
NECA2	Nepeta cataria	Catnip	IPF
PEEA	Penstemon eatoni	Eaton's penstemon, Scarlet bugler penstemon	NPF
PTAN2	Pterospora andromedea	Woodland pinedrops	NPS2F
SCAN4	Scutellaria antirrhinoides	Nose skullcap	NPF
SMRA	Smilacina racemosa	Fat false solomon's seal	NPF
SMST	Smilacina stellata	Starry false solomon's seal	NPF
SOMI	Solidago missouriensis	Missouri goldenrod, Prairie goldenrod	NPF
STLO2	Stellaria longipes	Longstalk starwort	NPF
TAOF	Taraxacum officinale	Common dandelion	IPF
THFE	Thalictrum fendleri	Fendler meadowrue	NPF

TABLE 9-5 (Cont.)

SPECIES PRESENCE LIST: Mixed Aspen-Conifer Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (39) (Cont.)		
URDI	Urtica dioica	Stinging nettle	NPF
VIAM	Vicia americana	American vetch	NPF
VIOLA	Viola sp.	Violet	NPF

[a]Codes (plant symbols), common names, and habit (plant character) are from SCS (Soil Conservation Service), 1978. List of Scientific and Common Plant Names for Utah.

[b]Taxonomy is according to Welsh and Moore, 1973. Utah Plants: Trachaeophyta, 3rd Edition, Brigham Young University Press, Provo, Utah; and SCS (Soil Conservation Service), 1982. National List of Scientific Plant Names; Vol. 1, List of Plant Names, and Vol. 2, Synonomy.

[c]Habit abbreviations: A = annual; B = biennial; F = forb: herbaceous non-grassy; G = grass; GL = grasslike: sedges and rushes; I = introduced; N = native; P = perennial; S = shrub; S2 = saprophytic; T = tree.

Aspen trees dominated the canopy layer providing about 30% of the total 50% tree cover in this area. These data are shown in Table 9-6, which provides the basic data and its analysis for trees, saplings, and shrubs in terms of density, dominance, cover frequency, and relative importance. These data will now be summarized.

9.3.2.1.2 Mixed Aspen-Conifer Tree and Shrub Data

Although seven tree species were found in this community (see Table 9-5), only five came into the quantitative sample. Total tree density estimated from the sample was 113 trees per acre, 78 (69%) of which were aspens. Aspen also dominated all other measurement parameters, including relative dominance (52%), cover (30%), frequency (52%), and relative importance (58%). The second most important tree species based on dominance was blue spruce with a dominance value of 36%. Blue spruce, however, were not as abundant as white fir, which only had a dominance value of 6% but which are present in twice the number of blue spruces (14 vs 7 per acre). The blue spruces are much larger than the white firs in this community, however, which accounts for their second-place dominance.

Saplings of aspen (207 per acre) and white fir (189 per acre) far exceed those of blue spruce (only 9 per acre), which suggests the eventual dominance in this area would be shared by aspen and white fir. It is clear there is a natural mortality rate among aspen saplings of about 62% since only 78 adult aspens per acre are found compared to 207 saplings. The failure rate for white fir saplings is even larger at about 93% (only 14 adult trees per acre vs 189 saplings). The mortality of seedling-sized plants is still higher: 877 white fir seedlings per acre are present in this community compared to only 189 saplings and 14 mature trees. Thus only 1.6% of the seedlings survive to maturity here. Each species of tree, sapling, and shrub that came within the quantitative samples can be examined in this fashion in the tables provided here. Aspen "seedlings," for example, which are probably not seedlings at all since most aspen stands reproduce by suckering, number 270 per acre, the saplings number 207, and the mature trees number 78 per acre. Therefore about 77% of the sucker-sized plants become saplings, and only 29% become mature trees. This is a mortality rate of about 71% of sucker-sized aspen plants.

It can be seen in Table 9-7 that no seedlings at all of blue spruce and only 9 per acre of saplings were found in this community. This suggests that the large trees already present here at a low density of only 7 per acre are relicts from a former, and different, forest composition compared to the young aspen-fir-maple community that exists now. Perhaps their age would extend beyond the time of early mining in this area, but the present habitat is not favorable for their vigorous reproduction.

TABLE 9-6. TREE AND SHRUB DATA: Mixed Aspen-Conifer Community, September 1, 1982

	DATA				DENSITY	
Species	Number of Points of Occurrence	Number of Individuals	Total Distance (feet)	Total Basal Area ($in.^2$)	Number Per Acre	D Relative Density (%)
TREES						
ABCO	4	6	177.42	223.0	14	12.4
ACGR3	4	5	122.25	116.0	12	10.6
PIPU	2	3	81.17	1304.3	7	6.2
POTR5	12	33	555.92	1849.0	78	69.0
PSME	1	1	1.00	107.5	2	1.8
Totals	23	48	937.76	3599.8	113	100.0
SAPLINGS						
ABCO	12	21	164.00	30.4	189	43.8
ACGR3	1	3	15.58	1.8	27	6.3
PIPU	1	1	33.08	1.8	9	2.1
POTR5	10	23	269.08	70.9	207	47.9
Totals	24	48	481.74	104.9	432	100.1
SHRUBS OVER ONE METER TALL				Average Height[a] (feet)		
ACGL	9	19	267.00	7.5	91	39.4
AMAL2	4	7	79.75	9.7	34	14.7
CHNA2	1	1	5.50	5.3	5	2.2
COST4	3	4	60.25	6.0	19	8.2
RICE	1	1	28.92	3.3	5	2.2
ROWO	7	14	148.08	4.5	67	29.0
SACA10	1	1	48.58	7.6	5	2.2
SYOR2	1	1	22.17	3.3	5	2.2
Totals	27	48	660.25	6.6[b]	231	100.1

TABLE 9-6. TREE AND SHRUB DATA: Mixed Aspen-Conifer Community, September 1, 1982

	DOMINANCE			COVER AND FREQUENCY		IMPORTANCE	
	Average Basal Area Per Tree ($in.^2$)	Basal Area Per Acre ($in.^2$)	Do Relative Dominance (%)	C Cover (%)	F Relative Frequency (%)	Importance Value (D+Do+F)	Relative Importance (%)
TREES							
ABCO	37.2	520.8	6.2	12.4	17.4	36.0	12.0
ACGR3	23.2	278.4	3.3	4.4	17.4	31.3	10.4
PIPU	434.8	3043.6	36.1	0.9	8.7	51.0	17.0
POTR5	56.0	4368.0	51.8	29.8	52.2	173.0	57.7
PSME	107.5	215.0	2.6	2.0	4.3	8.7	2.9
Totals	75.0(b)	8425.8	100.0	49.5(c)	100.0	300.0	100.0
SAPLINGS							
ABCO	1.4	264.6	28.2	NA(d)	50.0	122.0	40.6
ACGR3	0.6	16.2	1.7		4.2	12.2	4.1
PIPU	1.8	16.2	1.7		4.2	8.0	2.7
POTR5	3.1	641.7	68.4		41.7	158.0	52.6
Totals	2.2(b)	938.7	100.0	NA	100.1	300.2	100.0
SHRUBS OVER ONE METER TALL						CxF Index(e)	
ACGL	NA	NA	NA	7.3	33.3	243.1	60.4
AMAL2				2.7	14.8	40.0	9.9
CHNA2				0.3	3.7	1.1	0.3
COST4				3.3	11.1	36.6	9.1
RICE				0	3.7	0	0
ROWO				3.1	25.9	80.3	19.9
SACA10				0	3.7	0	0
SYOR2				0.4	3.7	1.5	0.4
Totals	NA	NA	NA	66.6	99.9	402.6	100.0

(a) Basal area is not measured for shrubs; the column space is therefore used for height measurements.
(b) Numbers marked (b) are averages.
(c) Tree cover includes cover contributed by saplings.
(d) NA means "not applicable"; these data are not measured.
(e) The importance index (D+Do+F) cannot be used for shrubs, hence the cover x frequency test for importance is shown here.

TABLE 9-7. UNDERSTORY QUADRAT DATA: Mixed Aspen-Conifer Community, September 1-2, 1982

	DATA FROM 60 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
TREE SEEDLINGS UNDER ONE METER TALL											
ABCO	65	8	13	1.08	2.2	13.3	2.7	877	.4	14.4	.61
ACGR3	137	9	19	2.28	4.7	15.0	3.0	1282	.5	34.2	1.46
POTR5	12	4	4	.20	.4	6.7	1.3	270	.1	1.3	.06
PSME	1	1	1	.02	.03	1.7	.3	67	.03	.03	.001
Subtotal	215	22	37	3.58	7.3	36.7	7.3	2496	1.0	49.9	2.13
SHRUBS UNDER ONE METER TALL											
ACGL	92	10	16	1.53	3.2	16.7	3.4	1079	.4	25.6	1.09
AMAL2	17	3	5	.28	.6	5.0	1.0	337	.1	1.4	.06
BERE	1386	50	1637	23.10	47.7	83.3	16.7	110416	45.1	1924.2	81.92
CHNA2	2	1	1	.03	.1	1.7	.3	67	.03	.1	.004
CHVI8	1	1	1	.02	.03	1.7	.3	67	.03	.03	.001
COST4	133	6	10	2.22	4.6	10.0	2.0	675	.3	22.2	.95
JUCO6	80	1	1	1.33	2.8	1.7	.3	67	.03	2.3	.10
PAMY	47	10	15	.78	1.6	16.7	3.4	1012	.4	13.0	.55
PRVI	14	2	7	.23	.5	3.3	.7	472	.2	.8	.03
ROWO	88	15	27	1.47	3.0	25.0	5.0	1821	.7	36.8	1.57
SYOR2	140	14	24	2.33	4.8	23.3	4.7	1619	.7	54.3	2.31
Subtotal	2000	113	1744	33.32	68.9	188.4	37.8	117632	48.0	2080.7	88.59

TABLE 9-7. UNDERSTORY QUADRAT DATA: Mixed Aspen-Conifer Community, September 1-2, 1982 (Cont.)

	DATA FROM 60 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
GRASSES AND GRASSLIKE SPECIES											
AGCR	15	2	9	.25	.5	3.3	.7	607	.2	.8	.03
AGDA	17	2	9	.28	.6	3.3	.7	607	.2	.9	.04
BRCI2	59	27	119	.98	2.0	45.0	9.0	8027	3.3	44.1	1.88
CAGE2	11	8	16	.18	.4	13.3	2.7	1079	.4	2.4	.10
CARO5	35	1	150	.58	1.2	1.7	.3	10118	4.1	1.0	.04
DAGL	9	5	14	.15	.3	8.3	1.7	944	.4	1.2	.05
FESO	10	2	9	.17	.3	3.3	.7	607	.2	.6	.03
POPR	130	8	451	2.17	4.5	13.3	2.7	30420	12.4	28.9	1.23
POSE	2	1	3	.03	.1	1.7	.3	202	.1	.1	.004
STCO3	59	11	162	.98	2.0	18.3	3.7	10927	4.5	17.9	.76
Subtotal	347	67	942	5.77	11.4	111.5	22.5	62938	25.8	97.9	4.16
FORBS											
APME	29	7	19	.48	1.0	11.7	2.3	1282	.5	5.6	.24
ANAR	6	3	19	.10	.2	5.0	1.0	1282	.5	.5	.02
ARMO4	4	3	9	.07	.1	5.0	1.0	607	.2	.4	.02
ASCH2	5	4	7	.08	.2	6.7	1.3	472	.2	.5	.02
BAHY	26	3	378	.43	.9	5.0	1.0	25496	10.4	2.2	.09
CYOF	25	13	34	.42	.9	21.7	4.4	2293	.9	9.1	.39
DERI2	1	1	2	.02	.03	1.7	.3	135	.1	.03	.001
DITR2	19	7	10	.32	.7	11.7	2.3	675	.3	3.7	.16
HAPA	1	1	1	.02	.03	1.7	.3	67	.03	.03	.001
LALA3	1	1	1	.02	.03	1.7	.3	67	.03	.03	.001

TABLE 9-7. UNDERSTORY QUADRAT DATA: Mixed Aspen-Conifer Community, September 1-2, 1982 (Cont.)

	DATA FROM 60 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
FORBS (Cont.)											
SMST	21	7	20	.35	.7	11.7	2.3	1349	.6	4.1	.17
SOMI	5	5	8	.08	.2	8.3	1.7	540	.2	.7	.03
STLO2	161	18	368	2.68	5.5	30.0	6.0	24822	10.1	80.4	3.42
TAOF	1	1	1	.02	.03	1.7	.3	67	.03	.03	.001
VIAM	3	3	3	.05	.1	5.0	1.0	202	.1	.3	.01
VIOLA	7	6	10	.12	.2	10.0	2.0	675	.3	1.2	.05
Subtotal	315	83	890	5.26	10.8	138.6	27.5	60031	24.5	108.8	4.62
CRYPTOGAMS (Combined Mosses and Lichens)											
Subtotal	30	14	23	.50	1.0	23.3	4.7	1551	.6	11.7	.50
TOTAL LIVING COVER	2907	—	3636	48.43	99.9	ΣF = 498.5	99.8	244648	99.9	2349.0	100.00
					Relative % of Non-Living Cover		Non-Living % ΣF				
NON-LIVING ROCK COVER											
ROCK	237	26	—	3.95	7.7	43.3	23.2	—	—	171.0	3.91
SOIL	592	26	—	9.87	19.1	43.3	23.2	—	—	427.4	9.78
LITTER	2264	60	—	37.73	73.2	100.0	53.6	—	—	3773.0	86.31
Total Non-Living	3093	—	—	51.55	100.0	ΣF = 186.6	100.0	—	—	4371.4	100.0
GRAND TOTAL	6000	—	—	99.98	—	—	—	—	—	—	—

The most vigorously reproducing tree species in this community is big-tooth maple (Acer grandidentatum). Mature trees are present at a rate of 12 per acre and the saplings at 27 per acre. Seedlings, however, number 1,282 per acre here. The mortality rate is obviously high (99%), but about half of the few that reach sapling size also achieve maturity.

Of the 13 species of shrubs observed in the community, 8 that attain 1 meter or more of height appeared in the quantitative samples. The others normally remain small and accordingly would not be counted in a sample aimed at tall shrubs only.

The most abundant tall shrub was smooth maple (Acer glabrum, 91 per acre) and the second was wild rose (Rosa woodsii, 67 per acre). The average height of all tall shrubs was 6.6 feet and the tallest was serviceberry (Amelanchier alnifolia), which averaged 9.7 feet tall in this community.

9.3.2.1.3 Aspen-Conifer Understory Quadrat Data

Table 9-7 summarizes the understory data from 60 1-meter-square quadrats observed for this area. Shrub species (under 1 meter tall) proved to be the most important life form, followed by forbs and then grasses about equally. Stem counts yielded truly astronomical numbers for a few species, for example, Oregon grape (Berberis repens), which is a small woody shrub that carpets the forest floor. These are present at a rate of over 110,000 per acre. All the remaining shrub species put together only account for an additional 7,000 plants per acre.

Total living cover in the understory was 48% with shrubs accounting for 33%, grasses 6%, forbs 5%, and cryptogams (lichens and mosses) 1%. Non-living cover totaled 52% with 4% rock, 10% bare soil, and 38% dead plant litter.

The most important species can be picked out in Table 9-7 in the relative importance column at the far right. Oregon grape far exceeds all others combined (82% of relative importance index). Longstalk starwort (Stellaria longipes) was next with 3.4% of the relative importance index. This is a typical understory forb species of aspen forest. Among the grasses, fringed brome (Bromus ciliatus) and Kentucky bluegrass (Poa pratensis) were the most important (1.9% and 1.2% of relative importance index, respectively).

9.3.2.1.4 Aspen-Conifer Productivity Data

Standing biomass, measured from a total of 75 clipped and estimated quadrats, was not impressively large in this community at 536 pounds (oven dry weight) per acre. Shrubs contributed 428 pounds per acre; grasses, 75; and forbs 33. These values do not account for the contribution made by trees and saplings, which are not included in productivity measurements of this type.

9.3.2.2 Conifer-Shrub Community

9.3.2.2.1 General Description and Species Presence List

The community is located directly uphill from the old mine entrance on a steep northwest- to north-facing exposure. The stand is rather open with a heavy undergrowth of birchleaf mountain mahogany shrubs (Cercocarpus montanus). The forest appears to be rather young except for a few scattered large trees. There is not much deadfall or evidence of tree cutting.

Fifty-three plant species were found in the sample area, as listed in Table 9-8. The dominant tree is Douglas fir (Pseudotsuga menziesii). Significant numbers of white fir (Abies concolor) and a few ponderosa pine (Pinus ponderosa) and pinyon pine (Pinus edulis) also occur. The greatest species diversity occurs among the forbs (26 species), followed by shrubs (15 species), grasses (6), and trees (6).

9.3.2.2.2 Conifer-Shrub Community Tree and Shrub Data (Map Symbol CS)

Table 9-9 summarizes the data for four species of trees occurring in the quantitative sampling data. Total tree density is 128 trees per acre. Saplings total 684 per acre, and from quadrat data, tree seedlings total 1,781 per acre. The combined total of mature and young trees is 2,593 per acre. Since mature trees represent about 5% of the combined total, a natural mortality rate of about 95% is suggested for all tree seedlings and saplings in this community. Table 9-9 and the quadrat data provide information for doing this test for the tree species individually. For example, mature Douglas fir trees represent 11% of all trees of that species, suggesting a mortality rate of 89%. Mature white fir trees, on the other hand, represent only 3% of all white fir trees, suggesting a mortality rate of 97% for white fir seedlings and saplings in this community. These data provide enough information to guess at population trends. For example, 1,295 white fir seedlings per acre were observed in the quadrat data. If 3% survive to maturity, about 39 trees per acre will be added to the community. Douglas fir, with 324 seedlings per acre and a survival rate of 11%, will add about 36 trees per acre to the community. These two rates of addition are not sufficiently different to suggest that white fir are replacing Douglas fir here, and it appears these two species may be in a state of equilibrium. Of course, for a community to be stable, the rate of addition of new trees is roughly balanced by tree deaths and removal. Some mature Douglas fir trees in this community were observed to be infected with dwarf mistletoe (Arceuthobium douglasii), which may be one of the mechanisms of tree removal at this site.

Although Douglas fir and white fir are the dominant trees in this community, the largest and probably oldest trees are

TABLE 9-8

SPECIES PRESENCE LIST: Conifer-Shrub Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
		TREES (6)	
ABCO	*Abies concolor*	White fir	NT
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper	NT
PIED	*Pinus edulis*	Pinyon pine	NT
PIFL2	*Pinus flexilis*	Limber pine	NT
PIPO	*Pinus ponderosa*	Ponderosa pine	NT
PSME	*Pseudotsuga menziesii*	Douglas fir	NT
		SHRUBS, VINES, AND SUCCULENTS (15)	
AMUT	*Amelanchier utahensis*	Utah serviceberry	NS
ARDO	*Arceuthobium douglasii*	Dwarf mistletoe	NP2HS
ARTR2	*Artemisia tridentata*	Big sagebrush	NS
BERE	*Berberis repens*	Oregon grape	NS
CELE3	*Cercocarpus ledifolius*	Curlleaf mountain mahogany	NS
CEMO2	*Cercocarpus montanus*	Birchleaf mountain mahogany	NS
CHVI8	*Chrysothamnus viscidiflorus*	Douglas rabbitbrush	NS
GUSA2	*Gutierrezia sarothrae*	Broom snake-wood	NHS
JUCO6	*Juniperus communis*	Common juniper, Prostrate juniper	NS
PAMY	*Pachystima myrsinites*	Mountain lover	NS

TABLE 9-8 (Cont.)

SPECIES PRESENCE LIST: Conifer-Shrub Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	SHRUBS, VINES, AND SUCCULENTS (15) (Cont.)		
PHMA5	Physocarpus malvaceus	Mallow ninebark	NS
RICE	Ribes cereum	Wax current	NS
ROWO	Rosa woodsii	Wood's rose	NS
SACA10	Sambucus caerulea	Blue elderberry	NS
SYOR	Symphoricarpos oreophilus	Mountain snowberry	NS
	GRASSES, SEDGES, AND RUSHES (6)		
AGTR	Agropyron trachycaulum	Slender wheatgrass	NPG
BRCI2	Bromus ciliatus	Fringed brome	NPG
CAGE2	Carex geyeri	Elk sedge	NPGL
HEKI	Hesperochloa kingii	Spike fescue	NPG
KOCR	Koelera cristata	Prairie junegrass	NPG
POSE	Poa secunda	Sandberg bluegrass	NPG
	FORBS (26)		
ACMI2	Achillea millefolium	Yarrow	NPF
AGGL	Agoseris glauca	False dandelion	NPF
ANPA4	Antennaria parvifolia	Pussytoes	NPF
ANSE4	Androsace septentrionalis	Pygmyflower rock jasmine	NAF
ARDR	Arabis drummondii	Drummond rockcress	NBF
ARPE	Arabis pendulina	Nodding rockcress	NPF

TABLE 9-8 (Cont.)

SPECIES PRESENCE LIST: Conifer-Shrub Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (26) (Cont.)		
ARLU	Artemisia ludoviciana	Gray sagewort, Louisiana sagewort	NPF
ARMO	Arnica mollis	Hairy arnica	NPF
ASEN2	Aster engelmannii	Engelmann aster	NPF
ASCO12	Astragalus convallarius	Timber poisonvetch	NPF
CALI14	Castilleja linariaefolia	Wyoming painted cup	NPF
CLPS	Clematis pseudoalpinus	Rocky Mountain clematis	NPF
EREN	Erigeron engelmannii	Engelmann daisy	NPF
ERAL4	Eriogonum alatum	Winged buckwheat	NPF
FRSP	Frasera speciosa	Showy elkweed	NPF
HEPA11	Heuchera parvifolia	Littleleaf alumroot	NPF
HYRI	Hymenoxys richardsonii	Pingue hymenoxys, Rubberweed	NPF
LIPE2	Linum perenne	Blue flax, Mountain flax	NPF
LYDR	Lychnis drummondii	Drummond campion	NPF
MACA2	Machaeranthera canescens	Hoary machaeranthera	NBF
PEEA	Penstemon eatoni	Eaton's penstemon, Scarlet bugler penstemon	NPF
PEWA	Penstemon watsonii	Watson's penstemon	NPF

TABLE 9-8 (Cont.)

SPECIES PRESENCE LIST: Conifer-Shrub Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
		FORBS (26) (Cont.)	
PHLO2	Phlox longifolia	Longleaf phlox	NPF
SEMU3	Senecio multilobatus	Lobeleaf groundsel	NPF
TAOF	Taraxacum officinale	Common dandelion	IPF
VIOLA	Viola sp.	Violet	NPF

[a]Codes (plant symbols), common names, and habit (plant character) are from SCS (Soil Conservation Service), 1978. List of Scientific and Common Plant Names for Utah.

[b]Taxonomy is according to Welsh and Moore, 1973. Utah Plants: Tracheophyta, 3rd Edition, Brigham Young University Press, Provo, Utah; and SCS (Soil Conservation Service), 1982. National List of Scientific Plant Names; Vol. 1, List of Plant Names, and Vol. 2, Synonymy.

[c]Habit abbreviations: A = annual; B = biennial; F = forb: herbaceous non-grassy; G = grass; GL = grasslike: sedges and rushes; HS = half-shrub; woody only at base; N = native; P = perennial; P2 = parasitic; S = shrub; T = tree.

TABLE 9-9. TREE AND SHRUB DATA: Conifer-Shrub Community, September 8, 1982

Species	DATA: Number of Points of Occurrence	DATA: Number of Individuals	DATA: Total Distance (feet)	DATA: Total Basal Area ($in.^2$)	DENSITY: Number Per Acre	DENSITY: D Relative Density (%)
TREES						
ABCO	6	13	238.3	1051.1	42	32.8
PIED	1	1	8.5	13.2	3	2.3
PIPO	2	2	58.4	882.5	6	4.7
PSME	10	24	429.5	1304.8	77	60.2
Totals	19	40	734.7	3251.6	128	100.0
SAPLINGS						
ABCO	8	18	160.9	30.2	308	45.0
JUSC2	2	2	15.0	4.4	34	5.0
PIED	1	1	6.4	13.2	17	2.5
PSME	10	19	137.0	70.6	325	47.5
Totals	21	40	319.3	118.4	684	100.0
				Average Height[a] (feet)		
SHRUBS OVER ONE METER TALL						
AMUT	4	9	107.5	3.8	172	22.5
CEMO2	10	29	140.8	4.9	554	72.5
RICE	1	1	10.0	5.1	19	2.5
SACA10	1	1	43.7	4.6	19	2.5
Totals	16	40	302.0	4.6[b]	764	100.0

TABLE 9-9. TREE AND SHRUB DATA: Conifer-Shrub Community, September 8, 1982 (Cont.)

	DOMINANCE			COVER AND FREQUENCY		IMPORTANCE	
	Average Basal Area Per Tree ($in.^2$)	Basal Area Per Acre ($in.^2$)	Do Relative Dominance (%)	C Cover (%)	F Relative Frequency (%)	Importance Value (D+Do+F)	Relative Importance (%)
TREES							
ABCO	80.9	3397.8	21.1	18.2	31.6	85.5	28.5
PIED	13.2	39.6	0.2	0	5.3	7.8	2.6
PIPO	441.3	2647.8	16.4	2.2	10.5	31.6	10.5
PSME	130.5	10048.5	62.3	19.6	52.6	175.1	58.4
Totals	81.3[c]	16133.7	100.0	40.0[c]	100.0	300.0	100.0
SAPLINGS							
ABCO	1.7	523.6	25.9	NA[d]	38.1	109.0	36.3
JUSC2	2.2	74.8	3.7		9.5	18.2	6.1
PIED	13.2	224.4	11.1		4.8	18.4	6.1
PSME	3.7	1202.5	59.4		47.6	154.5	51.5
Totals	3.0[c]	2025.3	100.1	NA	100.0	300.1	100.0
SHRUBS OVER ONE METER TALL						CxF Index[e]	
AMUT	NA	NA	NA	0.5	25.0	12.5	1.1
CEMO2				17.4	62.5	1087.5	98.2
RICE				1.1	6.3	6.9	0.6
SACA10				0	6.3	0	0
Totals	NA	NA	NA	19.0	100.1	1106.9	99.9

(a)Basal area is not measured for shrubs; the column space is therefore used for height measurements.
(b)Numbers marked (b) are averages.
(c)Tree cover includes cover contributed by saplings.
(d)NA means "not applicable"; these data are not measured.
(e)The importance index (D+Do+F) cannot be used for shrubs, hence the cover x frequency test for importance is shown here.

ponderosa pine (Pinus ponderosa), which number only about 6 per acre. No saplings or seedlings of ponderosa pines were found, however.

Shrubs are the important co-dominant life form in this community. The most abundant tall shrub (over 1 meter--small shrubs also occur but a discussion of them will be given with the quadrat data analysis) species is birchleaf mountain mahogany (Cercocarpus montanus, 554 per acre). The second most abundant tall shrub is serviceberry (Amelanchier utahensis, 172 per acre). The total of 764 tall shrubs per acre is 6 times that of mature trees; however, tree cover is 40% compared to only 19% for shrubs.

9.3.2.2.3 Understory Quadrat Data

The data on understory vegetation for the conifer-shrub community are summarized in Table 9-10. Grasses dominate the understory with a total relative importance value of 52%. Slender wheatgrass (Agropyron trachycaulum) was the most important grass species, contributing 49% toward the 52% relative importance total.

Shrubs (under 1 meter tall) are the next most abundant life form, with a 31% relative importance value. Oregon grape (Berberis repens), with 13% relative importance, was the most abundant small shrub, and the second ranking shrub after snowberry (Symphoricarpos oreophilus) in percent cover. Snowberry, however, ranked second to Oregon grape in relative importance (at 11%) because it is not as widespread and numerous, even though it is larger.

Cryptogams (combined lichens and mosses) are the next most abundant life form in terms of cover and frequency (but not biomass or forage value), with a relative importance of 12%.

Even young tree seedlings exceeded forbs in percent of living cover (8% vs 7%) and relative importance (3% vs 2%) but not in total numbers of individuals per acre and in species diversity. The most abundant forb species was Engelmann aster (Aster engelmannii), nodding rockcress (Arabis pendulina), and the Wyoming painted cup or Indian paintbrush (Castilleja linariaefolia). Total forbs number about 12,000 per acre, but they are insignificant compared to grasses and small shrubs. Moreover, their absolute cover value is slight in this community, only 2% compared to 15% for shrubs, 15% for grasses, and even 4% for cryptogams.

Non-living cover amounted to 61% of the understory, which shows the more or less barren nature of the ground in most places. Rock cover was 4%, soil was 12%, and litter (mostly conifer needles and dead twigs) amounted to 45% of the forest floor area.

TABLE 9-10. UNDERSTORY QUADRAT DATA: Conifer-Shrub Community, September 8, 1982

	DATA FROM 60 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occur-rence	No. of Indivi-duals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Indivi-duals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Impor-tance (%)
TREE SEEDLINGS UNDER ONE METER TALL											
ABCO	138	11	16	2.76	7.1	22	3.3	1295	1.0	60.7	2.58
JUSC2	2	2	2	.04	.1	4	.6	162	.1	.2	.01
PSME	10	7	4	.20	.5	14	2.1	324	.2	2.8	.12
Subtotal	150	20	22	3.00	7.7	40	6.0	1781	1.3	63.7	2.71
SHRUBS UNDER ONE METER TALL											
AMUT	34	10	15	.68	1.8	20	3.0	1214	.9	13.6	.58
BERE	228	33	298	4.56	11.8	66	10.0	24120	18.1	301.0	12.82
CEMO2	148	26	61	2.96	7.6	52	7.9	4937	3.7	153.9	6.55
CHVI8	8	5	5	.16	.4	10	1.5	405	.3	1.6	.07
JUCO6	12	2	1	.24	.6	4	.6	81	.1	1.0	.04
PHMA5	35	4	14	.74	1.9	8	1.2	1133	.8	5.9	.25
ROWO	22	6	24	.44	1.1	12	1.8	1943	1.5	5.3	.23
SYOR	258	24	39	5.16	13.3	48	7.3	3157	2.4	247.7	10.55
Subtotal	745	110	457	14.94	38.5	220	33.3	36990	27.8	730.0	31.09
GRASSES AND GRASSLIKE SPECIES											
AGTR	630	46	597	12.60	32.5	92	13.9	48321	36.2	1159.2	49.35
BRCI2	1	1	2	.02	.1	2	.3	162	.1	.04	.002
CAGE2	37	15	40	.74	1.9	30	4.5	3238	2.4	22.2	.95
HEKI	54	20	90	1.08	2.8	40	6.0	7285	5.5	43.2	1.84
KOCR	3	3	8	.06	.2	6	.9	648	.5	.4	.02
POSE	8	3	10	.16	.4	6	.9	809	.6	1.0	.04
Subtotal	733	88	747	14.66	37.9	176	26.5	60463	45.3	1226.0	52.20

TABLE 9-10. UNDERSTORY QUADRAT DATA: Conifer-Shrub Community, September 8, 1982 (Cont.)

	DATA FROM 60 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
FORBS											
ACMI2	2	2	5	.04	.1	4	.6	405	.3	.2	.01
AGGL	1	1	1	.02	.1	2	.3	81	.1	.04	.002
ANPA4	3	2	4	.06	.2	4	.6	324	.2	.2	.01
ANSE4	2	1	1	.04	.1	2	.3	81	.1	.1	.004
ARLU	4	3	9	.08	.2	6	.9	728	.5	.5	.02
ARMO	2	2	2	.04	.1	4	.6	162	.1	.2	.01
ARPE	10	9	16	.20	.5	18	2.7	1295	1.0	3.6	.15
ASCO12	4	1	1	.08	.2	2	.3	81	.1	.2	.01
ASEN2	37	13	45	.74	1.9	26	3.9	3642	2.7	19.2	.82
CALI14	15	10	15	.30	.8	20	3.0	1214	.9	6.0	.26
CLPS	11	3	9	.22	.6	6	.9	728	.5	1.3	.06
EREN	7	7	11	.14	.4	14	2.1	890	.7	2.0	.09
HEPA11	1	1	1	.02	.1	2	.3	81	.1	.04	.002
HYRI	4	2	2	.08	.2	4	.6	162	.1	.3	.01
LIPE2	1	1	1	.02	.1	2	.3	81	.1	.04	.002
MACA2	2	1	4	.04	.1	2	.3	324	.2	.1	.004
PEEA	3	1	1	.06	.2	2	.3	81	.1	.1	.004
PEWA	2	1	1	.04	.1	2	.3	81	.1	.1	.004
PHLO2	4	4	6	.08	.2	8	1.2	486	.4	.6	.03
SEMU	5	5	6	.10	.3	10	1.5	486	.4	1.0	.04
TAOF	3	3	2	.06	.2	6	.9	162	.1	.4	.02
Subtotal	123	73	143	2.46	6.6	146	21.9	11575	8.8	36.2	1.56

TABLE 9-10. UNDERSTORY QUADRAT DATA: Conifer-Shrub Community, September 8, 1982 (Cont.)

	DATA FROM 60 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
CRYPTOGAMS (Combined Mosses and Lichens)											
Subtotal	183	40	279	3.66	9.5	80	12.1	22582	16.9	292.8	12.47
TOTAL LIVING COVER	1936	—	1648	38.72	100.2	ΣF = 662	99.8	133391	100.1	2348.7	100.03
NON-LIVING COVER					Relative % of Non-Living Cover		Non-Living % ΣF				
ROCK	208	43	—	4.16	6.8	86	31.2	—	—	357.8	6.01
SOIL	603	45	—	12.06	19.7	90	32.6	—	—	1085.4	18.24
LITTER	2253	50	—	45.06	73.5	100	36.2	—	—	4506.0	75.74
Total Non-Living	3064	—	—	61.28	100.0	ΣF = 276	100.0	—	—	5949.2	99.99
GRAND TOTAL	5000	—	—	100.00	—	—	—	—	—	—	—

9.3.2.2.4 Conifer-Shrub Productivity Data

Productivity, measured from 75 clipped and estimated quadrats, amounted to 511 pounds (oven-dry weight) per acre in this community, the lowest of any measured in this study. Shrubs contributed 336 pounds per acre to this total; grasses 161, and forbs 14. These values are exclusive of trees and saplings, which are not included in productivity measurements of this type.

9.3.2.3 Mountain Grass-Shrub Community (Map Symbol GS)

9.3.2.3.1 General Description and Species Presence List

This plant community is located on the steep mountain slope above the mine portal service road that winds around the mixed aspen-conifer community in the drainage bottom. The exposure is about 290°, or west-northwest. The substrate is apparently sandstone, and large rock fragments and outcrops are distributed all over the hillside. Vegetation, consisting of evenly spaced shrubs and a thick understory of grasses, is distributed in almost steplike terraced clumps. No trees are present except at the extreme edges of the community where it grades into surrounding communities. The upper part of the community is less densely vegetated than the lower parts. At the extreme upper portion, the community grades into a zone of mountain brush distinctly different in character (more and larger shrubs consisting mainly of mountain mahogany). Shrubs in the sampled community were mainly the low corymbed buckwheat (Eriogonum corymbosum), plus lesser amounts of bush oceanspray (Holodiscus dumosus) and birchleaf mountain mahogany (Cercocarpus montanus).

The total number of plant species observed was only 27, making this community the least diverse in the area. These 27 species were divided into three life forms: 9 shrub species, 8 grasses, and 10 forbs. The complete presence list is shown in Table 9-11.

9.3.2.3.2 Grass-Shrub Community Tall Shrub Data

Because no trees or saplings were present here, no data for them are shown. Table 9-12, however, shows data for shrubs over one meter tall. Other data for smaller shrubs are presented below with the quadrat analysis.

Two species of shrubs were found that provide tall shrub data. These were the birchleaf mountain mahogany (Cercocarpus montanus) and bush oceanspray (Holodiscus dumosus). Total density of these tall shrubs was 73 per acre (50 of mahogany and 23 of oceanspray). However, shrubs under one meter tall contributed additional density counts as well--1,376 per acre for mahogany and 162 per acre for oceanspray. These observations suggest the "one meter shrub height" division point in the data is a rather arbitrary one, especially for birchleaf

TABLE 9-11

SPECIES PRESENCE LIST: Mountain Grass-Shrub Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	TREES (0)		
	SHRUBS AND VINES (9)		
AMUT	*Amelanchier utahensis*	Utah serviceberry	NS
ARFR4	*Artemisia frigida*	Fringed sagewort	NHS
CELE3	*Cercocarpus ledifolius*	Curlleaf mountain mahogany	NS
CEMO2	*Cercocarpus montanus*	Birchleaf mountain mahogany	NS
CHVI8	*Chrysothamnus viscidiflorus*	Douglas rabbitrush, Yellowbrush	NS
ERCO14	*Eriogonum corymbosum*	Corymbed eriogonum	NHS
GUSA2	*Gutierrezia sarothrae*	Broom snakeweed	NHS
HODU	*Holodiscus dumosus*	Bush oceanspray	NS
SYOR2	*Symphoricarpos oreophilus*	Mountain snowberry	NS
	GRASSES, SEDGES, AND RUSHES (8)		
AGSP	*Argopyron spicatum*	Bluebunch wheatgrass	NPG
AGTR	*Agropyron trachycaulum*	Slender wheatgrass	NPG
CAGE2	*Carex geyeri*	Elk sedge	NPGL
ELSA	*Elymus salinus*	Salina wildrye	NPG
FEOV	*Festuca ovina*	Sheep fescue	NPG
KOCR	*Koeleria cristata*	Prairie junegrass	NPG

TABLE 9-11 (Cont.)

SPECIES PRESENCE LIST: Mountain Grass-Shrub Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	GRASSES, SEDGES, AND RUSHES (8) (Cont.)		
ORHY	*Oryzopsis hymenoides*	Indian ricegrass	NPG
POSE	*Poa secunda*	Sandberg bluegrass	NPG
	FORBS (10)		
ANSE4	*Androsace septentrionalis*	Pygmyflower rockjasmine	NAF
CHFR3	*Chenopodium fremontii*	Fremont's goosefoot	NAF
HANU	*Haplopappus nuttallii*	Nuttall's goldenweed	NPF
HYRI	*Hymenoxys richardsonii*	Pingue hymenoxys, Rubberweed	NPF
LIPE2	*Linum perenne*	Blue flax, Mountain flax	NPF
OECA	*Oenothera caespitosa*	Tufted or stemless evening primrose	NPF
PEWA	*Penstemon watsonii*	Watson's penstemon	NPF
PHLO2	*Phlox longifolia*	Longleaf phlox	NPF
POGR9	*Potentilla gracilis*	Northwest cinquefoil	NPF
TARAX	*Taraxacum officinale*	Common dandelion	IPF

[a]Codes (plant symbols), common names, and habit (plant character) are from SCS (Soil Conservation Service), 1978. *List of Scientific and Common Plant Names for Utah*.

TABLE 9-11 (Cont.)

SPECIES PRESENCE LIST: Mountain Grass-Shrub Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]

[b]Taxonomy is according to Welsh and Moore, 1973. Utah Plants: Tracheophyta, 3rd Edition, Brigham Young University Press, Provo, Utah; and SCS (Soil Conservation Service), 1982. National List of Scientific Plant Names; Vol. 1, List of Plant Names, and Vol. 2, Synonymy.

[c]Habit abbreviations: A = annual; F = forb: herbaceous non-grassy; G = grass; GL = grasslike: sedges and rushes; HS = half-shrub; I = introduced; N = native; P = perennial; S = shrub.

TABLE 9-12. SHRUB DATA: Mountain Grass-Shrub Community

	DATA				DENSITY		COVER AND FREQUENCY		IMPORTANCE	
Species	Number of Points of Occurrence	Number of Individuals	Total Distance (feet)	Average Height (feet)	Number Per Acre	Relative Density (%)	C Cover (%)	Relative Frequency (%)	CxF Index	Relative Importance (%)
SHRUBS OVER ONE METER TALL										
CEMO2	12	33	858.0	5.4	50	68.5	1.2	63.2	75.8	91.1
HODU	7	15	315.2	4.0	23	31.5	0.2	36.8	7.4	8.9
Totals	19	48	1173.2	5.0	73	100.0	1.4	100.0	83.2	100.0

mountain mahogany because it is a thin shrub that produces occasional tall shoots whose development above the one-meter height is minimal in every way except length.

The tall mahogany shrubs averaged 1.65 meters (5.4 feet) in height and the oceanspray averaged 1.22 meters (4.0 feet) in height. Shrubs under 1 meter tall were not measured for height and do not come into these averages. Only 50 of 1,426 (3.5%) mahogany shrubs in this community exceed 1 meter in height. A larger proportion, 23 of 185 (12.4%), of bush oceanspray shrubs reach the one-meter height.

9.3.2.3.3 Understory Quadrat Data

Summary data from measurements taken with 50 one-meter-square quadrats are presented in Table 9-13. Grasses were the most abundant life form, averaging 30% absolute cover and 39% of summed frequency.

The most abundant grass species was slender wheatgrass (Agropyron trachycaulum), which exceeded all others by at least 20 times in abundance. The second-most abundant grass was bluebunch wheatgrass (Agropyron spicatum).

Shrubs were the second or co-dominant life form, accounting for 10% of absolute cover. The most abundant species was the little fringed sagewort (Artemisia frigida), which is actually only a "half-shrub," being woody at the base and herbaceous above. These were present in large numbers, over 5,000 per acre. The second-most abundant shrub is also a half-shrub, but much larger and with greater development of the woody parts, the corymbed buckwheat (Eriogonum corymbosum). This species accounted for over 6% of the 10% absolute cover contributed by shrubs in this community, and its density reached over 2,700 per acre. Finally, a truly woody shrub takes third place in abundance (1,376 per acre) and cover (1.2%), the birchleaf mountain mahogany.

Forbs contributed very little to the composition of this community. All forbs taken together only provided 0.9% of absolute cover. Many, such as the rockjasmine (Androsace septentrionalis), although perennial in habit, behave and contribute to the community more like annuals, being thin and insignificant in biomass and cover. Rockjasmine was the second-most abundant in this forb community, at 0.2% absolute cover and 809 individuals per acre. The most abundant forb was rubberweed (Hymenoxys richardsonii), which contributed 0.5% absolute cover and 1,133 individual plants per acre.

Total living cover in this community was 45%, and non-living cover was 55%. Of the non-living cover, 19% was rock, 28% was bare soil, and 8% was litter. The rocks provided habitat for 4% absolute cover by lichens and mosses.

TABLE 9-13. UNDERSTORY QUADRAT DATA: Mountain Grassland-Shrub Community, August 30-September 1, 1982

Species	DATA FROM 50 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
TREE SEEDLINGS UNDER ONE METER TALL											
-None-	0	0	0	0	0	0	0	0	0	0	0
SHRUBS UNDER ONE METER TALL											
ARFR4	104	29	67	2.08	4.6	58	12.5	5423	6.4	120.6	3.41
CELE3	1	1	1	.02	.04	2	.4	81	.1	.04	.001
CEMO2	60	7	17	1.20	2.7	14	3.0	1376	1.6	16.8	.47
ERCO14	321	21	34	6.42	14.3	42	9.1	2752	3.2	269.6	7.61
GUSA2	20	10	12	.40	.9	20	4.3	971	1.1	8.0	.23
HODU	11	2	2	.22	.5	4	.9	162	.2	.9	.03
SYOR2	7	2	2	.14	.3	4	.9	162	.2	.6	.02
Subtotal	524	72	135	10.48	23.3	144	31.1	10927	12.8	416.5	11.77
GRASSES AND GRASSLIKE SPECIES											
AGSP	55	15	30	1.10	2.5	30	6.5	2428	2.9	33.0	.93
AGTR	1351	50	550	27.02	60.3	100	21.6	44517	52.4	2702.0	76.29
CAGE2	29	10	14	.58	1.3	20	4.3	1133	1.3	11.6	.33
ELSA	12	1	1	.24	.5	2	.4	81	.1	.5	.01
FEOV	1	1	1	.02	.04	2	.4	81	.1	.04	.001
KOCR	2	2	4	.04	.1	4	.9	324	.4	.2	.01
ORHY	18	5	7	.36	.8	10	2.2	567	.7	3.6	.10
POSE	16	7	12	.32	.7	14	3.0	971	1.1	4.5	.13
Subtotal	1484	91	619	29.68	66.2	182	39.3	50102	59.0	2755.4	77.80

TABLE 9-13. UNDERSTORY QUADRAT DATA: Mountain Grassland-Shrub Community, August 30-September 1, 1982 (Cont.)

	DATA FROM 50 1.0 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
FORBS											
ANSE4	10	6	10	.20	.5	12	2.6	809	1.0	2.4	.07
CHFR3	1	1	1	.02	.04	2	.4	81	.1	.04	.001
HANU	2	1	1	.04	.1	2	.4	81	.1	.1	.003
HYRI	25	8	14	.50	1.1	16	3.5	1133	1.3	8.0	.23
LIPEZ	1	1	2	.02	.04	2	.4	162	.2	.04	.001
OECA	2	1	1	.04	.1	2	.4	81	.1	.04	.001
PEWA	1	1	2	.02	.04	2	.4	81	.1	.1	.003
PHLO2	2	2	4	.04	.1	4	.9	324	.4	.2	.01
Subtotal	44	21	35	.88	2.0	42	9.0	2833	3.4	10.9	.32
CRYPTOGAMS (Combined Mosses and Lichens)											
Subtotal	187	48	260	3.74	8.4	96	20.7	21044	24.8	359.0	10.14
TOTAL LIVING COVER	2239	—	1049	44.78	99.9	ΣF = 464	100.1	84906	100.0	3541.8	100.03
					Relative % of Non-Living Cover		Non-Living % ΣF				
NON-LIVING ROCK COVER											
ROCK	927	50	—	18.54	33.6	100	33.6	—	—	1854.0	33.7
SOIL	1415	50	—	28.30	51.2	100	33.6	—	—	2830.0	51.4
LITTER	419	49	—	8.38	15.2	98	32.9	—	—	821.2	14.9
Total Non-Living	2761	—	—	55.22	100.0	ΣF = 298	100.1	—	—	5505.2	100.0
GRAND TOTAL	5000	—	—	100.00	—	—	—	—	—	—	—

9.3.2.3.4 Productivity Data

Productivity, measured from 75 clipped and estimated quadrats, amounted to 938 pounds per acre (oven-dry weight) in this community. This was the highest productivity measured in any community of this study. Shrubs contributed 272 pounds per acre to the total, grasses 630 pounds per acre, and forbs only 36.

9.3.2.4 Upper Spring Grassland Community (Map Symbol G)

9.3.2.4.1 General Description and Species Presence List

This plant community is located in the bottom of a long ravine that runs up the mountain for about a mile to elevations of about 9,500 feet. No permanent stream exists, but water does collect in the system, making the ground moist in this area. The location on Plate 9-2 is at the switchback on the service road to the mine portal. This small grassy area (about 35 by 180 feet) has been provided with a gridwork of collector pipes to obtain a small amount of water for the North Emery Water Users Association. There is no longer a significant seepage of water on the surface since the pipeline was installed.

Grasses occupy the main area, and shrubs occur around the sides, especially at the uphill end. The area is shaded by tall white fir trees and blue spruces on the hillsides on each side, and lower level canopies of big-tooth maple. The dominant grass in the area is orchard grass (Dactylis glomerata), an introduced species probably planted when the collector pipes were installed. Thus, the area is not an undisturbed site and its value lies more in its water resource than in the vegetation that is found there.

Thirty-five plant species were observed in the area, 7 shrubs, 11 grasses, and 17 forbs. These are listed in Table 9-14. No trees or saplings were found inside the community boundary, although they grow all around it.

9.3.2.4.2 Spring-Grassland Quadrat Data

Table 9-15 summarizes the quadrat data from 50 one-quarter-meter square quadrats observed for this area. This quadrat size was the most suitable one for this grassy area.

The most important life form here was, of course, grasses, with 91% of the relative importance score. Shrubs and forbs were about equally important, although much less than grasses.

Total living cover in this community was 54%, of which grasses contributed 38%, shrubs 8%, forbs 7.5%, and cryptogams (mosses and lichens) 0.6%. Non-living cover was contributed by rock (9%), bare soil (21%), and litter (16%) for a total of 46%.

TABLE 9-14

SPECIES PRESENCE LIST: Upper Spring Grassland Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	TREES (0)		
	SHRUBS AND VINES (7)		
ARTR2	*Artemisia tridentata*	Big sagebrush	NS
COST4	*Cornus stolonifera*	Redosier dogwood	NS
RICE	*Ribes cereum*	Wax current	NS
ROWO	*Rosa woodsii*	Wood's rose	NS
RUST	*Rubus strigosus*	Wild raspberry	NS
SACA10	*Sambucus caerulea*	Blue elderberry	NS
SYOR2	*Symphoricarpos oreophilus*	Mountain snowberry	NS
	GRASSES, SEDGES, AND RUSHES (11)		
AGCR	*Agropyron cristatum*	Crested wheatgrass	IPG
AGDA	*Agropyron dasystachyum*	Thickspike wheatgrass	NPG
AGAL3	*Agrostis alba*	Redtop bentgrass	IPG
BRCI2	*Bromus ciliatus*	Fringed brome	NPG
BRIN2	*Bromus inermis*	Smooth brome	IPG
CAGE2	*Carex geyeri*	Elk sedge	NPGL
DAGL	*Dactylis glomerata*	Orchard grass	IPG
FESO	*Festuca sororia*	Ravine fescue	NPG
HOJU	*Hordeum jubatum*	Foxtail barley	NPG

TABLE 9-14 (Cont.)

SPECIES PRESENCE LIST: Upper Spring Grassland Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	GRASSES, SEDGES, AND RUSHES (11) (Cont.)		
POPR	*Poa pratensis*	Kentucky bluegrass	NPG
STCO3	*Stipa columbiana*	Columbia needlegrass	NPG
	FORBS (17)		
ACAR	*Actaea arguta*	Western baneberry	NPF
ASCH2	*Aster chilensis*	Pacific aster	NPF
ASEN2	*Aster engelmannii*	Engelmann aster	NPF
CIVU	*Cirsium vulgare*	Bull thistle	IBF
CYOF	*Cynoglossum officinale*	Hound's tongue	IBF
GABO2	*Galium boreale*	Northern bedstraw	NPF
GERI	*Geranium richardsonii*	Richardson's geranium	NPF
HADI	*Habenaria dilitata*	White bog orchid	NPF
HAFL2	*Hackelia floribunda*	Western stickseed	NBF
HAPA	*Hackelia patens*	Common stickseed	NPF
LALA3	*Lathyrus lanszwertii*	Thickleaf peavine	NPF
MEAL2	*Melilotus alba*	White sweetclover	IBF
MEOF	*Melilotus officinalis*	Yellow sweetclover	IBF
PEEA	*Penstemon eatoni*	Eaton's penstemon, Scarlet bugler penstemon	NPF
RANUN	*Ranunculus* sp.	Buttercup	NPF

TABLE 9-14 (Cont.)

SPECIES PRESENCE LIST: Upper Spring Grassland Community

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (17) (Cont.)		
RUCR	Rumex crispus	Curly dock	IPF
TAOF	Taraxacum officinale	Common dandelion	IPF

[a]Codes (plant symbols), common names, and habit (plant character) are from SCS (Soil Conservation Service), 1978. List of Scientific and Common Plant Names for Utah.

[b]Taxonomy is according to Welsh and Moore, 1973. Utah Plants: Tracheophyta, 3rd Edition, Brigham Young University Press, Provo, Utah; and SCS (Soil Conservation Service), 1982. National List of Scientific Plant Names; Vol. 1, List of Plant Names, and Vol. 2, Synonymy.

[c]Habit abbreviations: B = biennial; F = forb: herbaceous non-grassy; G = grass; GL = grasslike: sedges and rushes; I = introduced; N = native; P = perennial; S = shrub.

TABLE 9-15. UNDERSTORY QUADRAT DATA: Upper Spring Grassland Community, September 6-7, 1982

Species	DATA FROM 50 0.25 M^2 QUADRATS: Total of % Cover	DATA FROM 50 0.25 M^2 QUADRATS: No. of Quadrats of Occurrence	DATA FROM 50 0.25 M^2 QUADRATS: No. of Individuals	COVER: Average Cover Per Quadrat (% C)	COVER: Relative Cover (% Living Cover)	FREQUENCY: Frequency (% F)	FREQUENCY: Relative Frequency (% Σ F)	DENSITY: No. of Individuals Per Acre	DENSITY: Relative Density (%)	IMPORTANCE: CxF Index (%Cx%F)	IMPORTANCE: Relative Importance (%)
TREE SEEDLINGS UNDER ONE METER TALL											
-None-	0	0	0	0	0	0	0	0	0	0	0
SHRUBS UNDER ONE METER TALL											
ARTR2	2	2	2	.04	.1	4	.8	648	.2	.16	.01
RICE	77	3	10	1.54	2.9	6	1.2	3238	1.0	9.24	.26
ROWO	252	10	20	5.04	9.3	20	4.0	6475	2.1	100.80	2.84
RUST	69	7	5	1.38	2.6	14	2.8	1619	.5	19.32	.54
SYOR2	8	1	1	.16	.3	2	.4	324	.1	.32	.01
Subtotal	408	23	38	8.16	15.2	46	9.2	12304	3.9	129.84	3.66
GRASSES AND GRASSLIKE SPECIES											
AGAL3	44	15	55	.88	1.6	30	6.0	17807	5.7	26.40	.74
AGCR	13	2	3	.26	.5	4	.8	971	.3	1.40	.03
AGDA	37	15	41	.74	1.4	30	6.0	13274	4.3	22.20	.63
BRCI2	85	22	91	1.70	3.1	44	8.8	29462	9.5	74.80	2.11
CAGE2	2	1	1	.04	.1	2	.4	324	.1	.08	.002
DAGL	1607	47	350	32.14	59.5	94	18.8	113316	36.6	3021.16	85.21
FESO	83	28	78	1.66	3.1	56	11.2	25253	8.2	92.96	2.62
POPR	5	3	17	.10	.2	6	1.2	5504	1.8	.60	.02
STCO3	11	4	33	.22	.4	8	1.6	10684	3.4	1.76	.05
Subtotal	1887	137	669	37.74	69.9	274	54.8	216595	69.9	3241.00	91.41

TABLE 9-15. UNDERSTORY QUADRAT DATA: Upper Spring Grassland Community, September 6-7, 1982 (Cont.)

	DATA FROM 50 0.25 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
FORBS											
ASCH2	2	1	0	.04	.1	2	.4	0	0	.08	.002
ASEN2	27	5	10	.54	1.0	10	2.0	3238	1.0	5.40	.15
CIVU	79	15	29	1.58	2.9	30	6.0	9389	3.0	47.40	1.34
CYOF	69	12	31	1.38	2.6	24	4.8	10037	3.2	33.12	.93
GABO2	32	5	78	.64	1.2	10	2.0	25253	8.2	6.40	.18
GERI	110	14	27	2.20	4.1	28	5.6	8742	2.8	61.60	1.74
HAFL2	11	2	3	.22	.4	4	.8	971	.3	.88	.02
HAPA	4	2	2	.08	.1	4	.8	648	.2	.32	.01
LALA3	4	3	3	.08	.1	6	1.2	971	.3	.48	.01
MEAL2	11	4	5	.22	.4	8	1.6	1619	.5	1.76	.05
MEOF	11	8	7	.22	.4	16	3.2	2266	.7	3.52	.10
PEEA	3	1	1	.06	.1	2	.4	324	.1	.12	.003
RANUN	1	1	1	.02	.04	2	.4	324	.1	.04	.001
RUCR	3	1	0	.06	.1	2	.4	0	0	.12	.003
TAOF	10	6	8	.20	.4	12	2.4	2590	.8	2.40	.07
Subtotal	377	80	205	7.54	13.9	160	32.0	66372	21.2	163.64	4.61

TABLE 9-15. UNDERSTORY QUADRAT DATA: Upper Spring Grassland Community, September 6-7, 1982 (Cont.)

	DATA FROM 50 0.25 M^2 QUADRATS			COVER		FREQUENCY		DENSITY		IMPORTANCE	
Species	Total of % Cover	No. of Quadrats of Occurrence	No. of Individuals	Average Cover Per Quadrat (% C)	Relative Cover (% Living Cover)	Frequency (% F)	Relative Frequency (% ΣF)	No. of Individuals Per Acre	Relative Density (%)	CxF Index (%Cx%F)	Relative Importance (%)
CRYPTOGAMS (Combined Mosses and Lichens)											
Subtotal	28	20	45	.56	1.0	20	4.0	14569	4.7	11.20	.32
TOTAL LIVING COVER	2700	--	957	54.00	100.0	ΣF = 500	100.0	309840	99.7	3545.68	100.00
NON-LIVING ROCK COVER					Relative % of Non-Living Cover		Non-Living % ΣF				
ROCK	451	45	--	9.02	19.6	90	31.3	--	--	811.80	18.17
SOIL	1042	49	--	20.84	45.3	98	34.0	--	--	2042.32	45.71
LITTER	807	50	--	16.14	35.1	100	34.7	--	--	1614.00	36.12
Total Non-Living	2300	--	--	46.00	100.0	ΣF = 288	100.0	--	--	4468.12	100.00
GRAND TOTAL	5000	--	--	100.00	--	--	--	--	--	--	--

Among the grasses, the most abundant was orchard grass (Dactylis glomerata), an important introduced species often used in reclamation work. This species accounted for 32% of the total 38% absolute cover of grasses. Fringed brome (Bromus ciliatus, 1.7% cover) and ravine fescue (Festuca sororia, 1.7% cover) were the next most important grasses. Eight other grass species were present but only contributed about 2.5% to the absolute cover in the area.

The most important shrub species was wild rose (Rosa woodsii), which provided 5% absolute cover (9% of living cover). Wild raspberry (Rubus strigosus) and wax current (Ribes cereum) were the co-dominant shrubs, although they were much less abundant than wild rose.

The most important forb species was the moisture-loving Richardson's geranium (Geranium richardsonii), which contributed 2% to absolute cover and 6% to relative frequency. Indicative of the disturbed nature of this community, the second-most important forb was bull thistle (Cirsium vulgare), an indicator species of disturbance. Similarly, the third-ranked forb was houndstongue (Cynoglossum officinale), an introduced biennial forb of particularly noxious quality and another indicator of disturbance.

9.3.2.4.3 Productivity Data

Standing biomass, measured from 75 clipped and estimated quadrats, was 829 pounds per acre (oven-dry weight), which is second-highest of the four communities in this area that were measured for productivity. Unfortunately, this habitat type is of limited extent and the small area does not contribute much to total productivity or wildlife utilization in the area. Grasses provided 606 pounds per acre, shrubs 162 pounds, and forbs 61.

9.3.2.5 Main Spring Area (Map Symbols C, G, R)

9.3.2.5.1 General Description and Species Presence List

This area, intended to remain undisturbed during mining operations, is located at the north end of the lease area, just outside the lease boundary, but in the permit area. It is not an undisturbed area as construction of a water channel of cement has been done, and cuttings of trees and shrubs have been piled in the area. Evidence of digging and vehicle damage are also present.

The area was surveyed for a plant species presence list and 88 species were observed. These are shown in Table 9-16. Of the total, there were 8 tree species (5 conifers and 3 deciduous species), 16 shrubs, 18 grasses and grasslike species, and 46 forb species.

TABLE 9-16

SPECIES PRESENCE LIST: Lower Main Spring Area

Code[a]	Scientific Name[b]	Common Name	Habit[c]
		TREES (8)	
ABCO	*Abies concolor*	White fir	NT
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper	NT
PIPO	*Pinus ponderosa*	Ponderosa pine	NT
PIPU	*Pinus pungens*	Blue spruce	NT
POAN3	*Populus angustifolia*	Narrowleaf cottonwood	NT
POTR5	*Populus tremuloides*	Quaking aspen	NT
PRVI	*Prunus virginiana*	Common chokecherry	NT
PSME	*Pseudotsuga menziesii*	Douglas fir	NT
		SHRUBS, VINES, AND SUCCULENTS (16)	
ACGL	*Acer glabrum*	Rocky Mountain maple, Smooth maple	NT
ARTR2	*Artemisia tridentata*	Big sagebrush	NS
BERE	*Berberis repens*	Oregon grape	NS
CHNA2	*Chrysothamnus nauseosus*	Rubber rabbitbrush	NS
COST4	*Cornus stolonifera*	Redosier dogwood	NS
GUMI	*Gutierrezia microcephala*	Threadleaf snakeweed	NS
JUCO6	*Juniperus communis*	Common juniper, Prostrate juniper	NS
PAMY	*Pachystima myrsinites*	Mountain lover	NS

TABLE 9-16 (Cont.)

SPECIES PRESENCE LIST: Lower Main Spring Area

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	SHRUBS, VINES, AND SUCCULENTS (16) (Cont.)		
PHMA5	Physocarpus malvaceus	Mallow ninebark	NS
RICE	Ribes cereum	Wax current	NS
ROWO	Rosa woodsii	Wood's rose	NS
SABE2	Salix bebbiana	Bebb willow	NS,NT
SACA7	Salix caudata	Whiplash willow	NT
SAEX	Salix exigua	Coyote willow	NS
SACA10	Sambucus caerulea	Blue elderberry	NS
SYOR	Symphoricarpos oreophilus	Mountain snowberry	NS
	GRASSES, SEDGES, AND RUSHES (18)		
AGAL3	Agrostis alba	Redtop bentgrass	IPG
AGTR	Agropyron trachycaulum	Slender wheatgrass	NPG
BRCI2	Bromus ciliatus	Fringed brome	NPG
BRCA5	Bromus carinatus	Mountain brome	NPG
BRTE	Bromus tectorum	Cheatgrass	IAG
CAAQ	Carex aquatilis	Water sedge	NPEGL
DAGL	Dactylis glomerata	Orchard grass	PPG
ELSA	Elymus salina	Salina wildrye	NPG
EQAR	Equisetum arvense	Field horsetail, Jointgrass	NPH
EQHY	Equisetum hyemale	Western scouringrush	NPH

TABLE 9-16 (Cont.)

SPECIES PRESENCE LIST: Lower Main Spring Area

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	GRASSES, SEDGES, AND RUSHES (18) (Cont.)		
EQLA	*Equisetum laevigatum*	Smooth horsetail	NPH
FESO	*Festuca sororia*	Ravine fescue	NPG
HOJU	*Hordeum jubatum*	Foxtail barley	NPG
JUBA	*Juncus balticus*	Baltic rush, wiregrass	NPGL
ORHY	*Oryzopsis hymenoides*	Indian ricegrass	NPG
POPR	*Poa pratensis*	Kentucky bluegrass	NPG
STCO3	*Stipa columbiana*	Columbia needlegrass	NPG
STCO4	*Stipa comata*	Needle-and-thread grass	NPG
	FORBS (46)		
ACMI2	*Achillea millefolium*	Yarrow	NPF
AGGL	*Agoseris glauca*	False dandelion	NPF
APME	*Apocynum medium*	Intermediate dogbane	NPF
ARMI2	*Arctium minus*	Small burdock	NPF
ARLU	*Artemisia ludoviciana*	Louisiana sagewort, Gray sagewort	NPF
ASEN2	*Aster engelmannii*	Engelmann aster	NPF
ASOC	*Aster occidentalis*	Western aster	NPF
BAHY	*Bassia hyssopifolia*	Firehook bassia, Smotherweed	IAF
CADR	*Cardaria draba*	Whitetop	IPF

TABLE 9-16 (Cont.)

SPECIES PRESENCE LIST: Lower Main Spring Area

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (46) (Cont.)		
CHDO	*Chaenactis douglasii*	Douglas dustymaiden	NBF
CIEA	*Cirsium eatoni*	Eaton thistle	NBF
CISC	*Cirsium scopulorum*	Mountain thistle	NPF
CIVU	*Cirsium vulgare*	Bull thistle	IBF
COCA5	*Conyza canadensis*	Canada horseweed	NAF
CYOF	*Cynoglossum officinale*	Hound's tongue	NAF
DERI2	*Descurainia richardsonii*	Richardson tansy mustard	NBF
EPAN2	*Epilobium angustifolium*	Common fireweed	NPF
EPCI	*Epilobium ciliatum*	Northern willow herb, Hairy willowweed	NPF
EREN	*Erigeron engelmannii*	Engelmann daisy	NPF
ERAL4	*Eriogonum alatum*	Winged buckwheat	NPF
ERDE6	*Eriogonum deflexum*	Skeletonweed	NAF
FRSP	*Frasera speciosa*	Showy elkweed	NPF
GABO2	*Galium boreale*	Northern bedstraw	NPF
GARA	*Gayophytum ramosissimum*	Branchy groundsmoke	NAF
GEFR2	*Geranium fremontii*	Fremont's geranium	NPF
GERI	*Geranium richardsonii*	Richardson's geranium	NPF
GRSQ	*Grindelia squarrosa*	Curlycup gumweed	NBF

TABLE 9-16 (Cont.)

SPECIES PRESENCE LIST: Lower Main Spring Area

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (46) (Cont.)		
HAPA	Hackelia patens	Common stickseed	NPF
HANU	Haplopappus nuttallii	Nuttall goldenweed	NPF
LALA3	Lathyrus lanszwertii	Thickleaf peavine	NPF
LEDE	Lepidium densiflorum	Prairie pepperweed	NAF
MACA2	Machaeranthera canescens	Hoary machaeranthera	NBF
MAKI	Machaeranthera kingii	King's machaeranthera	NPF
OECA	Oenothera caespitosa	Tufted or stemless evening primrose	NPF
PODO4	Polygonum douglasii	Douglas knotweed	NAF
RUCR	Rumex crispus	Curly dock	IPF
SAKA	Salsola kali	Russian thistle	IAF
SEMU3	Senecio multilobatus	Lobeleaf groundsel	NPF
SIAL2	Sisymbrium altissimum	Tumblemustard	IAF
SMRA	Smilacina racemosa	Fat false solomon's seal	NPF
SMST	Smilacina stellata	Starry false solomon's seal	NPF
SOMI2	Solidago missouriensis	Missouri goldenrod, Prairie goldenrod	NPF
STLO2	Stellaria longipes	Longstalk starwort	NPF
TRDU	Tragapogon dubius	Yellow salsify, Goatsbeard	IBF

TABLE 9-16 (Cont.)

SPECIES PRESENCE LIST: Lower Main Spring Area

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (46) (Cont.)		
VETH	Verbascum thapsus	Flannel mullein	IBF
VIOLA	Viola sp.	Violet	NPF

[a]Codes (plant symbols), common names, and habit (plant character) are from SCS (Soil Conservation Service), 1978. List of Scientific and Common Plant Names for Utah.

[b]Taxonomy is according to Welsh and Moore, 1973. Utah Plants: Tracheophyta, 3rd Edition, Brigham Young University Press, Provo, Utah; and SCS (Soil Conservation Service), 1982. National List of Scientific Plant Names; Vol. 1, List of Plant Names, and Vol. 2, Synonymy.

[c]Habit abbreviations: A = annual; B = biennial; E = emergent aquatic; F = forb: herbaceous non-grassy; G = grass; GL = grasslike: sedges and rushes; H = horsetail: the genus Equisetum; I = introduced; N = native; P = perennial; S = shrub; T = tree.

About 20 species in this area are indicators of disturbance. Some examples are threadleaf snakeweed (Gutierrezia microcephala), cheatgrass (Bromus tectorum), burdock (Arctium minus), smotherweed (Bassia hyssopifolia), white top (Cardaria draba), several species of thistle (Cirsium ssp.), houndstongue (Cynoglossum officinale), fireweed (Epilobium angustifolium), gumweed (Grindelia squarrosa), stickseed (Hackelia patens), knotweed (Polygonum douglasii), curly dock (Rumex crispus), Russian thistle (Salsola kali), tumblemustard (Sisymbrium altissmum), goldenrod (Solidago missouriensis), salsify (Tragapogon dubius), and mullein (Verbascum thapsus).

Others are indicators of moist soil conditions, which is as expected since the area is low ground next to the Rilda Canyon stream and is also a spring or seep area for groundwater. Some examples are narrowleaf cottonwood (Populus angustifolia), dogwood (Cornus stolonifera), wax current (Ribes cereum), wild rose (Rosa woodsii), several willow species (Salix spp.), water sedge (Carex aquatilis), horsetail (Equisetum spp.), Baltic rush (Juncus balticus), Richardson's geranium (Geranium richardsonii), and false Solomon's seal (Smilacina spp.).

9.3.2.6 Riparian Community at Confluence of Rilda Canyon Creek and Huntington Canyon Creek (Not shown on Plates 9-1 or 9-2)

9.3.2.6.1 General Description and Species Presence List

This area was selectively studied because it may be disturbed to provide for an improved and safer junction between the road from the mine in Rilda Canyon and the main highway through Huntington Canyon. The studied area is along the east side of Rilda Creek beginning at the confluence with Huntington Creek and running upstream along Rilda Creek about 500 feet. It is not adjacent to the West Appa Coal Company lease or permit area, but is about 2 miles down Rilda Canyon from them.

The community is dominated by large trees and a thick understory of large shrubs. The ground is mostly bare or covered with conifer needles and fallen twigs. Away from the two streams, in the wedge of high ground between them, a typically desert plant community is found, quite different from any surrounding vegetation in either Huntington or Rilda Canyons. For example, there is a large population of yucca plants and several cactus species that are not observed commonly elsewhere in these canyons. This area was apparently occupied by Indians in the past, and some of the plants seen today may be relict populations of plant species imported by the Indians. Most of this area is not actually riparian habitat and accordingly was not intensively sampled during the study reported here.

The species presence list is given in Table 9-17. A total of 78 plant species was observed. Of these 11 were trees; 23 were

TABLE 9-17

SPECIES PRESENCE LIST: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	TREES (11)		
ABCO	*Abies concolor*	White fir	NT
BEOC2	*Betula occidentalis*	Water birch	NT
CELE3	*Cercocarpus ledifolius*	Curlleaf mountain mahogany	NS,NT
JUSC2	*Juniperus scopulorum*	Rocky mountain juniper	NT
PIPU	*Picea pungens*	Blue spruce	NT
PIED	*Pinus edulis*	Pinyon pine	NT
PIPO	*Pinus ponderosa*	Ponderosa pine	NT
POAN	*Populus angustifolia*	Narrowleaf cottonwood	NT
PRVI	*Prunus virginiana*	Common chokecherry	NT
PSME	*Pseudotsuga menziesii*	Douglas fir	NT
SHAR	*Shepherdia argentea*	Silver buffaloberry	NS,NT
	SHRUBS, VINES, AND SUCCULENTS (23)		
ACGL	*Acer glabrum*	Rocky mountain maple, Smooth maple	NS,NT
AMAL2	*Amelanchier alnifolia*	Saskatoon serviceberry	NS
AMUT	*Amelanchier utahensis*	Utah serviceberry	NS
ARTR2	*Artemisia tridentata*	Big sagebrush	NS

TABLE 9-17 (Cont.)

SPECIES PRESENCE LIST: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	SHRUBS, VINES, AND SUCCULENTS (23) (Cont.)		
CELE3	Cercocarpus ledifolius	Curlleaf mountain mahogany	NS,NT
CEMO2	Cercocarpus montanus	Birchleaf mountain mahogany	NS
CHNA2	Chrysothamnus nauseosus	Rubber rabbitbrush	NS
CHDE2	Chrysothamnus depressus	Dwarf rabbitbrush	NS
CLLI2	Clematis ligusticifolia	Western virgin's bower	NWV
COST4	Cornus stolonifera	Redosier dogwood	NS
COVI9	Coryphantha (Mammillaria) vivipara	Lavender pincushion cactus	NS4S
GUSA2	Gutierrezia sarothrae	Broom snakeweed	NHS
OPFR	Opuntia fragilis	Brittle prickly pear	NS4S
RHTR	Rhus trilobata	Squawbrush, Skunkbush sumac	NS
RICE	Ribes cereum	Wax current	NS
ROWO	Rosa woodsii	Wood's rose	NS
SALIX	Salix sp.	Willow	NS
SABE 2	Salix bebbiana	Bebb willow	NS,NT
SACA10	Sambucus caerulea	Blue elderberry	NS
SYOR2	Symphoricarpos oreophilus	Mountain snowberry	NS

TABLE 9-17 (Cont.)

SPECIES PRESENCE LIST: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	SHRUBS, VINES, AND SUCCULENTS (23) (Cont.)		
TECA2	Tetradymia canescens	Gray horsebrush	NS
YUHA	Yucca harrimaniae	Harriman yucca	NS
	GRASSES, SEDGES, AND RUSHES (10)		
AGAL3	Agrostis alba	Redtop bentgrass	IPG
AGTR	Agropyron trachycaulum	Slender wheatgrass	NPG
ARLO3	Aristida longiseta	Red threeawn grass	NPG
BRCA5	Bromus carinatus	Mountain brome	NPG
CAAQ	Carex aquatilis	Water sedge	NPEGL
CAGE2	Carex geyeri	Elk sedge	NPGL
EQHY	Equisetum hyemale	Western souringrush	NPH
JUBA	Juncus balticus	Baltic rush, Wiregrass	NPGL
POPR	Poa pratensis	Kentucky bluegrass	NPG
SPCR	Sporobolus cryptandrus	Sand dropseed	NPG
	FORBS (34)		
ANPA4	Antennaria parvifolia	Pussytoes	NPF
ARPE	Arabis pendulina	Nodding rockcress	NPF
ARLU	Artemisia ludoviciana	Louisiana sagewort, Gray sagewort	NPF
ASCH2	Aster chilensis	Pacific aster	NPF

TABLE 9-17 (Cont.)

SPECIES PRESENCE LIST: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (34) (Cont.)		
ASEN2	Aster engelmannii	Engelmann aster	NPF
ASTRA	Astragalus sp.	Locoweed	NPF
ASCO12	Astragalus convallarius	Timber poisonvetch	NPF
CASTI2	Castilleja sp.	Indian paintbrush	NBF
CHDO	Chaenactis douglasii	Douglas dustymaiden	NBF
CIEA	Cirsium eatoni	Eaton thistle	NBF
CISC	Cirsium scopulorum	Mountain thistle	NPF
CIUT	Cirsium utahense	Utah thistle	NBF
CIVU	Cirsium vulgare	Bull thistle	IBF
COMA2	Conium maculatum	Poison hemlock	IBF
CRHU2	Cryptantha humilis	Low cryptantha	NPF
CYOF	Cynoglossum officinale	Hound's tongue	IBF
ERAL4	Eriogonum alatum	Winged buckwheat	NPF
EURO5	Euphorbia robusta	Robust spurge	NPF
GIAG	Gilia aggregata	Scarlet gilia	NPF
GLLE3	Glycyrrhiza lepidota	American licorice	NPF
HADI	Habenaria dilitata	White bog orchid	NPF
HANU	Haplopappus nuttalli	Nuttall goldenweed	NPF
HYAC	Hymenoxys acaulis	Stemless hymenoxys	NPF
LATHY	Lathyrus sp.	Peavine	NPF

TABLE 9-17 (Cont.)

SPECIES PRESENCE LIST: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek

Code[a]	Scientific Name[b]	Common Name	Habit[c]
	FORBS (34) (Cont.)		
LEDE	Lepidium densiflorum	Prairie pepperweed	NAF
MACA2	Machaeranthera canescens	Hoary machaeranthera	NBF
OECA	Oenothera caespitosa	Tufted or stemless evening primrose	NPF
PELE2	Penstemon lentus	Thick penstemon	NPF
PETH2	Penstemon thompsoniae	Thompson's penstemon	NPF
SEMU3	Senecio multilobatus	Lobeleaf groundsel	NPF
SMST	Smilacina stellata	Starry false solomon's seal	NPF
TOFL2	Townsendia florifera	Showy townsendia	NAF
TRDU	Tragapogon dubius	Yellow salsify, Goatsbeard	IBF
VIAM	Vicia americana	American vetch	NPF

[a]Codes (plant symbols), common names, and habit (plant character) are from SCS (Soil Conservation Service), 1978. List of Scientific and Common Plant Names for Utah.

[b]Taxonomy is according to Welsh and Moore, 1973. Utah Plants: Tracheophyta, 3rd Edition, Brigham Young University Press, Provo, Utah; and SCS (Soil Conservation Service), 1982. National List of Scientific Plant Names; Vol. 1, List of Plant Names, and Vol. 2, Synonymy.

[c]Habit abbreviations: A = annual; B = biennial; E = emergent aquatic; F = forb: herbaceous non-grassy; G = grass; GL = grasslike: sedges and rushes; H = horsetail: the genus Equisetum; HS = half-shrub: woody only at the base; I = introduced; N = native; P = perennial; S = shrub; S4 = succulent: cactus, etc.; V = vine; W = woody.

shrubs, vines, or succulents; 10 were grasses; and 34 were forbs.

As would be expected for an area located so close to canyon roads, there is evidence from the plants that are present that past disturbance is still having an effect. Among the species found at this site are several indicators of disturbance. Some of these are broom snakeweed (Gutierrezia sarothrae), prickly pear cactus (Opuntia fragilis), four species of thistle (Cirsium spp.), poison hemlock (Conium maculatum), houndstongue (Cynoglossum officinale), licorice (Glycyrrhiza lepidota), and salsify (Tragapon dubius).

9.3.2.6.2 Riparian Tree, Sapling, and Shrub Data

Tree and shrub data are presented in Table 9-18. Mature trees number 120 per acre in this community. The dominant tree species is narrowleaf cottonwood (Populus augustifolia), which is present at a density of 39 per acre. Another tree (Rocky Mountain juniper, Juniperus scopulorum) is more numerous at 45 per acre, but the cottonwoods are so much larger that their dominance is clearly evident. In addition to the juniper, two more large coniferous trees are important in this community. These are Douglas fir (Pseudotsuga menziesii) and blue spruce (Picea pungens). Both grow to large size in this area, especially the blue spruce. These are not so numerous as the cottonwoods and junipers, only 15 per acre of the Douglas fir and 6 per acre of the blue spruces.

Saplings follow a different pattern. The most abundant species among the saplings is Rocky Mountain juniper at 188 per acre. The total juniper count of mature and young trees is thus 233 per acre, of which 45 or 19% are mature trees. This suggests a mortality rate of about 81% for young juniper trees. No seedling data are available to extend these observations to even younger trees.

The second-most abundant sapling-sized tree species is white fir. Among adult trees these number only 3 per acre. Saplings, however, are present in large numbers, 111 per acre. Either this species is increasing in this area or there is a large mortality rate of about 97% for young white fir trees. A similar high mortality rate (93%) for white fir was observed in the mixed Aspen-Conifer stand at the West Appa Coal Company lease area.

Saplings of narrowleaf cottonwood are less abundant than are mature trees, based on the sample observed in this study. Only 22 per acre of saplings were found compared to 39 per acre of mature trees. If this observation is accurate, about 64% of young cottonwood trees survive to maturity.

TABLE 9-18. TREE AND SHRUB DATA: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek, September 14, 1982

	DATA				DENSITY	
Species	Number of Points of Occurrence	Number of Individuals	Total Distance (feet)	Total Basal Area (in.^{2})	Number Per Acre	D Relative Density (%)
TREES						
ABCO	1	1	10.83	21.2	3	2.5
CELE3	1	2	67.50	138.9	6	5.0
JUSC2	9	15	233.17	823.4	45	37.5
PIPU	2	2	19.17	633.6	6	5.0
PIED	2	2	33.42	88.1	6	5.0
POAN	8	13	310.67	2238.6	39	32.5
PSME	4	5	90.00	866.4	15	12.5
Totals	27	40	764.75	4810.2	120	100.0
SAPLINGS						
ABCO	5	10	102.25	21.0	111	25.0
JUSC2	8	17	178.42	36.7	188	42.5
PIPU	3	3	38.00	1.5	33	7.5
PIED	1	1	16.17	0.5	11	2.5
POAN	2	2	31.17	4.7	22	5.0
PSME	6	7	30.50	4.1	78	17.5
Totals	25	40	396.51	68.5	443	100.0

TABLE 9-18. TREE AND SHRUB DATA: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek, September 14, 1982 (Cont.)

Species	DATA				DENSITY	
	Number of Points of Occurrence	Number of Individuals	Total Distance (feet)	Total Basal Area (in.^{2})	Number Per Acre	D Relative Density (%)
SHRUBS OVER ONE METER TALL				Average Height(a) (feet)		
AMAL2	3	3	66.83	5.7	6	7.6
AMUT	1	1	43.83	4.6	2	2.5
BEOC2	4	7	71.67	13.7	14	17.8
CELE3	2	2	97.50	8.5	4	5.1
CEMO2	1	1	75.00	4.3	2	2.5
CHNA2	3	3	193.50	4.9	6	7.6
COST4	1	2	29.00	4.3	4	5.1
RICE	1	1	14.00	3.3	2	2.5
ROWO	9	18	269.50	4.4	35	44.4
SALIX	1	1	42.00	8.2	2	2.5
SACA10	1	1	37.50	3.9	2	2.5
Totals	27	40	940.33	6.4(b)	79	100.1

TABLE 9-18. TREE AND SHRUB DATA: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek, September 14, 1982 (Cont.)

	DOMINANCE			COVER AND FREQUENCY		IMPORTANCE	
	Average Basal Area Per Tree (in.^{2})	Basal Area Per Acre (in.^{2})	Do Relative Dominance (%)	C Cover (%)	F Relative Frequency (%)	Importance Value (D+Do+F)	Relative Importance (%)
TREES							
ABCO	21.2	63.6	0.4	2.6	3.7	6.6	2.2
CELE3	69.5	417.0	2.9	0	3.7	11.6	3.9
JUSC2	54.9	2470.5	17.1	25.8	33.3	87.9	29.3
PIPU	316.8	1900.8	13.2	5.7	7.4	25.6	8.5
PIED	44.1	264.6	1.8	1.2	7.4	14.2	4.7
POAN	172.2	6715.8	46.5	8.7	29.6	108.6	36.2
PSME	173.3	2599.5	18.0	13.1	14.8	45.3	15.1
Totals	120.3[b]	14431.8	99.9	57.1[c]	100.0	299.8	99.9
SAPLINGS							
ABCO	2.1	233.1	30.3	NA[d]	20.0	75.3	25.1
JUSC2	2.2	413.6	53.8		32.0	128.3	42.8
PIPU	0.5	16.5	2.1		12.0	21.6	7.2
PIED	0.5	5.5	0.7		4.0	7.2	2.4
POAN	2.4	52.8	6.9		8.0	19.9	6.6
PSME	0.6	46.8	6.1		24.0	47.6	15.9
Totals	1.7[b]	768.3	99.9	NA	100.0	299.9	100.0

TABLE 9-18. TREE AND SHRUB DATA: Riparian Community at Confluence of Rilda Canyon Stream and Huntington Canyon Creek, September 14, 1982 (Cont.)

	DOMINANCE			COVER AND FRQUENCY		IMPORTANCE	
	Average Basal Area Per Tree ($in.^2$)	Basal Area Per Acre ($in.^2$)	Do Relative Dominance (%)	C Cover (%)	F Relative Frequency (%)	Importance Value (D+Do+F)	Relative Importance (%)
SHRUBS OVER ONE METER TALL						CxF Index[e]	
AMAL2	NA	NA	NA	3.4	11.1	37.7	17.9
AMUT				0	3.7	0	0
BEOC2				9.1	14.8	134.7	63.9
CELE3				0	7.4	0	0
CEMO2				0	3.7	0	0
CHNA2				0	11.1	0	0
COST4				0	3.7	0	0
RICE				0	3.7	0	0
ROWO				1.1	33.3	36.6	17.4
SALIX				0	3.7	0	0
SACA10				0.5	3.7	1.9	0.9
Totals	NA	NA	NA	14.1	99.9	210.9	100.1

[a] Basal area is not measured for shrubs; the column space is therefore used for height measurements.
[b] Numbers marked (b) are averages.
[c] Tree cover includes cover contributed by saplings.
[d] NA means "not applicable"; these data are not measured.
[e] The importance index (D+Do+F) cannot be used for shrubs, hence the cover x frequency test for importance is shown here.

Douglas fir saplings occur at a rate of 78 per acre compared to the 15 per acre of adult trees found. This suggests a mortality rate of about 84% for the young of this species.

Shrubs over one meter tall were measured for height and point-to-shrub distances were measured for estimating density. Eleven of the 23 shrub species in the community fell into this sample. The most abundant tall shrub was wild rose (Rosa woodsii) at 35 per acre. Its average height was 4.4 feet (1.34 meters). The second-ranked species was water birch (Betula occidentalis), listed with the trees in Table 9-17. This plant is shrublike when young but grows to tree size eventually. It has multiple stems and behaves as a shrub until the stems grow to trunk size and the tree tops out at over 25 or 30 feet in height. In the sample here shrub-sized water birch numbered 14 per acre. Mature tree-sized specimens did not fall into the sample. The average height of shrubby water birches was 13.7 feet (4.2 meters), the tallest shrubs observed. Serviceberry (Amelanchier alnifolia) and rubber rabbitbrush (Chrysothamnus nauseosus), at 6 per acre each, were third-ranked for abundance. Serviceberry shrubs averaged 5.7 feet (1.74 meters) in height and rabbitbrush height averaged 4.9 feet (1.49 meters).

Only four shrubs were abundant enough and large enough to receive a relative importance score. These were water birch (63.9% relative importance), serviceberry (17.9%), wild rose (17.4%), and elderberry (Sambucus caerulea) with 0.9% of the total relative abundance score. These plants only numbered 2 per acre in this community.

9.4 THREATENED AND ENDANGERED SPECIES

No threatened or endangered species were found in the vicinity of the West Appa Coal Company lease area or other nearby areas studied.

The nearest populations of any possibly sensitive species are in Huntington Canyon, Nine-Mile Canyon, and Horse Canyon. The species found in these areas is a variety of the northern sweetvetch, Hedysarum boreale var. canone. This species is currently being considered as a candidate for T&E listing. About 15 populations are known in the area. It grows on wet clay soils in semi-riparian areas in association with willows and other streamside vegetation. No specimens of this plant were found in the lease area or in the riparian areas nearby.

Three other possibly sensitive species exist within about 20 miles of the West Appa Coal Company permit area. All three are found in subalpine and alpine habitats at elevations from 9,000 to 11,000 feet on the Wasatch Plateau in the vicinity of Joes Valley and southward. All three grow on Flagstaff limestone substrate. These plants are the plateau catchfly (Silene petersonii var. petersonii), the heliotrope milkvetch (Astragalus montii), and the sedge fescue (Festuca dasyclada). The sedge fescue is not actually known as the original population upon which the presence record is based has not been relocated.

The West Appa lease area has some exposures of Flagstaff limestone at the extreme west end of Section 36 in the vicinity of the long narrow stand of limber pine forest shown on Plate 9-1 (Map Symbol CL). The elevation in this area is 10,000 feet, which matches the known elevation range of these three species.

It should be made clear, however, that this area is beyond all possibility of disturbance from mining activities at the West Appa Coal Mine. The mining operations area is at an elevation of about 7,500 to 7,600 feet at least 2 miles away in an entirely different watershed. Moreover, the Flagstaff limestone area up on the west end of the lease area has long been the site of a forest road, man-made catch basins for water, a major power transmission line, grazing allotments, and other forms of disturbance. No West Appa constructions except for an already-completed exploratory drilling pad are contemplated for this distant site. Even if these species were present, no possible mining activity could affect them.

9.5 EFFECTS OF MINING OPERATIONS ON VEGETATION

The total area to be permitted for mining activities is about 26 acres. The boundary of this permit area is shown on the vegetation maps (Plates 9-2 and 9-3). The areas of each vegetation type within the permit boundary are shown in Table 9-19. Of the total area of 26 acres, only about 60% or 15.1 acres will actually be disturbed during the construction and operation of the West Appa Coal Company mine. The remaining 40% will probably not be disturbed. For example, the large lower spring area, which will be protected during mining operations, is included within the proposed permit boundary because water rights from this source will be transferred to West Appa and the water will be used for various purposes in the mining operations area. When the 3.8-acre already-disturbed area (map symbol D) is removed from the 15.1-acre area of probable disturbance, it will be seen that only about 11.3 acres of existing vegetation inside the proposed permit boundary will actually be disturbed. This amounts to only about 43% of the total 26 acres. The 3.8-acre already-disturbed area consists of existing roads and shoulders, past construction sites (e.g. the old scale house foundation), the old coal pile, and waste talus from the old mine entrance access road. All of this unproductive area will be incorporated into the new mine surface facilities area, with concomitant reduction in new disturbance. It should be noted that when reclamation is carried out, the entire 15.1 acres will be revegetated rather than only the 11.3 acres of new disturbance. This represents 134% restoration of existing vegetation and constitutes a valuable mitigation measure.

TABLE 9-19

EXTENT OF EXISTING VEGETATION COMMUNITIES INSIDE PROPOSED BOUNDARY OF MINING OPERATIONS PERMIT AREA

Vegetation Type	Map Symbol	Approximate Area Inside Proposed Permit Boundary (Acres)	(%)	Approximate Area To Be Disturbed (Acres)	(% of Permit Area)
Aspen-Conifer	AC	4.9	18.8	3.4	13.1
Conifer	C	1.3	5.0	0.8	3.1
Conifer-Shrub	CS	4.3	16.5	0.5	1.9
Already Disturbed	D	3.8	14.6	3.8	14.6
Desert Shrub	DS	0.7	2.7	0.6	2.3
Grass	G	2.4	9.2	1.6	6.2
Grass-Shrub	GS	1.4	5.4	0.8	3.1
Mountain Shrub	MS	3.5	13.5	0.1	0.4
Riparian	R	3.7	14.2	3.5	13.5
TOTAL		26.0	99.9	15.1	58.2

The approximate areas of disturbance shown in Table 9-19 can be compared with the quantitative vegetation data shown in Tables 9-6, 9-7, 9-9, 9-10, 9-12, 9-13, 9-15, and 9-18. These tables show, among other things, the density (number of individuals per acre) of tree seedlings, trees, saplings, and shrubs and the productivity or standing biomass per acre for shrubs, grasses, and forbs. These data were all collected in four communities within the permit area and the tree data were also collected in a fifth community outside the permit area.

This comparison is provided in Tables 9-20 and 9-21. The number of woody plants to be disturbed is calculated for trees, saplings, and shrubs; and the understory productivity to be removed from the ecosystem because of mine construction is calculated for shrubs, grasses, and forbs.

The unmeasured communities shown in the tables amount to only 2.5 acres for tree data and to 6.0 acres for productivity data. These areas were not designated for quantitative sampling at the time of the DOGM (and other agencies) site visit, which was held prior to field data gathering to determine the extent of quantitative sampling needed. Some of these areas were not judged to require sampling because they were already highly disturbed, or they would not be disturbed, or they were too small in extent to be of concern.

Table 9-20 shows that a total of about 870 trees, 3,360 saplings, 1,500 tall shrubs (over 1.0 meter tall), and 47,000 small shrubs will be displaced by construction in 12.6 acres that were measured for woody plant density. Even larger numbers of individual smaller plants will be removed, but density counts for these are less meaningful than the biomass, or the weight of new growth per growing season, that is produced by such species. Table 9-21 shows a total of 3,326 pounds (oven-dry weight) of new vegetative growth that will be lost per growing season in 9.1 acres that were measured for this parameter (the already-disturbed area is included since its productivity is essentially zero). Interpolating this amount to the entire 15.1 acres, about 5,500 pounds per year will be lost from understory productivity. Of this amount, 58% will be shrub biomass, 36% will be grass, and 6% will be herbaceous forbs.

9.6 MITIGATION AND MANAGEMENT PLANS

Considerable research has been done in the field of reclamation, especially since the early 1970's when the desireability of reclaiming surface-mined lands became a national issue. Since then, regulatory agencies have developed requirements for the restoration of newly-disturbed lands to their approximate pre-mining conditions, and they have also extended the requirement to many previously disturbed areas.

TABLE 9-20. ESTIMATED EFFECTS OF MINING ON TREES, SAPLINGS, AND SHRUBS.

PLANT COMMUNITY		TREE SEEDLINGS		TREES		SAPLINGS		TALL SHRUBS		UNDERSTORY SHRUBS	
Name and Map Symbol	Area to be Disturbed (Acres)	Existing (no./acre)	Total no. affected	Existing (no./acre)	Total no. affected	Existing (no./acre)	Total no. affected	Existing (no./acre)	Total no. affected	Existing (no./acre)	Total no. affected
Aspen-Conifer (AC)	3.4	2,496	8,486	113	384	432	1,469	231	785	7,216 110,416[a]	24,534 375,414[a]
Conifer-Shrub (CS)	0.5	1,781	891	128	64	684	342	764	382	12,870 24,120[a]	6,435 12,060[a]
Grass-Shrub (GS)	0.8	0	0	0	0	0	0	73	58	10,927	8,742
Grass (G)	0.6	0	0	0	0	0	0	0	0	12,304	7,382
Riparian (R)	3.5	NA[b]	NA	120	420	443	1,551	79	277	NA	NA
Already Disturbed (D)	3.8	0	0	0	0	0	0	0	0	0	0
TOTALS	12.6		9,377		868		3,362		1,502		47,093
Unmeasured Communities[c]	2.5										387,474[a]
	15.1										

[a] Data for Oregon Grape (Berberis repens) are shown separately. This small shrub is a woody plant of the forest floor that is present in large numbers (2 or 3 per square foot) but which seldom grows more than a few inches tall and therefore is not very shrublike in appearance or in its role in the habitat. Typical shrubs are best represented by the smaller numbers shown.

[b] NA means "not available." These data were not collected in this community.

[c] Conifer (C), 0.8 acres; Desert Shrub (DS), 0.6 acres; Mountain Shrub (MS), 0.1 acre; and additional Grass, 1.0 acre.

TABLE 9-21. ESTIMATED EFFECTS OF MINING ON UNDERSTORY PRODUCTIVITY[a]

PLANT COMMUNITY		SHRUBS		GRASSES		FORBS		TOTAL	
Name and Map Symbol	Area to be Disturbed (Acres)	Existing (lb./acre)	Amount removed (pounds)	Existing (lb./acre)	Amount removed (pounds)	Existing (lb./acre)	Amount removed (pounds)	Existing (lb./acre)	Amount removed (pounds)
Aspen-Conifer (AC)	3.4	428	1,455	75	255	33	112	536	1,822
Conifer-Shrub (CS)	0.5	336	168	161	81	14	7	511	256
Grass-Shrub (GS)	0.8	271	217	631	505	35	28	937	750
Grass (G)	0.6	162	97	606	364	61	37	829	498
Already Disturbed (D)	3.8	0	0	0	0	0	0	0	0
TOTALS	9.1		1,937		1,205		184		3,326
Unmeasured Communities[b]	6.0								
	15.1								

[a] Weights in body of table are oven-dry weights of standing biomass from the current year's growth as measured in mid-September, 1982.

[b] Conifer (C), 0.8 acres; Desert Shrub (DS), 0.6 acres; additional Grass (G), 1.0 acre; Mountain Shrub (MS), 0.1 acre; and Riparian (R), 3.5 acres.

The reclmation problems encountered are unique to each region and type of surface disturbance. Acceptable and environmentally sound reclamation depends on quality research and on the application of the best current practices in each situation requiring reclamation. In the arid West, the amount of reclamation research work has not been as extensive as in some other areas, nor has it been able to provide solutions to all the problems that exist. Nevertheless, an impressive reclamation literature exists, and qualified consultants and companies also exist who can provide a complete array of reclamation services.

By the time reclamation will be carried out at the West Appa Coal Company mine in Rilda Canyon, any specific details that could be proposed now will be replaced by superior practices. A final reclamation plan will have to be formulated a few years before the closing of the mine. Adequate lead time is important because many reclamation materials and services are available only on many months advance notice; bare root stock, container-grown plants, and native seeds supplies being examples. Moreover, the necessity for demonstrating the success of planting methods and the ability to successfully grow plants in stockpiled soil should be demonstrated in advance of full-scale reclamation effforts. This is normally done by establishing a study plot, or plots, that will be planted, managed, and monitored for a period of two or three years prior to doing full-scale reclamation. A field trial study with replicated plots and the capability of detecting plant responses among several variable environmental factors is important to the success of the reclamation work. Such a study will be outlined below as part of the reclamation strategy being proposed here.

Whoever actually carries out the reclamation work, whether it be West Appa personnel, a consultant, or a contractor, will conduct a literature review of current practices. At the present time many references exist that would provide good background. For example, a recent bibliography (Daniels, et al, 1981) identifies many references on arid land reclamation methodology. Earlier reclamation symposia, reviews, and bibliographies have been published by the U.S. Department of Interior (USDI) Office of Surface Mining (1981), USDI Fish and Wildlife Service (1978), Goodman and Bray (1975), Bituminous Coal Research, Inc. (1975), Johnson and Van Cleve (1974), Dalested and Leistritz (1974), Gifford, et al (1972), Frawley (1971), and Bowden (1961). The purpose of this literature review would be to compile information on state-of-the-art plant establishment techniques in order that the best and most cost-effective methods could be used. The most recent and best discussion on current revegetation methods at this writing is the excellent Symposium on Reclamation Planting of Disturbed Sites (Dennis Hansen and colleagues at Native Plants, Inc., 1982).

The construction of the surface facilities for the West Appa Coal Company will result in the disturbance of about 15 acres of vegetation, as has been shown. Within this area of disturbance, about 10 or 11 acres of soil resources will also be disturbed to allow for recontouring and construction. Some 19,200 cubic yards of topsoil and subsoil will be stockpiled for later reclamation purposes. Since the already-disturbed roads, coal pile, and former construction sites will not contribute any useful topsoil to this stockpile, but they will be reclaimed later, additional soil will have to be brought in. Actual measurement will have to be made to determine a more accurate figure. The alternative would be to demonstrate that revegetation could be successful on this area without topsoil addition.

The stockpiled soil will be tested for its ability to sustain plant growth by doing a test plot study well in advance of reclamation time. This study will be done at a location near the stockpile where test soil can readily be obtained. Replicated plots (2 per variable being tested) will be established within the test area and these will be planted with appropriate seed and young plant mixtures. The plots will be divided into two groups before planting. One will consist of untreated soils exactly as taken from the stockpile. This will be the control group. The second group will consist of soils that have been treated with fertilizer. The type and rate of application of fertilizer will be determined from a suitable soil fertility test to be done by a qualified soils laboratory such as the one at Utah State University in Logan, Utah.

Within the two groups of soils, other variables will be tested. For example, it will be important to know whether a mulch will be required, and if so what kind is best. Therefore, three mulch tests will be superimposed upon the two soil fertility tests. These tests will consist of no mulch, a hydromulch at a rate of about 0.4 pounds per square meter (0.8 ton/acre), and hay or straw mulch at a rate of about 1 pound per square meter (2 tons/acre).

Seeds of native and suitable introduced plant species are fairly expensive. The rate of application required for successful revegetation should be tested. The same is true for any live plants to be set out. Therefore at least two rates of seed application will be tested, a low or medium rate (15 to 20 pounds per acre, all species combined) and a high rate (25 pounds per acre). An interesting control experiment will be to plant no seeds at all in some plots. Native plants and especially adventive weeds will seed themselves wherever space is available. The unplanted plots will provide a control by which the relative proportions of planted versus self-established plants can be estimated.

With two soils (fertilized and control), three mulches (none, hydromulch, and hay) three planting rates (none, light, and heavy), and two replicates of each plot, 36 total test plots would be required.

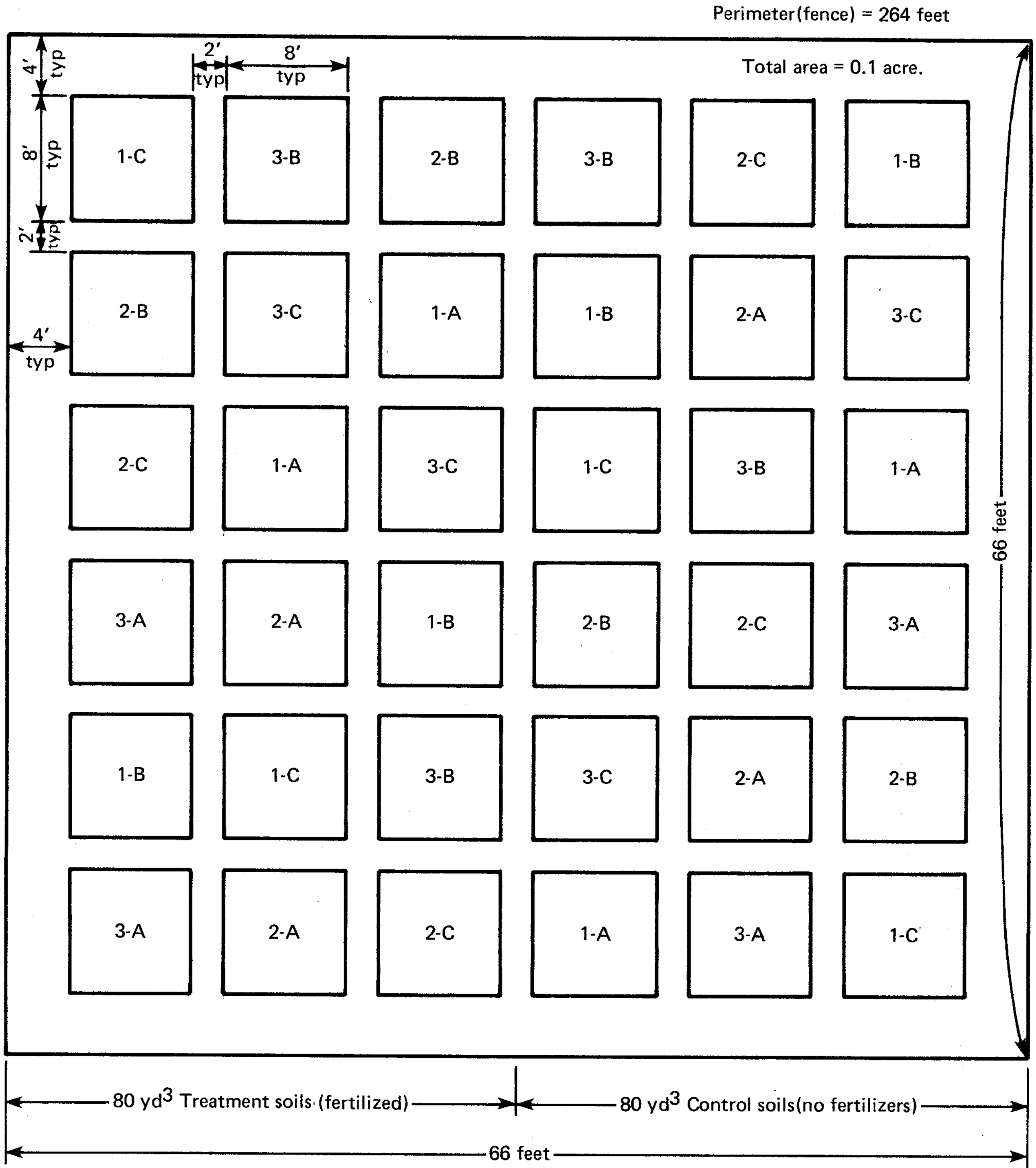
These 36 test plots can be established in an area of about 0.1 acre if each is about 8 feet square. At 10 x 10 feet each, about 0.15 acres would be required. The size is not critical within limits.

The existing soil in the 0.1-acre study area would have to be tilled or bladed to remove vegetation and provide a good surface to receive a layer of stockpile soil. This soil would be applied to a depth marked by stakes similar to the intended reclamation rate of application. If desired, subsoil and topsoil layers can both be so applied. Assuming a total depth of 1 foot for the stockpile soils, the 0.1-acre study area will require about 160 cubic yards of soil. When smoothed, one-half the area will be treated with fertilizer and the study plots will be laid out. Each half will contain 18 plots with three mulch and three seed-rate treatments in a randomized design. The plots themselves will be marked with stakes and they will be separated from neighboring plots by about two-foot-wide pathways.

This experimental design is pictured in Figure 9-1. The study area would be fenced if necessary with a 3 or 4 foot high loose-mesh (hog wire) fence on metal stakes for protection against trespass but not to exclude wildlife. The plots would be marked at their corners with rebar stakes (144 required) and identified with aluminum tags. Planting would be done according to a schedule similar to that to be used for reclamation, probably in the autumn. Seeds and bare-root stock or container-grown plants would have to be ordered months in advance, perhaps even the previous summer to ensure obtaining what was desired. The soil and test plots would have to be prepared well in advance of delivery.

About 51 shrubs per plot would have to be planted as bare-root or container-grown plants (1,830 in all) to achieve the average density of the existing vegetation (see Table 9-20 and others). Excess numbers should be planted. Fully 90% of them should be Oregon grape (Berberis repens). The remainder should be of several species including mountain mahogany (Cercocarpus montanus and C. ledifolius), serviceberry (Amelanchier alnifolia and A. utahensis), smooth maple (Acer glabrum), wild rose (Rosa woodsii), snowberry (Symphoricarpos oreophilus), and others. The named species are presently the most abundant in the existing vegetation.

Similarly, seeds of grasses and forbs would have to be obtained. The most abundant species in the existing vegetation of the four



Mulch Variables

1. No mulch
2. Hydromulch (0.8 ton/acre)
3. Hay (2.0 ton/acre)

Seed Rate Variables

A. No seeds
B. Low (15 lb/acre)
C. High (25 lb/acre)

Figure 9-1. Design of a 3-variable (soil, mulch, seed) doubly replicated revegetation study area.

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baseline-sampled communities (see Tables 9-7, 9-10, 9-13, 9-15) are, among the grasses: fringed brome (Bromus ciliatus), Kentucky bluegrass (Poa pratensis), Columbia needlegrass (Stipa columbiana), slender wheatgrass (Agropyron trachycaulum), orchard grass (Dactylis glomerata), and ravine fescue (Festuca sororia). Among the forbs, the most abundant species are weeds (poverty weed and houndstongue, for example). But others more desirable include longstalk starwort (Stellaria longipes), Englemann aster (Aster englemannii), Wyoming painted cup (Castilleja ligusticifolia), rockcress (Arabis pendulina), rubberweed (Hymenoxys richardsonii), bedstraw (Galium boreale), and Richardson geranium (Geranium richardsonii). Many other desirable species could and should be used as well.

The test plots, once prepared and planted, will have to be monitored by standard ecological sampling techniques. Two or three one-meter-square quadrats will be located randomly within each study plot. Seedling emergence density and seedling survival density would be measured the first year. During the second year, percent cover measurements would be added, and in the third year aboveground biomass data would be added to the observations. To assess seed-rate success, seeds of each species will have to be counted to determine the number per pound before planting. The results would be analyzed each year using an ANOVA (Analysis of Variance) program in which the sources of variation would be substrate, seeding, mulch, substrate x seeding, substrate x mulch, seeding x mulch, substrate x seeding x mulch, and error. A statistical significance level of 0.05 (95% confidence level) will be used for discrimination between treatments.

The results of the study plot analysis will help determine the course of actual revegetation work. It is expected that fertilizer and mulch treatments will be found beneficial. It is also expected that higher seed rates will yield higher germination, survival, cover, and biomass among desirable species and that adventive and ruderal species will be reduced. Much will be learned about seedbed preparation, mulching techniques, fertilization, soil sampling, species selection, scheduling, monitoring, and plant growth. These experiences will provide a good basis for the management of the full-scale reclamation.

The cost for such a test plot study will be high, perhaps in excess of $100,000. The experience gained from it could well save that much on the full-scale reclamation.

9.7 REVEGETATION METHODS AND JUSTIFICATIONS

Revegetation will proceed after the mining buildings and other equipment have been removed, the mine entrances sealed, and the

the operations area has been recontoured and the stockpiled topsoil redistributed.

Seeds of grass and forbs will be drilled in using a conventional grassland drill equipped with depth bands and a seed box with agitator. Where slopes are too steep, hand broadcast methods or hydroseeding will be used. Two passes of the drill will yield a good seedbed distribution. Live plants, either bare-root stock or container-grown, will then be planted by hand. This team will be able to place about 600 container-grown plants per hour, more or less, depending on the conditions at the site. Each planting hole will receive a slow-release fertilizer tablet in the bottom of the hole before the plant stem is placed. The plants will be transported from a suitable holding area, where temperature and moisture are held optimum, to the work site by pickup truck. These plants will be of shrub and tree species.

The rates per acre will vary per species. Small shrubs may be placed at a rate of 5,000 to 40,000 per acre (3 feet apart to 1 foot apart). Larger shrubs will be placed at rates of about 1,000 to 3,000 per acre (6 feet to 4 feet apart). Trees will be placed at a rate of about 400 to 700 per acre (10 to 7 feet apart). All of these rates are higher than for mature plant spacing, except for the small shrubs like Oregon grape. But mortality rates will be high too, and these rates will be appropriate for the first planting. Monitoring of the site during the following months will yield information on success rates. If indicated by monitoring data, a second planting may be ordered. This will likely be a smaller effort, with localized areas receiving the most attention.

9.8 REVEGETATION MONITORING

The 15-acre revegetation project will be observed periodically to assess plant response to the site. The condition of the soil will also be examined. For example, any newly-developed gullies or other erosion can be detected and corrected. Survival or mortality counts of the transplanted shoots will be made. When dead plants are found, they will be dug up and examined for cause of death. Such things as moisture stress, insect damage, frost or wind, trampling, or other problems can be recognized and corrective measures implemented. Survival rates of 80% or more are probably possible.

When the plantings have been established, during or after the second year following reclamation work, an ecological study will be undertaken to measure cover, frequency, density, productivity, and the other variables that can be measured in the field. The approach will be similar to that used for gathering the baseline data shown in the early sections of this chapter. The results of the two studies will be compared. The purpose will be to meet the tests for release of bond. If the test falls short of desired results, recommendations for supplemental planting or other management practices will be made, and the test will be repeated the following year.

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CHAPTER X

FISH AND WILDLIFE RESOURCES

Prepared for
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April, 1983

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CHAPTER 10

FISH AND WILDLIFE RESOURCES

10.1 SCOPE

The proposed West Appa mine in Rilda Canyon would result in placement of mine-mouth facilities in the bottom of this steep canyon and the improvement of an existing road from State Route 31 to the facilities. Because of the steepness of the terrain, biological impacts can reasonably be expected to be confined to the Canyon bottom where approximately 10 acres of wildlife habitat will be replaced by facilities. Adjacent areas (including along approximately 2 miles of haul road) will be impacted, to a lesser extent, by encroachment.

Although Rilda Canyon is only lightly used at present, coal mining has sporadically occurred in the canyon during most of this century. The site of West Appa's mine is the exact location of the Helco Mine, last operated in the 1960s. As a result of that activity, the area proposed for surface facilities shows various degrees of disturbance.

The major environmental concern associated with the Rilda Canyon Mine development is its the potential effect on several developed springs, immediately on, and adjacent to, the mine site. The springs are discussed in detail in other sections of this permit application as they pertain to human use, but they also have significant biological value. They are the source of virtually all the perennial flow in Rilda Canyon, and as such, have value for wildlife and as a source of Huntington Creek water.

Other environmental concerns addressed in this section include general habitat losses, impacts on raptors and the use of the canyon by wintering big game. Prior studies in the canyon, plus expertise of local wildlife agency personnel, suggested that these impacts would be minor, but, nevertheless, they have been investigated.

This chapter is intended to address three topics: 1) present biological conditions in the proposed project area; 2) probable impacts should the project be implemented; and 3) suggested means of mitigating the impacts. Wherever possible, existing data sources have been utilized. These have been supplemented by special field studies. The levels of effort have been determined after consultations with the U.S. Forest Service, U.S. Fish and Wildlife Service, Utah Division of Wildlife Resources and Utah Division of Oil, Gas and Mining. No official consultation process exists for wildlife since UMC 783.20 has been remanded.

10.2 METHODOLOGY

Because it was the concensus of the consulted wildlife agencies that the potential for major impacts to wildlife was limited, few field studies were deemed necessary. Instead, literature sources such as Vertebrate Species of Southeastern Utah (Dalton et al., 1978) were extensively used. Also, the botanical studies elucidated habitat types in the project area. These descriptions were used to predict the wildlife species likely to be affected by the project.

The descriptive portion of this section is organized along the lines of the investigations. First, there is a discussion of wildlife by habitat type. Second, we provide a list of potential inhabitants based on Dalton et al. (1978), and finally special studies are discussed.

A special study was conducted to determine whether raptors are nesting near the project site. On 26 November 1982, FB&D, Inc. personnel conducted a foot search of Rilda Canyon from the forks of Rilda to Huntington Creek, looking for raptor nests. More distant locations within sight of the proposed facilities were examined using a Bushnell spotting scope equipped with a 22X objective. All stick nests located during the survey were photographed using a 400mm lens and their location was mapped on a USGS topographic map (refer to Plate 10-1).

A spring raptor nesting survey will be conducted in 1983. This will help determine if any of the observed stick nests are active and whether any nest sites were missed. An addendum will be added to this application describing the results of the raptor nesting survey.

Although the creek in Rilda Canyon supports no fish, it does have a diverse macroinvertebrate population. These organisms and the contribution of water, make the creek important for fish in Huntington Creek. Because of this, the U.S. Forest Service requested that a quantitative assessment be made of the macroinvertebrates. FB&D, Inc. enlisted in aid of Dr. James Van Gundy to conduct this study. His choice of sampling stations and techniques follow. The location of the sampling stations is found in Figure 10-1.

Station No. 1 was located approximately 0.25 mile above the upper North Emery Water Users spring.

Station No. 2 lies directly below (downstream) from the lowest North Emery Water Users spring.

Station No. 3 was located approximately 100 feet above the V-notch weir at the lower end of Rilda Creek.

A modified Surber Sampler was used to collect square foot samples, which were pooled. All loose rocks and the solid creek bottom were scrubbed by boot and hand to dislodge macroinvertebrates. Because of the general scarcity of microhabitat all suitable habitat within the sample area was sampled. The samples were removed from the sampler and, with only minor sorting to remove large leaves and pebbles, were preserved, detritus and all, in 80 percent ethyl alcohol for sorting in the laboratory.

Once existing conditions in the project area are established, probable impacts to the biotic community will be addressed on an impact-by-impact basis. The impacts will be subdivided into short-term construction-related impacts and long-term losses (including habitat destruction and operating impacts). Finally, a detailed mitigation plan will be offered. In some instances, mitigations will be generic (e.g. revegetation) and in some, specific (e.g. berms around north spring).

10.3 EXISTING FISH AND WILDLIFE RESOURCES

Rilda Canyon has received comparatively little impact by man. Several mines that operated on a small scale shut down by the 1950s, and since that time, human use has been sporadic. There is a wide variety of vegetation communities in the Canyon, resulting in extensive edge development. In short, Rilda Canyon is a biologically productive area. Of special note in the canyon is: (1) the riparian strip along the creek; (2) the north-south facing canyon slopes producing a mosaic of montane habitats (aspen, conifer, mountain shrub, etc.) on the north-facing slope; (3) a desert type habitat (pinyon-juniper) on the south-facing slope; (4) and the extensive cliffs in the Canyon. The above habitats are conducive to the existence of big game populations, grouse, raptors and fur bearers, as well as a generally diverse wildlife population.

A table of wildlife likely to occur in Rilda Canyon has been prepared and will be referred to throughout the rest of this chapter. The primary source of information for this table was derived from Dalton et al. (1978), supplemented by other texts (Bebler and King, 1979; Peterson, 1941; Woodbury, 1931). An attempt has been made to identify those habitats occurring within the leasehold where each species of wildlife is most likely to be found. For many mobile species, however, boundaries between habitats mean little, and they may be found almost anywhere. This table is found in Section 10.3.2.

10.3.1 Wildlife Habitats of the Mine Plan Area

The wildlife habitats in this study have been keyed to the vegetation communities. Five major communities occur in the mine plan area. These are:

1) Mixed Aspen-Conifer 4.9 acres
2) Conifer-Shrub 4.3 acres
3) Disturbed 3.8 acres
4) Mountain Shrub 3.5 acres
5) Riparian 3.7 acres

These make up 20.2 acres of the 26 acres in the proposed permit area. Although all except the disturbed habitat have important wildlife values, the riparian and mountain shrub habitats can be singled out as the most important. The riparian habitat provides food, cover and nesting/breeding areas for a wide variety of wildlife. This narrow band of dense vegetation along the creek forms a continuous pathway for wildlife movements. The mountain shrub habitat is important as browse for big game and also harbors many smaller species.

One other habitat is important in the area. This is the creek itself. No fish occupy the creek, but furbearers live in it and it supplies a water source for large and small wildlife.

The mine plan area, itself, has very little cliff and rubble habitat; although it is common in the area, especially on the south-facing slopes of Rilda Canyon. Because of this, and the general lack of snags and large lone trees, the probability of raptor nests is reasonably low.

10.3.2 Wildlife

10.3.2.1 Aquatic Wildlife and Habitat and Value Determination

The creek in Rilda Canyon flows perennially from the springs in the project area to the confluence with Huntington Creek. The average flow at the mouth is approximately 3-6 cfs. There are no fish inhabiting the creek upstream from its mouth, but there is a diverse macroinvertebrate population. Table 10-1 shows the results of the October macroinvertebrate sampling in the Rilda Canyon creek. A spring sampling will take place in 1983 and be reported as an addendum to this report. A synopsis of conditions encountered at each sampling station appears below.

Station No. 1 - This station was frozen solid in the autumn sampling period and no free-flowing water was present; however, it is probable that some hyporheic organisms still remained.

Station No. 2 - The flow here was found to be approximately 1 cfs. A modified Surber Sampler was used to collect 3 square feet of substrate. No more suitable substrate was found at this location.

Station No. 3 - The flow at this point was about 2 cfs. The substrate here was cemented by marl; hence, macroinvertebrate habitat was limited. The sample consisted of 4 square feet of rock and moss clumps.

Table 10-1 Macroinvertebrates collected in Rilda Canyon creek, Emery County, Utah, 12 October 1982.

	TAXON	NUMBER COLLECTED
Station 1	None collected, creek dry	
Station 2 (3 ft^2)	TURBELLARIA:TRICLADIDA	
	Polycelis sp.	167
	GASTROPODA:	
	Gyraulis sp.	1
	Torquis sp.	1
	OLIGOCHAETA	
	Oligochaeta (unidentified)	9
	INSECTA:TRICHOPTERA	
	Psychoronia sp.	7
	Parapsyche elsis	42
	Rhyacophila sp.	75
	INSECTA:EPHEMEROPTERA	
	*Baetis tricaudatis**	63
	Cinygmula sp.	131
	Ephemerella sp.	2
	INSECTA:PLECOPTERA	
	Megarcys signata	3
	Zapada cinctipes	14
	Taenionema sp.	29
	Doddsia occidentalis	2
	INSECTA:COLEOPTERA	
	Heterlimnius sp. (adults)	52
	Heterlimnius sp. (larvae)	3
	Helichus sp.	1
	Stenelmis sp.	1
	Scirtes sp. (?)	1
	INSECTA:DIPTERA	
	Tipula sp.A	5
	Tipula sp.B	2
	Tipula sp.C	1
	Simulium sp.	2
	Liriope sp.	2
	Euparyphus sp.	1
	Polymera sp.	1

Table 10-1 Macroinvertebrates collected in Rilda Canyon creek, Emery County, Utah, 12 October 1982 (cont.)

	TAXON	NUMBER COLLECTED
	Dicranota sp.	1
	Johannesenomyia sp.	2
	Chironomid A	10
	Chironomid B	4
	Chironomid C	1
	Chironomid D	1
	Chironomid E	1
	TOTAL SPECIES = 33	TOTAL INDIVIDUALS = 638
Station 3 (4 ft^2)	TURBELLARIA:TRICLADIDA	
	Polycelis sp.	23
	INSECTA:TRICHOPTERA	
	Parapsyche elsis	11
	Symphitopsyche osleri	3
	Rhyacophila sp.	39
	Hydropsyche sp. (very small)	33
	INSECTA:EPHEMEROPTERA	
	Paraleptophlebia vacina (?)	1
	*Baetis tricaudatis**	338
	INSECTA:PLECOPTERA	
	Zapada cinctipes	18
	Taenionema sp.	2
	Alloperla sp.	9
	INSECTA:DIPTERA	
	Tipula sp. A	2
	Tipula sp. B	1
	Polymera sp.	1
	Pericoma sp.	9
	Simulium sp.	5
	Dicranota sp.	1
	Chironomid A	5
	Chironomid B	1
	Chironomid C	4
	Chironomid D	6
	Chironomid E	6
	Chironomid F	1
	Chironomid G	1
	Chironomid H	21
	TOTAL SPECIES = 24	TOTAL INDIVIDUALS = 542

Table 10-1 Macroinvertebrates collected in Rilda Canyon creek, Emery County, Utah, 12 October 1982 (cont.)

TAXON	NUMBER COLLECTED

(*) Some very small individuals of Baetis key-out as B. bicaudatis, but are probably very immature specimens of B. tricaudatis as well. These specimens are tallied with B. tricaudatis.

The results of the sampling reveal a limited potential for macroinvertebrate productivity in the creek because of the cemented marl-like bottom. The high diversity belies the low biomass in the creek.

10.3.2.2 Terrestrial Wildlife and Habitat and Value Determination

The following Table (10-2) lists all species of vertebrate wildlife likely to be encountered in Rilda Canyon if an exhaustive 5-year survey were undertaken for each major group (i.e., mammals, birds, reptiles and amphibians). By tallying the number of species likely to be found in each delineated habitat, a general idea of each habitat's value, compared to the others, can be gleaned. Of course, a true rating of habitat value based on this approach would not be possible without a long list of caveats. For example, even though a large number of species occurs in pinyon-juniper, the sheer abundance of this habitat type decreases its value for preservation of relatively small areas. However, one habitat type distinguishes itself as singularly important. Riparian habitat is scarce throughout Utah, yet in Rilda Canyon, 59 percent (105 of 178) of all probable species occurs in riparian habitat. All other habitats hold important wildlife values, but none so important as riparian. A synopsis of number of species per habitat appears below.

Riparian	105
Pinyon-Juniper	68
Mixed Aspen-Conifer	61
Aspen Forest	42
Meadows	47
Cliff	14
Mountain-Grassland-Shrub	67
Conifer-Shrub	75
Mountain Conifer	61
Mixed Mountain Shrub	56
Grassland Spring	32

The large number of species for each habitat compared to a total of 178 species indicates most species occupy more than one habitat type.

10.3.2.3 Mammals

The Rilda Canyon area is relatively rich in mammal species; there are 49 species possibly making use of the Canyon during some part of the year. Many of these species are game or furbearers, which will be discussed in Section 10.3.3, but a large number of the species are also small mammals whose major interest to wildlife biologists is as a prey base for the carnivores that exist in the Canyon. The disturbance caused by the mine construction will be translated directly to loss of the prey base to predators such as raptors and carnivorous mammals

Table 10-2. Wildlife List For Those Species That May Occur On The West Appa Leasehold At Least Once in Five Years.

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
I. MAMMALS												
Masked Shrew <u>Sorex cinereus</u>	RO				RO						RO	
Merriam Shrew <u>Sorex merriami</u>		RO			RO		RO					
Dusky Shrew <u>Sorex obscurus</u>	RO										RO	
Little Brown Myotis (NA) <u>Myotis lucifugus</u>												
Fringed Myotis (NA) <u>Myotis thysanodes</u>												
California Myotis (NA) <u>Myotis californicus</u>												

Legend for two-letter status description:

First Letter: R = Resident S = Seasonal (NA) = Habitat types not applicable because the species only occur in the air

Second Letter:
A = Abundant: a common species, very numerous
C = Common; certain to be seen or heard in suitable habitat
U = Uncommon; present, but not certain to be seen
O = Occasional; seen only a few times per year
R = Rare; seen at intervals, 2-5 years

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Small-footed Myotis (NA) *Myotis leibii*												
Silver-haired Bat (NA) *Lasionycteris noctivagans*												
Big Brown Bat (NA) *Eptesicus fuscus*												
Hoary Bat (NA) *Lasiurus cinereus*												
Townsend's Big-eared Bat (NA) *Plecotus townsendii*												
Brazilian Free-tailed Bat (NA) *Tadarida brasiliensis*												
Nuttall's Cottontail *Sylvilagus nuttallii*	RC	RC	RC	RC		RC			RC			
Desert Cottontail *Sylvilagus audubonii*		RC			RC		RC	RC		RC		
Snowshoe Hare *Lepus americanus*	RC		RC	RC				RC	RC			

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
White-tailed Jackrabbit *Lepus townsendii*		RC			RC		RC	RC			RC	
Black-tailed Jackrabbit *Lepus californicus*		RA			RA		RA	RA			RA	
Least Chipmunk *Eutamias minimus*		RC	RC				RC	RC		RC		
Cliff Chipmunk *Eutamias dorsalis*	RU	RU				RU						
Uinta Chipmunk *Eutamias umbrinus*						RC	RC	RC	RC	RC		
Yellow-bellied Marmot *Marmota flaviventris*					RC		RC					
Uinta Ground Squirrel *Spermophilus armatus*					RA		RA				RA	
Golden-manteled Ground Squirrel *Spermophilus lateralis*			RA		RA		RA	RA		RA		

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Rock Squirrel *Spermophilus variegatus*	RC	RC				RC	RC					
Red Squirrel *Tamiasciurus hudsonicus*			RC					RC	RC			
Northern Flying Squirrel *Glaucomys sabrinus*			RC						RC			
Northern Pocket Gopher *Thomomys talpoides*					RC		RC	RC				
Great Basin Pocket Mouse *Perognathus parvus*		RC										
Western Harvest Mouse *Reithrodontomys megalotis*					RC						RC	
Pinyon Mouse *Peromyscus truei*		RC										
Desert Woodrat *Neotoma lepida*		RC										

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Bushy-tailed Woodrat *Neotoma cinerea*						RC	RC			RC		
Porcupine *Erithizon dorsatum*	RC	RC	RU					RC	RC	RC		
Coyote *Canis latrans*	RC	RC	RC	RC	RC		RC		RC	RC		
Red Fox *Vulpes fulva*	RC	RC	RC	RC	RC		RC	RC	RC	RC		
Gray Fox *Urocyon cinereoargenteus*	RC	RC			RC		RC	RC		RC		
Black Bear *Ursus americanus*	RR		RR	RR			RR	RR	RR	RR		
Ringtail *Bassariscus astutus*	RC		RC	RC				RC		RC		
Raccoon *Procyon lotor*	RO										RO	

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Marten Martes americana			RO	RO				RO	RO			
Ermine Mustela erminea	RR											
Long-tailed Weasel Mustela frenata	RU										RU	
Badger Taxidea taxus		RC			RC		RC					
Striped Skunk Mephitis mephitis	RC	RC			RC		RC	RC		RC	RC	
Mountain Lion Felis concolor	RU	RU	RU	RU	RU		RU	RU	RU	RU		X
Bobcat Lynx rufus	RU	RU	RU	RU	RU		RU	RU	RU	RU		X
Wapiti or Elk Cervus elaphus			RC	RC	RC		RC	RC	RC	RC		X
Mule Deer Odocoileus hemionus	RA	RA	RA	RA	RA		RA	RA		RC		X

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Moose <u>Alces alces</u>	RR		RR	RR							RR	X
II. BIRDS												
Turkey Vulture <u>Cathartes aura</u>		RC				RC						
Goshawk <u>Accipiter gentilis</u>			RO	RO					RO			
Sharp-shinned Hawk <u>Accipiter striatus</u>	RU	RU	RU	RU			RU	RU	RU	RU		
Cooper's Hawk <u>Accipiter cooperii</u>	RU	RU	RU				RU	RU	RU	RU		
Red-tailed Hawk <u>Buteo jamaicens</u>	RC	RC	RC	RC		RC	RC	RC	RC	RC		
Swainson's Hawk <u>Buteo swainsoni</u>		SO					SO	SO		SO		
Rough-legged Hawk <u>Buteo lagopus</u>	SC	SC			SC		SC	SC		SC		
Golden Eagle <u>Aquila chrysaetos</u>		RC				RC		RC		RC		

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Bald Eagle *Haliaeetas leucocephalus*	SO	SO				SO	SO	SO				X
Prairie Falcon *Falco mexicanus*	RO	RO			RO	RO	RO					X
Peregrine Falcon *Falco peregrinus*					RR	RR					RR	X
Merlin *Falco columbarius*		SO			SO		SO					X
American Kestrel *Falco sparverius*	RC	RC					RC	RC		RC		
Blue Grouse *Dendragapus obscurus*			RU	RU				RU	RU	RU		X
Ruffed Grouse *Bonasa umbellus*	RU		RU	RU				RU	RU			X
Chukar *Alectoris chuckar*		RU										X
Band-tailed pegeon *Columba fasciata*	RU		RU					RU	RU	RU		X

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
House Finch *Carpodacus mexicanus*	RA				RA		RA			RA	RA	
Pine Grosbeak *Pinicola enucleator*	RU		RU					RU	RU			
Rosey Finch *Leucosticte arcata*	RC				RC		RC					
Pine Siskin *Spinus pinus*			RC					RC	RC			
American Goldfinch *Spinus tristis*	RC											
Lesser Goldfinch *Spinus psaltria*	RC						RC			RC		
Red Crossbill *Loxia curvirostra*								SU	SU			
Green-tailed Towhee *Chlorura chlorura*		SC					SC	SC		SC		
Rufous-sided Towhee *Pipilo erythrophthalmus*	RC						RC	RC		RC		

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Mourning Dove *Zenaidura macroura*	SA	SA					SA	SA		SA		X
Yellow-billed Cuckoo *Coccyzus americanus*	SR											
Screech Owl *Otus asio*	RR											
Flammulated Owl *Otus flammeolus*			SR					SR	SR	SR		
Great Horned Owl *Bubo virginianus*	RC		RC	RC				RC	RC	RC		
Pygmy Owl *Glaucidium gnoma*	RR	RO	RO	RO				RO	RO			
Spotted Owl *Strix occidentalis*	RR								RR			X
Long-eared Owl *Asio otus*	RO	RO										
Short-eared Owl *Asio flammeus*				RO			RO				RO	

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Saw-whet Owl <u>Aegolius</u> <u>acadicus</u>	RO		RO	RO				RO	RO			
Poor-will <u>Phalaenoptilus</u> <u>nuttallii</u>	SU											
Common Nighthawk <u>Chordeiles</u> <u>minor</u>		SC			SC		SC				SC	
Black Swift <u>Cypseloides</u> <u>niger</u>		SU			SU		SU				SU	
White-throated Swift <u>Aeronautes</u> <u>saxatalis</u>		SC			SC		SC	SC		SC	SC	
Black-chinned Hummingbird <u>Archilochus</u> <u>alexandri</u>	SC	SC					SC	SC		SC		
Broadtailed Hummingbird <u>Selasphorus</u> <u>platycercus</u>	SC	SC	SC		SC		SC	SC		SC	SC	
Rufous Hummingbird <u>Selasphorus</u> <u>rufus</u>			SC	SC	SC		SC	SC	SC	SC		
Calliope Hummingbird <u>Stellula</u> <u>callipe</u>			SC	SC	SC		SC	SC	SC	SC		

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Belted Kingfisher <u>Megaceryle</u> <u>alcyon</u>	RO											X
Common Flicker <u>Colaptes</u> <u>cafer</u>	RA	RA					RA			RA		
Yellow-bellied Sapsucker <u>Sphyrapicus</u> <u>varius</u>	RC		RC	RC				RC	RC			
Williamson's Sapsucker <u>Sphyrapicus</u> <u>thyroideus</u>			SU					SU	SU			
Hairy Woodpecker <u>Dendrocopos</u> <u>villosus</u>	RC		RC	RC				RC	RC			
Downy Woodpecker <u>Denrocopos</u> <u>pubescens</u>	RC							RC				
Northern Three-toed Woodpecker <u>Picoides</u> <u>tridactylus</u>			RU					RU	RU			
Piliated Woodpecker <u>Dryocopus</u> <u>pileatus</u>			RR						RR			X

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Eastern Kingbird *Tyrannus tyrannus*	SC		SC	SC					SC			
Western Kingbird *Tyrannus verticalis*		SC					SC	SC		SC		
Willow (Traill's) Flycatcher *Empidonax traillii*	SC				SC		SC				SC	
Hammonds Flycatcher *Empidonax hammondii*									SU			
Dusky Flycatcher *Empidonax oberholseri*							SC	SC		SC		
Gray Flycatcher *Empidonax wrightii*		SR										
Western Flycatcher *Empidonax difficilis*	SC		SC	SC					SC			
Western Wood Pewee *Contopus sordidulus*	SC							SC	SC			
Olive-sided Flycatcher *Nuttallornis borealis*									SU			

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Violet-green Swallow *Tachycineta thalassina*	SC				SC	SC	SC				SC	
Tree Swallow *Iridoprocne bicolor*	SC				SC		SC				SC	
Barn Swallow *Hirundo rustica*	SO				SO						SO	
Cliff Swallow *Petrochelidon pyrrhonota*	SU										SU	
Purple Martin *Progne subis*			SU	SU				SU	SU			X
Gray Jay *Perisoreus canadenis*									RR			
Steller's Jay *Cyanocitta stelleri*			RC					RC	RC			
Scrub Jay *Aphelocoma coerulescens*	RA	RA										
Black-billed Magpie *Pica pica*	RA	RA										

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Common Raven <u>Corvus corax</u>	RC	RC					RC	RC	RC	RC		
Black-capped Chickadee <u>Parus atricapillus</u>		RC										
Mountain Chickadee <u>Parus gambelii</u>	RA		RA	RA					RA			
Plain Titmouse <u>Parus inormatus</u>	RC		RC	RC					RC			
Common Bushtit <u>Psaltriparus minimus</u>		RC										
White-breasted Nuthatch <u>Sitta carolinensis</u>	RC	RC										
Red-breasted Nuthatch <u>Sitta canadensis</u>	RC	RC	RC	RC				RC	RC			
									RC			

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Brown Creeper *Certhia familiaris*	RC		RC	RC				RC	RC			
House Wren *Troglodytes aedon*	SC		SC	SC					SC			
Rock Wren *Salpinctes obsoletus*						RC						
Catbird *Dumetella carolinensis*	SU											
Sage Thrasher *Oreoscoptes monanus*		RC										
Robin *Turdus migratorius*	RA		RA	RA								
Swainson's Thrush *Hylocichla ustulata*	SC		SC	SC				SC	SC			
Hermit Thrush *Hylocichla guttata*	SC		SC					SC	SC			
Veery *Hylocichla fuscescens*	SU											

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Mountain Bluebird *Sialia currucoides*					RA		RA	RA		RA	RA	X
Townsend's Solitaire *Myadestes townsendi*		RC						RC	RC			
Blue-gray Gnatcatcher *Polioptila caerulea*	SC	SC	SC				SC	SC		SC		
Golden-crowned Kinglet *Regulus satrapa*		RU							RU			
Ruby-crowned Kinglet *Regulus calendula*	RC	RC							RC			
Northern Shrike *Lanius excubitor*		SU										
Loggerhead Shrike *Lanius ludovicianus*		RC										
Solitary Vireo *Vireo solitarius*	SU	SU										

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Warbling Vireo *Vireo gilvus*	SC		SC									
Orange-crowned Warbler *Vermivora celata*	SC		SC				SC	SC		SC		
Virginia's Warbler *Vermivora virginiae*	SC	SC										
Yellow Warbler *Dendroica petechia*	SC		SC	SC								
Audubon's Warbler *Dendroica auduboni*	SC		SC	SC								
Black-throated Gray Warbler *Dendroica nigrescens*		SC										
Mac Gillivray's Warbler *Oporornis tolmiei*	SC											
Yellow-breasted Chat *Icteria Virens*	SC											

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Wilson's Warbler *Wilsonia pusilla*	SC									SC		
American Redstart *Setophaga ruticilla*	SU											
Western Meadowlark *Sturnella neglecta*					RA		RA				RA	
Bullock's Oriole *Icterus bullockii*	SU											
Western Tanager *Piranga ludoviciana*			SC	SC				SC	SC			
Black-headed Grosbeak *Pheucticus melanocephalus*	SC	SC										
Lazuli Bunting *Passerina amoena*	SC						SC	SC		SC		
Cassin's Finch *Carpodacus cassinii*	RA		RA					RA	RA			

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Junco *Junco hyemalis*		RC	RC	RC				RC	RC			
Tree Sparrow *Spizella arborea*	SC											
Chipping Sparrow *Spizella passerina*	SC		SC	SC				SC	SC			
White-crowned Sparrow *Zonotrichia leucophrys*		RC					RC	RC		RC		
Fox Sparrow *Passerella iliaca*	SU		SU	SU					SU			
Song Sparrow *Melospiza melodia*	RC				RC		RC			RC	RC	
III. REPTILES AND AMPHIBIANS												
Fence Lizard *Sceloporus undulatus*	RA				RA	RA	RU			RA		
Sagebrush Lizard *Sceloporus graciosus*	RA						RA			RU		
Mountain Short-horned Lizard *Phrynosoma douglassi*	RU											

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Rocky Mountain Rubber Boa _Charina bottae_	RR		RR	RR	RR				RR		RR	
Wandering Garter Snake _Thamnophis elegans_	RC										RC	
Western Racer _Coluber constrictor_					RU		RU			RU		
Striped Whipsnake _Masticophis taeniatus_		RU					RU	RU		RU		
Gopher Snake _Pituophis melanoleucus_	RC	RC			RC		RC	RC	RC	RC	RC	
Milk Snake _Lampropeltis triangulum_	RR				RR						RR	X
Utah Mountain Kingsnake _Lampropeltis pyromelana_	RR	RR			RR		RR			RR		X
Night Snake _Hypsiglena torquata_	RR	RR			RR							
Midget Faded Rattlesnake _Crotalus viridus_	RR				RR		RR			RR	RR	

Table 10-2 (Cont'd)

	Riparian	Pinyon-Juniper	Mixed Aspen-Conifer	Aspen Forest	Meadows	Cliff	Mountain Grassland-Shrub	Conifer-Shrub	Mountain Conifer	Mixed Mountain Shrub	Grassland Spring	High-Interest Species
Great Basin Spadefoot Toad <u>Scaphiopus</u> <u>intermantanus</u>	RC	RC			RC		RC	RC		RC	RC	
Woodhouse's Toad <u>Bufo</u> <u>woodhousei</u>	RU										RU	

that widely range throughout the region. The impact of the project on other mammals such as bats will be difficult to assess and probably of a very low magnitude. Impacts to the riparian zone will have the largest negative impact on mammals in Rilda Canyon.

10.3.2.4 Birds

Birds, by nature of their avian lifestyles, are able to physically occupy very many vegetation communities. Their limitations are generally related to feeding habits. Therefore, although a bird species may be seen in many places, the nature of its feeding may dictate the area that it can actually survive. Those birds most affected by the Rilda Canyon project will be birds that are adapted to deciduous trees, grasslands and mountain shrub feeding patterns. Even though some impact will occur to these species, the amount of habitat actually lost will be so small as to make quantitative measurement of the impact virtually impossible.

Other birds will be impacted in a more indirect way. Some of the raptors do not tolerate human encroachment very well, and, therefore will stay outside the human activity sphere around the project area where humans can be seen and heard.

The Rilda Canyon project area is of greatest significance to birds during the spring and summer months. Winters are long and hard at this elevation, and most birds will over-winter at other locations, either migrating south or moving to more hospitable areas within the general Huntington Canyon area.

10.3.2.5 Reptiles and Amphibians

The reptiles and amphibians that may occur in the Rilda Canyon area appear in Table 10-2. Most species of this group are difficult to detect because of unobtrusive habits, naturally low population levels and cryptic coloring. Several species are more obvious, such as *Sceloporus* lizards, but the presence of most, particularly snakes, can only be inferred without time-consuming field investigations. All reptiles are protected in Utah, but a few species of reptiles and amphibians are of special concern in Utah. The Utah milk snake (*Lampropeltis triangulum gentilis*) and Utah mountain kingsnake (*L. pyromelana infralabialis*) are two reptiles of concern to the nongame branch of the Utah Division of Wildlife Resources that may occur in the study area. There is no real way to determine if either snake is present, so it must be assumed that some potential habitat will be lost. The tiger salamander (*Ambystoma tigrinum*) is an amphibian of concern, that could be in the area; however, its habitat requirements are probably not met in Rilda Canyon. The tiger salamander prefers to breed in shallow lakes and emphemeral pools; neither exist in Rilda Canyon.

10.3.3 Species of Special Significance

Mule Deer - Mule deer are the premier big game species of Utah. They are ubiquitous in the state occurring from the treeline to the desert floors. Rilda Canyon has excellent mule deer habitat (i.e., extensive edge and shrub habitats); however, at present, mule deer utilization of the canyon appears low. This is evidenced by the low level of hunter activity, lack of observations during site visits and the relative dearth of tracks in snow and mud. One major deer trail was found just west of the project site (Figure 10-1), but not in view of it. During the winter mule deer, driven off the higher terrain, utilize the south-facing slopes of Rilda Canyon that stay relatively free of snow.

Elk (Wapiti) - The present elk population was introduced into the area from Yellowstone in 1913 (Ellison, 1954). Prior to that, elk were not present. The project area and leasehold is within the boundaries of the Manti herd (Unit 327). The herd generally stays on East Mountain during spring-fall, but some animals move into Rilda Canyon, particularly the upper elevations of the south-facing slope, after heavy snows force them off East Mountain. Few elk occupy the bottom of Rilda Canyon, although elk tracks were observed. Elk are grazers and make use of meadows and mountain shrub habitat that has extensive grass. When not feeding, elk tend to occupy dense timber. Some grazing and cover habitat occurs in the project area. Elk do not occupy a small home range, but instead will move for miles, if disturbed.

Moose - A small moose herd occurs in the general vicinity of Rilda Canyon (Joe's Valley and Electric Lake). The moose prefers dense riparian habitat, interspersed with wet meadows. Narrow canyons, such as Rilda Canyon, would normally only be occupied by moose if large feeding areas occurred nearby. They do not. This coupled with the lack of moose sightings within 5 miles of Rilda Canyon point to the conclusion Rilda Canyon can presently be eliminated as moose habitat.

Cougar (Mountain Lion) - Cougar are at the top of the food chain and, as such, are never abundant. One pair for 50 square miles is not unusual. The Rilda Canyon area has a large cougar population, compared with most locations in the state. A professional guide was met in Rilda Canyon where he had staked out a cougar location for an out-of-state client. He confirmed that the cougar population was high in the vicinity. Cougar are mobile and can easily avoid man, but depend on large mammals for prey. Any reduction in deer numbers caused by the project could adversely affect cougars.

Black Bear - Black bear are rare in Utah. They are mobile and are catholic feeders, thereby adaptable to most montane habitats. They are, however, wary of man and encroachment has drastically reduced their range. A few bear probably occur in the East Mountain area, but none have been reported in the vicinity of Rilda Canyon. It is unlikely that the project will adversely impact black bear.

Furbearers - Low numbers of furbearers may occur in Rilda Canyon. The most likely species present in the area of the project are beaver, skunk, bobcat, long-tailed weasel, ermine and badger. Some pine marten may occur at higher elevations. The riparian habitat has the highest value for furbearers and a continuous riparian strip is important for animal movements. The project will sever the riparian strip for approximately 670 feet.

Mountain Grouse - Blue grouse and ruffed grouse inhabit the general area of the Rilda project. They can be found in conifers, mixed conifers-aspens and in riparian woodlands. Both will feed on buds, seeds, insects and berries. At present, populations of both species of gamebird are low in the area, but these birds cycle, and at times are quite abundant. No individuals of either species were observed during site visits. It must be presumed that the project will result in loss of 26 acres of grouse habitat.

10.3.3.1 Threatened and Endangered Species

There is little potential for the Rilda Canyon project to impact federally listed or proposed threatened or endangered species or species of high federal concern. The threatened northern bald eagle utilizes the area in winter for foraging. The endangered peregrine falcon may occasionally forage or roost in the area during its migratory flights. Prairie falcons and golden eagles are regularly seen in the area, but no eyries occur within 0.5 miles of the project site.

10.3.3.2 Raptors

According to Dalton et al. (1978), 26 species of raptors occur in southeastern Utah (Table 10-3). Perhaps 10-15 of these might regularly occur during some part of the year in the vicinity of Rilda Canyon. Fewer yet would be expected to nest in the area. Likely nesters, on or near the leasehold, are turkey vulture, sharp-shinned hawk, Cooper's hawk, red-tailed hawk, golden eagle, prairie falcon, American kestrel, great horned owl, pygmy owl, long-eared owl and short-eared owl.

In November 1982 a survey was taken in Rilda Canyon for the presence of raptor stick nests. All deciduous trees had lost their leaves, making visibility good. The survey encompassed the area from the forks of Rilda Canyon (approximately 0.3 mile beyond any anticipated facilities) to the confluence with Huntington Canyon. Both ridgelines were examined with a spotting scope. Three stick nests were found. A large stick nest was observed on the ridgeline north of the mine site, approximately 0.6 mile from the facilities (Figure 10-1).

TABLE 10-3

RAPTORS OF SOUTHEASTERN UTAH

(after Dalton et al., 1978)

1	Turkey Vulture*	14	Prairie falcon*
2	Goshawk	15	Peregrine falcon
3	Sharp-shinned hawk*	16	Merlin
4	Cooper's hawk*	17	American kestrel*
5	Red-tailed hawk*	18	Screech owl
6	Red-shouldered hawk	19.	Flammulated owl
7	Swainson's hawk	20	Great-horned owl*
8	Rough-legged hawk*	21	Pygmy owl
9	Ferruginous hawk*	22	Burrowing owl
10	Golden eagle*	23	Spotted owl
11	Bald eagle	24	Long-eared owl*
12	Marsh hawk	25	Short-eared owl*
13	Osprey	26	Saw-whet owl

*Probably occurring with regularity during some part of the year in Rilda Canyon.

Another large stick nest was observed from the road approximately 0.7 mile down from the mine and about 0.5 mile off the road, again on the ridgeline to the north. An immature golden eagle was seen flying near this nest. Finally, a small stick nest (approximately 18 inches diameter) was observed just off the road on the south around 1.2 miles down from the mine. This last nest may not be a raptor nest.

An additional survey for nesting raptors will be conducted in spring 1983. The results of this survey will be reported as an addendum as soon as they are available.

10.4 EXPECTED IMPACTS OF MINING OPERATIONS ON FISH AND WILDLIFE

The first suite of impacts to wildlife associated with the Rilda Canyon Project will be those of construction. Approximately 10 acres of wildlife habitat will be no longer available for wildlife use. This will result in a direct loss of some individuals of species that have limited foraging ranges and/or mobility. Examples are smaller rodents, reptiles and amphibians. Losses of these smaller animals could possibly be translated to losses of larger, carnivorous animals, although in the case of the Rilda Project, this would be difficult to document because of the small amount of habitat actually being lost. In a narrower sense, certain species of concern, such as the Utah milksnake and the Utah mountain kingsnake may lose individuals from their population; however, there is no proof of their existence in the project area.

The actual impacts of the project will be mitigated to some extent by the fact that mining has occurred in the area in the past and evidence of mining occurs over most of the area where the facilities will be located. The impacts of the project, therefore, will result from an expansion of disturbance around the old site. This expansion is expected to cover approximately 10 acres.

The new development will eliminate around 3 acres of riparian habitat in the bottom of Rilda Canyon, which is probably the major impact (to wildlife) caused by the project. At the same time that the riparian habitat is lost, there will be modifications to the Rilda Canyon stream in the area of the facilities. The modifications will include culverting and soil over the top of the culverts so the facilities may occupy the present area of the stream. Not only will this result in loss of riparian habitat, but also the streamside vegetation is typically used as a path for wildlife movement, and this path will be obstructed for approximately 670 feet. The impacts to the creek itself will be somewhat less severe than to the riparian habitat because the flow of the creek at this point is low, averaging approximately 1 cfs, and production of macroinvertebrates is commensurately small. No fish occupy the portion of the stream that will be affected by the culverting and filling.

The impacts of operation are much more difficult to assess. The effects of human encroachment on wildlife populations are highly debated. Some experts assert that some species, particularly the larger ones, will avoid human operations, while others believe that animals become acclimated to humans in time if the activities are of a constant nature. Probably both beliefs are partially true. Some species acclimate to humans better than others. Certainly in the absence of harrassment, many species of mammals and birds will approach humans very closely. Still, it is probable that the encroachment in Rilda Canyon will eliminate raptor nesting and perhaps raptor activities in the close proximity to the mine itself. It is expected that 156 trucks will utilize the haul road daily. Some of the trucking activity will probably occur after dark. This subjects wildlife to the danger of being struck by vehicular traffic along the haul road that is presently absent. This danger is amplified at night when many of the larger species are active. Of particular concern are big game species during the winter months when they tend to congregate in the canyon bottom.

It remains to be determined whether the improvement of the road up Rilda Canyon will result in increased nonmining human activities in the canyon such as snowmobiling, which could result in additional harrassment of wildlife in the Rilda Canyon area.

One possible operational impact of the Rilda Canyon mine is the noise generated by the exhaust fan. Although loud, the noise is of a constant nature, and it is believed that wildlife will become acclimated to the sound after a short period of time.

Fugitive emissions are another potential impact to wildlife. They will probably be minimal in Rilda Canyon. The facility's placement in the bottom of the canyon will result in minimal amounts of wind to redistribute the coal dust off the facility site, and secondly, state-of-the-art means of controlling these emissions will be utilized.

10.5 MITIGATION AND MANAGEMENT PLANS

The Rilda Canyon Coal Mine project is expected to have limited impacts to wildlife. The facilities will be crowded into a 26-acre permit area (10 acres disturbed) in the bottom of a narrow canyon. The facilities will not be visible 0.25 mile up or down canyon. Nevertheless, the project is located in a relatively pristine area known to harbor a diverse wildlife community. The major potential impacts that need consideration for mitigation are:

(1) Direct habitat losses

(2) Encroachment losses--noise, human presence, vehicle-wildlife collisions, illegal hunting, etc.

(3) Degradation of quality and volume of Rilda Canyon Creek.

Proposed mitigations for these potential impacts are presented in the following paragraphs.

Direct habitat losses can be minimized, but not eliminated. The engineering plan calls for packing the facilities into only 10 acres. Direct habitat losses will be minimized outside the 10 acres by construction features such as interceptor ditches at the perimeter to prevent water flows across the developed site (Plate 3-3); routing of all surface flows in the permit area to a detention pond; and signing of buffer zones. To assure that direct habitat losses are not permanent, all soils capable of supporting vegetation will be stockpiled and managed for ultimate replacement on the mine site upon its abandonment.

Encroachment impacts on wildlife are unavoidable over the duration of mining. Noise and human presence will cause wildlife to avoid nearby suitable habitats. Mitigation will take the form of wildlife education for the miners, prohibition of hunting on the leasehold on company time, discouraging trucks from driving at excessive speeds at night and in winter when wildlife are most vulnerable to vehicle collisions, and perhaps other measures requested by wildlife agency personnel. By bussing the employees to and from the mine, vehicular impacts and illegal hunting will be reduced.

Prevention of degradation of the water in the Rilda Canyon creek necessitates several engineered structures. Approximately 670 linear feet of stream at the mine site will be culverted to provide adequate space for facility placement and to minimize the chance of contaminants entering the creek. The lower spring (Plate 3-3) will be sealed from the surface and a water collection system installed to efficiently remove clean water from the spring area. A permit area surface runoff collection system will be constructed to route all surface flows to a sedimentation pond equipped with an oil and solids skimmer. West Appa Coal Company will do all in its power to assure a continuous adequate, high-quality flow in the creek. Should it obtain the rights to water in the springs in Rilda Canyon, West Appa Coal Company will release more water than presently is released to the creek. Water quality will be regularly monitored in the creek for the duration of mining. Should a problem occur, the proper agencies will be immediately informed.

10.6 STREAM BUFFER ZONES DETERMINATION

The placement of facilities at the Rilda Canyon mine will necessitate destroying approximately 3 acres of riparian habitat and placing a dirt covered culvert along approximately 670 feet of the streambed. The riparian vegetation outside the area utilized for facilities will be rigorously protected by berms, fencing and company policy. At the conclusion of mining at the Rilda Canyon Mine, the stream will be restored by removing the overburden and the culverts, recontouring the creek banks and restoring the riparian vegetation. All drainage within the facilities compound will be routed so that it enters the sedimentation pond and does not pollute the creek either with contaminants or siltation.

10.7 FISH AND WILDLIFE MONITORING

No known species group or habitat, except for the creek in Rilda Canyon, is likely to be continuously adversly impacted by the Rilda Canyon project. Minor displacements of some species will, of course, occur but the impact of the project on any one species in the canyon is expected to be minimal. Because of this, the only monitoring that is proposed is of water quality in the creek in Rilda Canyon to insure that the microinvertebrate population remains healthy and that no contaminants are washed downstream into the Class III fishery in Huntington Creek. Should any nesting raptors be found within one-half mile of the Rilda Canyon mine or within the bottom of Rilda Canyon along the route of the haulage road, monitoring will be conducted to determine the impact of the facilities and activities at the facilities on the nesting raptors. The condition of the stored topsoil will also be monitored regularly to insure that it is not eroded away, contaminated or otherwise rendered unfit for later restoration of the vegetation on the site.

10.8 REFERENCES

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10.9 PLATES

CHAPTER XI

CLIMATOLOGY AND AIR QUALITY

Prepared for

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Salt Lake City, Utah

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CHAPTER XI

CLIMATOLOGY AND AIR QUALITY

11.1 SCOPE

This chapter presents a description of the existing air quality and meteorological environment in the vicinity of the West Appa Coal Company proposed mining operation in Rilda Canyon. It also estimates the air quality emissions expected during mining activities. It will be shown that controlled particulate emissions will total less than 250 tons per year during full-scale operations. The maximum planned coal production will eventually be 1.5 million tons per year. Accordingly, the air quality emissions estimates provided here are divided into three parts. Phase 1 estimates will assume a production rate of less than 460,800 tons of coal per year and hauling of coal over an improved and watered gravel road in Rilda Canyon. Estimates for phase 2 will assume 921,600 tons of coal per year with hauling to be done on a chemically stabilized gravel road in Rilda Canyon. Estimates for phase 3 will assume the full coal production of 1.5 million tons to be hauled over an asphalt road in Rilda Canyon. This three-phase operation is necessary partly because the Forest Service permit for the existing Rilda Canyon road prohibits the amount of traffic necessary to haul the full production. It would not be correct to estimate fugitive emissions for the full production rate to be hauled over the existing gravel road. Neither would it be correct to presume a paved road will be available during the first, reduced-tonnage period of mining.

Reference should be made to Chapter III where engineering details are presented, especially the engineering drawings that show the mining operations area from several viewpoints. These include a plant site perspective (Plate 3-1), showing a visual simulation of the operations area during mining; a mechanical flow sheet (Plate 3-2), showing all coal-handling equipment and transfer points; a plot plan (Plate 3-3), showing the layout of the proposed facilities; and a mechanical arrangements drawing (Plate 3-4), showing dimensional elevation sections of the coal-handling equipment and complimenting the generalized flow sheet of Plate 3-2.

It is mainly Plate 3-2 (Mechanical Flow Sheet) that provided the basis for estimating the air quality emissions to be discussed later in this chapter. Before doing any emissions calculations shown in this chapter, the Utah State Bureau of Air Quality was consulted and all the coal transfer points for which emissions estimates were required were identified on a working copy of Plate 3-2. Appropriate emission factors and formulas were obtained, as well as copies of the current guidelines.

These consultations provide assurance that all the important emission points are discussed in this chapter and that the correct emission factors are used.

According to the guideline material provided by the Utah State Bureau of Air Quality ("Compilation of Past Practices and Interpretations by EPA Region VIII on Air Quality Mining"), any source with an emission rate of 250 tons per year is subject to PSD review (PSD means "Prevention of Significant Deterioration" of air quality). PSD review requires more extensive data, modeling, monitoring, analysis, and other intensive effort than does review for smaller, non-major sources that have emissions of less than 250 tons per year.

In both types of review, fugitive dust is carefully defined and treated in different ways depending on the circumstances. For example, fugitive dust emissions occur during overburden and topsoil removal, grading operations, and operating vehicles over dirt and paved roads. Fugitive dust does not occur during coal handling, or processing operations such as mining, conveying, crushing, screening, storage, and loading for transfer. These operations all result in air quality emissions that are not called fugitive dust. Potential emissions (i.e., estimated uncontrolled emissions) include both fugitive dust and the emissions from processing coal. When air quality control equipment and/or practices are used, the actual emissions will be less than the potential emissions. The total controlled emissions are called "allowable emissions" when the terms of the air quality approval order are set. The total allowable emissions from all operations, including fugitive dust, are to be achieved by application of BACT (Best Available Control Technology) to all sources of emission. It is understood that BACT encompasses many factors, including cost of control, feasibility, and case-by-case review. The proposed control measures suggested in the analysis below are intended to achieve a total controlled emission rate of less than 250 tons per year.

In the analysis provided below, it will be shown that total emissions will be less than 250 tons per year. Accordingly, PSD review will not be required and no material supporting a PSD level of review is presented here (e.g., one year's baseline meteorology and air quality data, among others).

11.2 METHODOLOGY

Precipitation and temperature data are from the monthly data summaries for Utah weather stations published by the U.S. Department of Commerce. The nearest weather station to the Rilda Canyon mine site is at Hiawatha, about 9 miles to the northeast. The elevation at the Rilda mine site is between 7,520 feet (coal loadout pad) and 7,658 feet (mine portal). The Hiawatha weather station is at 7,200 feet. The difference in elevation of about 350 feet is not excessive, nor is the distance too great for characterizing the Rilda site in a general way using Hiawatha weather observations.

Evaporation data are not currently being measured at any site near Rilda Canyon, nor at Hiawatha. This parameter was measured at the Huntington Power Plant, however, and found to be 34 inches annually (personal communication, UP&L Co.).

Relative humidity data are not available for the area.

Wind data are provided through the courtesy of the Utah Power & Light Company, which operated a surface wind instrument at the mouth of Rilda Canyon during 1977 and 1978. These data are the nearest and most current wind measurements available for the area.

Air quality emission factors were provided by the Bureau of Air Quality, Utah State Department of Health. These will be explained in the sections where they are used. The source points at which emissions are to be estimated were selected in consultation with the Bureau of Air Quality.

11.3 EXISTING ENVIRONMENT

11.3.1 Precipitation

Monthly and annual precipitation at Hiawatha, Utah (9 miles from Rilda Canyon and 350 feet lower in elevation) is shown in Table 11-1. Two sets of data are presented: A 43-year averaged record for the period 1917 to 1960, and a ten-year recent record extending from 1973 through 1982.

Normal annual precipitation at Hiawatha is 14.15 inches. During the last ten years the annual precipitation has ranged from 8.6 to 18.6 inches and has fallen short of normal during six years. In 1980, 1981, and 1982, however, the normal amount was exceeded by 4.5, 4.5, and 3.4 inches, respectively. This means that the vegetation field sampling studies conducted in the late summer of 1982 were done during a wetter-than-average water year, and that the data will be acceptable for baseline studies.

The precipitation of the last ten years has been about equally distributed throughout the months of the year, except for June, a normally dry month. The ten-year average for June is 0.4 inches, but the remainder of the year produces monthly averages ranging from 0.7 to 1.5 inches per month. The wettest month is March (1.5 inches).

Snowfall has been only poorly reported at Hiawatha during the last ten-year period, but annual amounts of 114 inches (1978), 92 inches (1982), and 61 inches (1981) seem to be based on fairly complete records.

TABLE 11-1. PRECIPITATION AT HIAWATHA, CARBON COUNTY, UTAH

Month	Monthly[a] Average Precipitation 1917-1960	Total Precipitation (Inches)[b] 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	Monthly Average Precipitation 1973-1982
Jan	0.85	0.24	0.84	1.00	0.36	0.60	1.63	2.09	3.41	0.29	3.08	1.35
Feb	1.02	1.22	0.13	0.88	1.14	0.32	1.97	0.88	3.77	0.30	0.36	1.10
Mar	1.01	1.86	0.15	1.55	0.11	T	1.93	3.52	1.88	2.82	1.56	1.54
Apr	0.92	1.11	0.59	0.58	3.02	0.07	1.32	0.72	0.76	0.84	0.22	0.92
May	1.08	0.41	T	1.01	1.62	3.10	0.80	1.23	2.78	2.40	0.64	1.40
June	0.96	0.55	T	1.86	0.06	0.24	0.55	T	T	0.20	0.40	0.39
July	1.22	2.95	1.59	0.62	1.24	1.92	0.42	0.73	0.30	1.49	1.81	1.31
Aug	1.97	1.05	0.28	0.77	0.46	2.15	0.47	0.87	0.82	2.64	1.08	1.06
Sept	1.17	0.37	0.33	0.67	2.46	1.24	0.19	0.10	2.53	2.29	3.83	1.40
Oct	1.25	0.19	0.35	0.31	0.28	0.85	0.26	0.28	2.07	3.71	0.34	1.16
Nov	0.72	0.45	0.89	1.07	0.05	0.34	4.32	0.66	0.36	0.43	3.02	1.16
Dec	0.90	0.61	0.49	0.12	0.00	1.42	1.45	0.12	T	1.21	1.23	0.67
Annual	13.07	11.01	8.64	10.44	10.80	12.25	15.31	11.20	18.68	18.62	17.57	13.45
Annual Departure From Normal[c]	--	-3.14	-5.51	-3.71	-3.35	-1.90	+1.16	-2.95	+4.53	+4.47	+3.42	-0.70

[a]Source: Utah Power & Light Co., 1979. Wilberg Mine Permit, Cottonwood Portal Modification.
[b]Source: DOE (U.S. Department of Commerce) 1973-1982. Monthly and Annual Climatological Data for Utah.
[c]Normal annual precipitation at Hiawatha is 14.15 inches.

Precipitation at Rilda Canyon would be generally similar to the observed amounts reported for Hiawatha. Mountainous terrain, however, produces highly variable weather patterns and this should be taken into account.

11.3.2 Temperature

Average temperatures per month at Hiawatha for the ten-year period of 1973 through 1982 are shown in Table 11-2. The extreme temperatures (highest and lowest per month) and the average daily maximum and minimum temperatures are more useful than average temperatures, and these are shown in Table 11-3 for 1980, 1981, and 1982, plus the 47-year period of 1914 to 1960.

Temperature is affected by elevation in mountainous terrain, and the Rilda Canyon area at 7,500 feet is one of moderate temperatures. The record extremes (at Hiawatha) range from minus 18°F (February) to 95°F (July). The hottest and coldest months on the average are July and January. Summertime average daily maximum temperatures range from about 65°F to 82°F. Wintertime average daily minimum temperatures range between about 14°F and 24°F.

11.3.3 Evaporation

No data are available at Hiawatha or Rilda Canyon on evaporation, but at the Huntington Power Plant the annual evaporation is given as 34 inches (UP&L Co., personal communication).

11.3.4 Relative Humidity

No data on relative humidity are available.

11.3.5 Wind

During 1978, the Utah Power & Light Company operated a network of wind stations in the Huntington Canyon area. One of these stations (U-3, Rilda) was located in the mouth of Rilda Canyon. Another, measuring winds at the mountain top was located on Wild Horse Ridge (Station C-7). A third was located in Meetinghouse Canyon (Station U-2). Data from the Rilda Canyon station are shown in Table 11-4 and Exhibit 11-1 through the courtesy of the Utah Power & Light Company. These data show the average wind speed for five months to be about 1.0 meter/sec with monthly maximum speeds ranging from 2.7 to 6.7 meters/sec.

Other data gathered by the Utah Power & Light Company between 1969 and 1976 in Huntington Canyon show a well-developed mountain valley wind regime to predominate throughout the year (UP&L, 1979; Natomas, 1981). During the mid-morning to afternoon hours, winds flow up-canyon. The reverse occurs during the evening and early morning hours.

TABLE 11-2. AVERAGE DAILY TEMPERATURE PER MONTH FOR TEN YEARS (1973-1982) AT HIAWATHA, UTAH (°F)[a]

Month	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1973-1982 Average
Jan	18.5	--[b]	21.0	23.4	24.9	--	15.2	24.6	31.2	20.8	22.5
Feb	24.4	--	24.7	30.5	33.6	25.3	21.5	28.8	29.6	24.1	26.9
Mar	31.7	37.2	31.0	31.5	31.5	38.1	32.2	28.8	32.5	32.6	32.7
Apr	39.0	39.9	35.4	41.3	47.1	43.7	--	41.5	45.7	38.1	41.3
May	48.4	55.7	47.4	53.7	48.2	48.6	--	46.4	47.7	48.8	49.4
June	--	--	57.2	59.3	68.8	64.9	62.6	60.4	64.5	56.1	61.7
July	--	--	68.7	--	--	71.7	--	69.2	67.8	65.7	68.6
Aug	64.9	67.5	66.1	65.8	69.5	67.7	64.2	64.7	64.8	64.5	66.0
Sept	--	59.1	59.2	59.1	59.8	57.5	62.5	57.1	58.5	54.7	58.6
Oct	--	48.5	45.6	47.6	50.2	51.6	51.2	44.7	41.5	39.6	46.7
Nov	--	33.4	31.4	37.6	35.0	33.9	28.0	34.3	35.2	28.0	33.0
Dec	--	23.1	26.1	28.3	29.2	17.7	26.6	34.1	25.5	23.7	26.0
Annual Average	--	--	42.8	--	--	--	--	44.6	45.4	41.4	--

[a]Source: DOE (U.S. Department of Commerce) 1973-1982. Monthly and Annual Climatological Data for Utah.

[b]The dash indicates missing data. When missing data occur in a column, the annual average for that column cannot be calculated. Averages across the table rows (monthly averages) are possible and are based on the number of years for which data exist.

TABLE 11-3. MONTHLY AND ANNUAL EXTREME AND AVERAGE TEMPERATURES (°F) AT HIAWATHA, UTAH FOR THE PERIOD 1914-1960 AND THE THREE YEARS OF 1980, 1981, AND 1982

Month	1913 to 1960[a] Record Highest	1913 to 1960[a] Average Daily Maximum	1913 to 1960[a] Average	1913 to 1960[a] Average Daily Minimum	1913 to 1960[a] Record Lowest	1980[b] Highest	1980[b] Average Daily Maximum	1980[b] Average	1980[b] Average Daily Minimum	1980[b] Lowest
Jan	54	32	23	14	-12	43	33.5	24.6	15.6	3
Feb	57	36	27	18	-18	—[c]	—	28.8	—	—
Mar	66	44	34	23	- 1	46	38.2	28.8	19.3	6
Apr	80	55	44	32	7	71	52.8	41.5	30.1	16
May	86	65	53	40	19	72	56.8	46.4	35.9	25
June	93	75	62	49	26	—	74.4	60.4	46.3	36
July	95	82	69	56	40	—	—	69.2	—	—
Aug	93	79	67	55	35	88	77.6	64.7	51.7	38
Sept	92	72	59	47	25	79	69.1	57.1	45.0	29
Oct	78	59	48	37	10	77	55.9	44.7	33.5	18
Nov	63	44	34	24	- 2	61	45.0	34.3	23.6	10
Dec	58	35	26	17	-12	57	45.5	34.1	22.6	12
Annual	95	56	45	34	-18	—	—	44.6	—	—

TABLE 11-3. MONTHLY AND ANNUAL EXTREME AND AVERAGE TEMPERATURES (°F) AT HIAWATHA, UTAH FOR THE PERIOD 1914-1960 AND THE THREE YEARS OF 1980, 1981, AND 1982 (Cont.)

	1981[b]					1982[b]				
Month	Highest	Average Daily Maximum	Average	Average Daily Minimum	Lowest	Highest	Average Daily Maximum	Average	Average Daily Minimum	Lowest
Jan	53	42.0	31.2	20.4	9	41	31.2	20.8	10.4	-9
Feb	53	41.5	29.6	17.7	2	48	34.0	24.1	14.1	-11
Mar	53	41.9	32.5	23.0	16	52	42.0	32.6	23.1	11
Apr	74	58.7	45.7	32.7	18	64	50.4	38.1	25.7	13
May	73	59.3	47.7	36.1	25	77	61.5	48.8	36.0	26
June	89	78.7	64.5	50.3	32	79	70.1	56.1	42.0	26
July	88	81.7	67.8	53.8	38	86	79.0	65.7	52.4	34
Aug	89	77.3	64.8	52.2	43	85	76.4	64.5	52.5	46
Sept	77	69.7	58.5	47.2	34	82	65.3	54.7	44.1	29
Oct	67	51.5	41.5	31.5	19	59	50.4	39.6	28.8	18
Nov	60	45.0	35.2	25.3	8	49	37.4	28.0	18.5	5
Dec	46	34.8	25.5	16.2	0	44	33.5	23.7	13.9	-1
Annual	89	56.8	45.4	33.9	0	86	52.6	41.4	30.1	-11

(a)Source: Utah Power & Light Co., 1979. Wilberg Mine Permit, Cottonwood Portal Modification.
(b)Source: DOC (U.S. Department of Commerce), 1973-1982. Monthly and Annual Climatological Data for Utah.
(c)Dashes indicate missing data.

TABLE 11-4. DAILY WIND DIRECTION AND AVERAGE WIND SPEED IN RILDA CANYON[a]

Day of Month	Dec 1977 Direction	Dec 1977 Speed (m/sec)	Jan 1978 Direction	Jan 1978 Speed (m/sec)	Feb 1978 Direction	Feb 1978 Speed (m/sec)	Mar 1978 Direction	Mar 1978 Speed (m/sec)	April 1978 Direction	April 1978 Speed (m/sec)
1	---	---	SW	1.2	ENE	0.6	NE	0.1	SSE	1.3
2	---	---	SW	0.6	SSE	0.3	ENE	0.1	SSW	0.9
3	---	---	SE	0.2	S	0.1	ENE	0.2	E	0.9
4	---	---	ENE	0.7	SSW	0.4	S	0.1	SSE	0.2
5	---	---	ENE	0.2	SSE	0.5	ENE	0.2	SW	3.1
6	---	---	SW	0.6	ESE	0.4	SW	0.8	NE	0.6
7	---	---	SW	0.5	E	0.2	WSW	0.3	ENE	1.7
8	---	---	SW	0.8	SW	1.4	SSW	0.2	SE	0.5
9	---	---	E	0.2	SW	0.5	W	0.1	SW	2.1
10	---	---	SSE	0.2	SSE	0.3	WSW	0.6	WSW	4.4
11	---	---	SSE	0.1	SSE	0.2	NE	0.4	SW	1.9
12	---	---	SW	0.9	SW	0.3	NE	0.2	SW	1.9
13	---	---	SSW	0.6	SW	1.0	SSW	0.4	SW	1.3
14	SSW	1.8	WSW	0.1	SW	1.4	SW	0.9	SW	1.3
15	SSW	0.9	ENE	0.6	SSW	0.4	WSW	0.6	SW	1.8
16	SW	1.4	S	0.5	WSW	1.4	SW	0.1	ENE	0.4
17	SSE	0.2	SSW	0.3	SW	1.2	SSW	0.5	SW	3.9
18	SSW	0.8	SW	0.6	SW	1.9	SSW	0.1	SSW	1.4
19	SW	0.8	NNW	0.1	WSW	2.3	SSE	0.1	S	0.9
20	SW	0.9	SW	0.6	WSW	2.0	SW	0.5	SSW	1.1
21	SW	1.8	SW	0.7	SSW	1.1	SSW	0.3	SW	3.4
22	SE	0.6	SW	0.7	SSW	1.3	SSW	0.9	SW	3.2
23	S	0.5	WSW	1.4	SW	1.0	SW	1.2	SW	1.8
24	SW	1.5	WSW	2.4	SW	0.2	SW	2.3	S	0.8
25	S	0.6	SW	1.0	SSW	0.5	SSW	1.5	SW	1.0
26	SSW	0.4	ESE	0.3	SW	0	SSW	1.3	ESE	0.6

TABLE 11-4. (Cont'd)

Day of Month	Dec 1977 Direction	Dec 1977 Speed (m/sec)	Jan 1978 Direction	Jan 1978 Speed (m/sec)	Feb 1978 Direction	Feb 1978 Speed (m/sec)	Mar 1978 Direction	Mar 1978 Speed (m/sec)	April 1978 Direction	April 1978 Speed (m/sec)
27	E	0.4	WSW	0.1	SSW	0.3	S	1.1	SW	1.8
28	E	0.5	SW	0.3	SE	0.2	SW	3.2	SW	1.3
29	SE	0.3	S	0.4	---	---	SSW	2.0	SSW	0.9
30	S	0.3	SW	0.4	---	---	SSW	1.3	S	0.5
31	SSW	0.6	SSW	0.2	---	---	SSE	0.5	---	---
Average Speed (m/sec)	0.8		0.6		0.8		0.7		1.6	
Maximum speed (m/sec)	2.7		4.0		4.5		5.4		6.7	
Direction	SW		WSW		WSW		SW		WSW	
Time	0500		1200		1200		0300		1200	
Date	12/24		1/24		2/19		3/28		4/5	

(a) Source: Courtesy of Utah Power & Light Co., Wind Data from Station U3-Rilda Canyon.
Note: Although the Rilda Canyon station was operated during the period December 1977 through February 1979, the remaining data is not in a form suitable for presentation here.

11.4 EFFECTS OF MINING OPERATIONS ON AIR QUALITY

The most significant air quality emissions associated with mining activities in Rilda Canyon will be particulate material. Particulates will be emitted during coal handling, stockpiling, screening, crushing, loading, and hauling. Of these, fugitive dust from the gravel haul road in Rilda Canyon during hauling could produce the greatest quantities. The haul road is 2.3 miles long; a round trip is therefore 4.6 miles, disregarding haul distances outside of Rilda Canyon. At full production (1.5 million tons of coal per year), some 156 40-ton truck trips per day (240 days per year) will be required to haul the coal. This yields 172,224 vehicle-miles per year in Rilda Canyon.

11.4.1 Estimate of Uncontrolled Emissions

If control measures were not implemented, and the gravel road remained unwatered, untreated chemically, or unpaved, almost 1,400 tons per year of fugitive dust would be entrained by coal-hauling trucks alone. This estimate is based on an emission factor of 16.00 pounds per vehicle mile for trucks, as shown in equation 11-1.

eq. 11-1
$$E = 0.6(0.81s)\left(\frac{S}{30}\right)^2\left(\frac{365-w}{365}\right)\frac{N}{4}$$

in which E = the emission factor in pounds per vehicle mile,

s = silt content of road surface (12% assumed),

S = vehicle speed (20 m.p.h. assumed),

w = the number of "wet" days per year (100 assumed), and

N = the number of wheels per vehicle (N = 34 for trucks and N = 4 for support vehicles)

An additional 24 tons per year would be entrained by 4-wheel support vehicles, which are here assumed to travel 15% of the distance travelled by the coal hauling trucks, or 25,850 vehicle miles per year, and to operate with an emission factor of E = 1.88 pounds per vehicle mile (identical derivation as for trucks except N = 4).

By comparison, exhaust emissions from the coal-hauling trucks, consuming 45,300 gallons of fuel per year over the same road in Rilda Canyon (at 3.8 miles per gallon), would total only about 16 tons per year. This estimate is based on emission factors in

Table 3.2.7-1, "Off-highway Truck" column, of EPA Publication AP-42, 3rd Ed., Part A, 1977. The total vehicle emission would be composed of the following pollutants: carbon monoxide, 2.1 tons/year; exhaust hydrocarbons, 0.7 ton/year; oxides of nitrogen, 11.9 tons/year; aldehydes, 0.2 ton/year; sulfur oxides, 0.7 ton/year; and exhaust particulates, 0.4 ton/year. Vehicle emissions will not be considered further in this discussion.

Uncontrolled particulate emissions at the mining operations area, assuming full production of 1.5 million tons of coal per year, could potentially reach about 302 tons per year in addition to the road fugitive. This estimate is based on emission factors provided by the Bureau of Air Quality and a full calculation is provided in tables to be presented below. Before doing so, however, a discussion of control strategies will be presented that will provide a rationale for the format of the emissions tables.

11.4.2 Description of Control Measures

Ten emission sources will be discussed. Of these, eight relate to coal handling and two are associated with the haul road. The coal handling sources will be discussed first.

11.4.2.1 Conveyor to Stockpile

Coal emerges from the mine portal on a 48-inch conveyor (#BC-101 on Plate 3-4) and travels 147 feet to a transfer and sampling building. At this point transfer is made to a second conveyor angled 54° to the right (east) of the direction of travel. This conveyor (#BC-102 on Plate 3-4) carries the coal 484 feet to the coal stockpile. The transfer building is not considered an emission point in this discussion. At maximum production of 1.5 million tons of coal per year, if no controls were used, the potential emission from this conveyor would be 0.02 pounds per ton x 1.5 million tons per year = 15.0 tons per year.

Control measures include covering the conveyor on three sides and providing water sprays at the conveyor dump point. The transfer building is an enclosed structure. These control measures will provide 90% reduction in emissions to 1.5 tons per year at maximum production.

11.4.2.2 Coal Stockpile

The coal stockpile size will be 20,000 tons. Its diameter will be 200 feet and the stacking tube height is 88 feet. The coal pile height, however, will be closer to 80 feet at maximum size. The ground area occupied by the pile will be 0.72 acres and the surface area will be 0.92 acres. Assuming a constant wind speed of 5 meters per second (even though the actual wind speed is much less), uncontrolled emissions from this pile could reach

32.2 tons per year (by 1.6u pounds/acre per hour in which u = the wind speed in meters per second and 1 year = 8,760 hours).

Control will be a water spray at the stacking tower where new coal is being added to the pile. Thus all new coal, which goes onto the surface of the pile, will be wet. This control measure will reduce emissions by 50% to 16.1 tons per year. The stacking tube is, of course, an effective control device since the coal is dumped inside of its enclosed structure.

11.4.2.3 Conveyor from Stockpile to Crushing and Screening Building

A 42-inch-wide conveyor (#BC-103 in Plate 3-4) will carry coal from the base of the coal stockpile 286 feet to the crushing and screening building. This conveyor would contribute 15.0 tons per year to emissions if uncontrolled (by 0.02 pounds per ton x 1.5 million tons/year at maximum production).

Control measures include covering on three sides and providing a water spray at the dump point. The conveyor is loaded inside an enclosed reclaim tunnel under the stockpile. These control measures are 90% effective and controlled emissions will therefore be reduced to 1.5 tons per year at maximum production.

11.4.2.4 Double-deck Screen

The screen, crusher, and stoker screen to be described next are all located inside one building, which will provide 90% reduction in potential emissions. The screen can produce a possible 0.1 pounds per ton of coal, or 74.9 tons per year at full production. Controlled emissions (enclosed in building) will be reduced to 7.5 tons per year.

11.4.2.5 Crusher

The crusher, considered here to be a secondary crusher so as to maximize possible emissions, can produce 0.06 pounds per ton of coal, or 44.9 tons per year if uncontrolled. All coal will not be crushed, so the calculation is conservative.

Controlled emissions (enclosed in building) will be reduced 90% to 4.5 tons per year.

11.4.2.6 Stoker Screen

The stoker screen, which may not be installed until a later date, can produce a possible emission of 0.1 pounds per ton of coal, or 74.9 tons per year if uncontrolled.

Controlled emissions (enclosed in building) will be reduced 90% to 7.5 tons per year.

11.4.2.7 Conveyor from Crushing-Screening Building to Truck Loadout Hopper

Coal will be carried from the crushing-screening building to the coal loadout hopper by a 42-inch-wide conveyor (#BC-104 in Plate 3-4) running a distance of 230 feet. Uncontrolled emissions could reach 15.0 tons per year (by 0.02 pounds per ton of coal produced x 1.5 million tons per year).

Control measures include covering on three sides and providing a water spray at the dump point. These measures will reduce emissions by 90% to 1.5 tons per year.

11.4.2.8 Loadout Hopper to Truckbed

The loadout hopper (205-ton capacity) can produce up to 0.04 pounds per ton of uncontrolled emissions, or 30.0 tons per year at full production.

Control measures include a retractable chute on the loadout opening, and water spray at the top of the hopper. These control measures will reduce emissions by 95% to 1.5 tons per year.

11.4.2.9 Truck Travel on Rilda Canyon Road

If no control measures were used, the gravel haul road could produce 16 pounds of dust per vehicle-mile for trucks and 1.88 pounds per year for support vehicles. The emission factors and amounts of fugitive dust were already discussed above in Section 11.4 where a total potential emission of about 1,400 tons per year was calculated. This is by far the most significant source of emissions in the entire operation.

The most effective way to reduce this fugitive dust to an acceptable level is to pave the entire length of Rilda Canyon road. This would reduce the 1,400-ton uncontrolled emission by more than 99% to only 8.6 tons per year. Paving is, in fact, the intended control measure when full production is approached in the mining operation. Paving, however, is not cost-effective at low production rates, which would be the case when mining operations begin, and continuing for the first few years of operation. Therefore a three-step control strategy will now be proposed that is tied to coal production quantities, and hence to the number of truck trips and the vehicle mileage required to haul the mined coal.

The three steps consist of (1) watering the existing or improved gravel road while production is at or below about 31% of full production, or 460,800 tons per year, resulting in controlled dust that would not exceed 216 tons per year; (2) use of chemical soil stabilizers such as calcium chloride, magnesium chloride, or some other acceptable substance while production is above 31% to about 62% of full production, or 921,600 tons per year, resulting in controlled dust that would be reduced to 129 tons per year; and (3) paving Rilda Canyon road when production exceeds 62%, resulting in a reduction of road fugitive to about 9 tons per year. These three production amounts are tied to the number of trucks per shift, trips per truck, and shifts per day required to haul the indicated tonnages of coal. If, for example, a single truck were added to the number already working for the first (low production) scenario, the road fugitive dust would increase by an unacceptable amount unless the next control strategy were adopted. The chemical control strategy has a much greater spread of effectiveness and is not tied precisely to the 62% of full production vehicle mileage. The purpose of the control strategies described above is to keep the total controlled emissions from all sources below 250 tons per year and thus avoid having to meet PSD review requirements, while at the same time remaining cost-effective.

The final source of emissions will now be discussed, after which all of the above control strategies will be summarized in tabular form according to the three coal production milestones at which new road fugitive control measures are required.

11.4.2.10 Support Vehicle Travel on Rilda Canyon Road

Support vehicles, consisting mainly of 4-wheel traffic, will also use the Rilda Canyon road. The total mileage is assumed to be 15% of the coal-handling truck mileage, or about 25,850 vehicle-miles at full production. If the road were untreated, this traffic could contribute about 24 tons per year to road fugitive (emission factor is the same as for trucks, as shown in equation 1, except $N = 4$ instead of $N = 34$ and thus $E = 1.88$ pounds per vehicle mile).

Control measures already discussed could reduce this to 1.3 tons per year.

11.4.3 Estimate of Controlled Emissions

Table 11-5 provides a summary of the controlled emissions discussed in the sections above. The three control strategies for the Rilda Canyon fugitive dust are shown as Phase I, II, and III in the three columns of the table. This approach is necessary because it would not be possible to haul the full 1.5 million ton production out of Rilda Canyon on the existing road without excessive emissions. On the other hand, it is not cost-effective to introduce paving until production justifies it.

The total controlled emissions of Phase I (460,800 tons production, existing gravel road, and watering for dust suppression) are estimated to be 239.8 tons per year. Of this amount, fully 90% is from road fugitive dust and 10% is from coal handling operations.

TABLE 11-5. SUMMARY OF PARTICULATE EMISSIONS AT WEST APPA COAL COMPANY RILDA MINE[a]

A. Basic Rationale	Phase I	Phase II	Phase III Full Production
Coal production per year (tons/year)	460,800	921,600	1,497,600
Number of truck trips per day	48	96	156
Truck mileage, Rilda Canyon Road (vehicle-miles/year)	53,000	106,000	172,200
Emission factor for trucks (pounds/vehicle-mile)	16.00	16.00	0.1
Support vehicle mileage, Rilda Canyon (vehicle-miles/year)	7,950	15,900	25,850
Emission factor for support vehicles (pounds/vehicle-mile)	1.88	1.88	0.1 lb./veh. mi.
Road fugitive control method	Water	Chemical	Paving
Road fugitive control efficiency	50%	85%	0.1 lb./veh. mi.

Mining operations area: Assume coal pile constant at maximum size, wind speed at 5 m/sec, and remaining emissions proportional to coal production.

B. Summary of Emissions	UNCONTROLLED Full Production (tons/year)	CONTROLLED (tons/year) Phase I	Phase II	Phase III
1. Road fugitive	1402.1	215.7	129.4	9.9
2. All conveyors	4.5	1.5	2.7	4.5
3. Coal stockpile	16.1	16.1	16.1	16.1
4. Screening and crushing	19.5	6.0	12.0	19.5
5. Loadout to trucks	1.5	0.5	0.9	1.5
TOTALS	1443.7	239.8	161.1	51.5

(a) See Tables 11-6, 11-7, and 11-8 for complete calculations.

The total controlled emissions of Phase II (921,600 tons production, existing gravel road, and chemical dust suppression) are estimated to be 161.1 tons per year. Of this amount, 129.4 tons or 80% is from road fugitive and 31.7 tons (20%) is from coal handling at the mining operations area. The amount of coal handling dust is higher than in Phase I because of increased production. The amount of road fugitive is less than in Phase I because chemical control is 85% effective instead of only 50% effectiveness for water sprinkling.

The total controlled emissions from Phase III operations (full production of 1.5 million tons per year, and paving of Rilda Canyon road) are estimated to be 51.5 tons per year. Of this amount, only 19% or 9.9 tons of emissions is from road fugitive and 81% is from coal handling. This 81% amounts to 41.6 tons per year. This is larger than Phase I and II emissions because the coal production rate is higher. The road fugitive is low because paving is about 99.4% effective in reducing road dust in this case.

Table 11-5 is a condensation of the extended calculations shown in Tables 11-6, 11-7, and 11-8, which correspond to the three production rates and control scenarios described. Both uncontrolled and controlled emissions are shown in these complete tables.

11.4.4 Estimated Cost of Emission Control

Costs for assuring control of particulate emissions are shown in Table 11-9 for each of the ten sources described in the sections presented above. The total exceeds $1 million. The costs shown include the cost of materials, cost of labor to install, and a small contingency.

It should be realized that some of the emission control features that are described also serve other functions. For example, conveyor coverings, beside reducing particulate emissions, protect the conveyor itself from being overturned by wind gusts. The stacking tube not only reduces particulate emissions by enclosing the entire discharge from the conveyor belt, it also provides the best method of building a large coal stockpile, managing mining production, and providing for rapid and uncomplicated coal loadout. The buildings that house the screening, crushing, sampling, and transfer equipment also provide safety, security, and protection from the elements. Similar examples of dual roles for other emission control equipment could also be given. For these reasons, it is not easy to put one unambiguous figure down as the sole cost of emission control. In Table 11-9 the costs shown were carefully proportioned to reflect the amount of material and labor that contributed directly to emission control even though the structures described might also serve other functions.

TABLE 11-6. CALCULATION OF PARTICULATE EMISSIONS AT WEST APPA COAL COMPANY, RILDA MINE, DURING PHASE I (PRODUCTION RATE OF UP TO 460,800* TONS PER YEAR AND GRAVEL ROAD WITH WATER DUST SUPPRESSION)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
1. Conveyor to stockpile, excluding transfer sampling building, mine, and mine entrance, which are not separate source points.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Quality	Conveyor partially covered - 90%. Water spray at dump point. Conveyor dumps inside of enclosed stacking tube.	4.6	0.5
2. Stockpile, 20,000 tons: diameter 200 ft. by height about 80 ft. = 837,800 cubic feet volume, 0.72 acres ground area, and 0.92 acres surface area.	1.6u lbs. per acre per hour, in which u is wind speed in meters/second. Assume wind is 5.0 meters/ second and 1 year = 8,760 hours.	Table 1, Summary of Past BACT Determinations Made by Region VIII for Large Surface Coal and Uranium Operations (Item 10a)	Water spray - 50%.	32.2	16.1
3. Conveyor from stock-pile to crushing and screening building.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Quality	Conveyor partially covered - 90%. Water spray at dump point. Conveyor is loaded inside enclosed tunnel under stockpile.	4.6	0.5

TABLE 11-6. (Cont'd)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
4. Double-deck screen inside building.	0.1 lbs./ton	Table 1, Item 20	Inside building - 90%.	23.0	2.3
5. Crusher (secondary) inside building.	0.06 lbs./ton	Table 1, Item 19	Inside building - 90%.	13.8	1.4
6. Stoker screen inside building.	0.1 lbs./ton	Table 1, Item 20	Inside building - 90%.	23.0	2.3
7. Conveyor from crushing and screening building to truck loadout hopper.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Qualtiy	Conveyor partially covered - 90%.	4.6	0.5
8. Loadout hopper to truckbed, equipped with loadout chute.	0.04 lbs./ton	D.E. Robinson, Bureau of Air Quality	Retractable chute on loadout, minimize number of openings. Water spray at silo loading point - 95%.	9.2	0.5
9. Truck travel on Rilda Canyon gravel haul road of length 2.3 miles. Truck use = 53,000 veh. mi./year	E = 16.00 lbs./ veh. mi.	See Equation 11-1 in Section 11.4, using N = 34	Water spray - 50%.	424.0	212.0

TABLE 11-6. (Cont'd)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
10. Support vehicle travel on Rilda Canyon gravel road assuming 15% of truck mileage: 7,950 veh. mi./yr.	1.88 lbs./veh. mi.	See Equation 11-1 in Section 11.4, using N = 4	Water spray - 50%.	7.5	3.7
			TOTAL	546.5	239.8

* 4 trucks per shift x 2 shifts per day x 6 trips per truck per shift = 48 trips per day.
48 x 4.6 miles per round trip on Rilda Canyon road (gravel) = 220.8 miles per day, and 220.8 x 240 days per year = 52,992 vehicle miles per year.
At 40 tons per truck load, 48 trips per day, and 240 days per year, the production is 460,800 tons per year.

TABLE 11-7. CALCULATION OF PARTICULATE EMISSIONS AT WEST APPA COAL COMPANY, RILDA MINE, DURING PHASE II (PRODUCTION RATE OF 921,600* TONS PER YEAR AND GRAVEL ROAD WITH CHEMICAL DUST CONTROL)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
1. Conveyor to stock-pile, excluding transfer sampling building, mine, and mine entrance, which are not separate source points.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Quality	Conveyor partially covered - 90%. Water spray at dump point.	9.2	0.9
2. Stockpile, 20,000 tons: diameter 200 feet by height about 80 feet = 837,800 cubic feet volume, 0.72 acres ground area, and 0.92 acres surface area.	1.6u lbs. per acre per hour, in which u is wind speed in meters per second. Assume wind is 5.0 meters/second and 1 year = 8,760 hours.	Table 1, Summary of Past BACT Determinations Made by Region VIII for Large Surface Coal and Uranium Operations (Item 10a)	Water spray - 50%.	32.2	16.1
3. Conveyor from stock-pile to crushing and screening building.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Quality	Conveyor partially covered - 90%. Water spray at dump point.	9.2	0.9
4. Double-deck screen inside building.	0.1 lbs/ton	Table 1, Item 20	Inside building - 90%.	46.1	4.6

TABLE 11-7. (Cont'd)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
5. Crusher (secondary) inside building.	0.06 lbs./ton	Table 1, Item 19	Inside building - 90%.	27.6	2.8
6. Stoker screen inside building.	0.1 lbs./ton	Table 1, Item 20	Inside building - 90%.	46.1	4.6
7. Conveyor from crushing and screening building to truck loadout hopper.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Quality	Conveyor partially covered - 90%. Water spray at dump point.	9.2	0.9
8. Loadout hopper to truckbed.	0.04 lbs./ton	D.E. Robinson, Bureau of Air Quality	Retractable chute on loadout, minimize number of openings. Water spray at silo loading point - 95%.	18.4	0.9
9. Truck travel on Rilda Canyon gravel haul road of length 2.3 miles. Truck use = 106,000 veh. mi./yr.	E = 16.00 lbs./veh. mi.	See Equation 11-1 in Section 11.4, using N = 34	Chemical control - 85%.	848.0	127.2

TABLE 11-7. (Cont'd)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year)	
				Uncontrolled	Controlled
10. Support vehicle travel on Rilda Canyon gravel road assuming 15% of truck mileage: 15,900 veh. mi./yr.	1.88 lbs./veh. mi.	See Equation 11-1 in Section 11.4, using N = 4	Chemical control - 85%.	14.9	2.2
			TOTAL	1,060.9	161.1

* 8 trucks per shift x 2 shifts per day x 6 trips per truck per shift = 96 trips per day.
96 x 4.6 miles per round trip on Rilda Canyon road = 441.6 miles per day, and 441.6 x 240 days per year = 105,984 vehicle miles per year.
At 40 tons per truck load, 96 trips per day, and 240 days per year, the production is 921,600 tons per year.

TABLE 11-8. CALCULATION OF PARTICULATE EMISSIONS AT WEST APPA COAL COMPANY, RILDA MINE, DURING PHASE III (FULL PRODUCTION RATE OF 1,497,600* TONS PER YEAR AND PAVED ROAD)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
1. Conveyor to stock-pile, excluding transfer sampling building, mine, and mine entrance, which are not separate source points.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Quality	Conveyor partially covered - 90%. Water spray at dump point.	15.0	1.5
2. Stockpile, 20,000 tons: diameter 200 feet by height about 80 feet = 837,800 cubic feet volume, 0.72 acres ground area, and 0.92 acres surface area.	1.6u pounds per acre per hour, in which u is wind speed in meters per second. Assume wind = 5.0 m/sec and 1 year = 8,760 hours.	Table 1, Summary of Past BACT Determinations Made by Region VIII for Large Surface Coal and Uranium Operations (Item 10a)	Water spray - 50%. Conveyor dumps inside stacking tube.	32.2	16.1
3. Conveyor from stock-pile to crushing and screening building.	0.02 lbs/ton	D.E. Robinson, Bureau of Air Quality	Conveyor partially covered - 90%. Water spray at dump point. Conveyor is loaded in enclosed tunnel under stockpile.	15.0	1.5
4. Double-deck screen inside building.	0.1 lbs/ton	Table 1, Item 20	Inside building - 90%.	74.9	7.5

TABLE 11-8. (Cont'd)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
5. Crusher (secondary) inside building.	0.06 lbs/ton	Table 1, Item 19	Inside building - 90%.	44.9	4.5
6. Stoker screen inside building.	0.1 lbs./ton	Table 1, Item 20	Inside building - 90%.	74.9	7.5
7. Conveyor from crushing and screening building to truck loadout hopper.	0.02 lbs./ton	D.E. Robinson, Bureau of Air Qualtiy	Conveyor partially covered - 90%. Water spray at dump point.	15.0	1.5
8. Loadout hopper to truckbed.	0.04 lbs./ton	D.E. Robinson, Bureau of Air Quality	Retractable chute on loadout, minimize number of openings, water spray at silo loading point - 95%.	30.0	1.5
9. Truck travel on Rilda Canyon paved haul road of length 2.3 miles. Truck use = 172,200 veh. mi./yr.	0.1 lbs./ veh. mi.	D.E. Robinson, Bureau of Air Quality	Paving of Rilda Canyon road assumes no further control measures beyond E = 0.1 lb./veh. mi. This achieves more than 99% control compared to untreated gravel road.	8.6	8.6

TABLE 11-8. (Cont'd)

Description of Source	Emission factor for potential emissions	Reference	BACT Control Measures and Efficiency Factor	Emissions (tons/year) Uncontrolled	Controlled
10. Support vehicle travel on Rilda Canyon road assuming 15% of truck mileage: 25,850 veh. mi./yr.	0.1 lbs./veh. mi.	D.E. Robinson, Bureau of Air Quality	Paving: E = 0.1 lb./ veh. mi.	1.3	1.3
			TOTAL	311.8	51.5

* 13 trucks per shift x 2 shifts per day x 6 trips per truck per shift = 156 trips per day.
156 x 4.6 miles per round trip on Rilda Canyon road (paved) = 717.6 miles per day, and 717.6 x 240 days per year = 172,224 vehicle miles per year.
At 40 tons per truck load, 156 trips per day, and 240 days per year, the production is 1,497,600 tons per year.

TABLE 11-9

ESTIMATED COST OF EMISSION CONTROL

Emission Source	Items Contributing to Emission Control	Cost (including materials, labor and contingency)
1. Conveyor to stockpile	147 feet of conveyor covering between mine portal and transfer-sampling building, part of cost of the building, 484 feet of conveyor covering between building and coal stockpile, and water spray system at conveyor transfer and discharge points	$167,395
2. Stockpile	Water spray at conveyor discharge point at top of stacking tube, and stacking tube itself	$84,017
3. Conveyor from stockpile to crushing and screening building	286 feet of conveyor covering with water spraying system at discharge point, and including cost of reclaim tunnel as an enclosed coal transfer space	$469,927
4. Double-deck screen 5. Crusher 6. Stoker screen	Items 4, 5, and 6 are enclosed inside a building. The building cost shown excludes supporting structure for the coal handling equipment and the equipment itself	$143,535
7. Conveyor from crushing-screening building to coal loadout hopper	230 feet of conveyor covering with water spraying system at discharge point	$19,649

TABLE 11-9 (Cont.)

ESTIMATED COST OF EMISSION CONTROL

Emission Source	Items Contributing to Emission Control	Cost (including materials, labor and contingency)
8. Discharge from loadout hopper to trucks	Loadout chute and water spray	$28,069
	Subtotal of coal handling emission control	$912,592
9. & 10. Rilda Canyon road fugitive dust suppression	A. Watering at $42/hr x 140 days/year x 6 hours/day	$35,280/year
	B. Chemical dust suppression without watering, 3 applications per year	$19,500/year
	C. Asphalt pavement	$256,893

The total cost of emission control during coal handling is estimated to be $912,592, all of which represents initial costs of construction. Added to this amount will be the cost of fugitive dust control along Rilda Canyon road. During part of the early mining operations, water will be used and the cost of this control will be $35,280 per year. Watering is not done during all 240 hauling days per year because part of the work year falls during winter months. Also, watering is not necessary constantly during the days when it is required. A schedule of 140 water days per year and 6 hours during each 16-hour work day is projected. The cost of chemical control, which is to be adopted when 460,800 tons per year of coal production is attained, is estimated to be $19,500 per year. The application of chemicals is required only about three times a year. Asphalt paving, which will be installed when coal production approaches 1 million tons per year, will cost $256,893 and any maintenance needed will be in addition to this amount.

11.5 CLIMATOLOGICAL AND AIR QUALITY MONITORING

No ongoing monitoring program for climatic and air quality data will be carried out in Rilda Canyon.

11.6 REFERENCES

1. Bureau of Air Quality, Utah State Division of Environmental Health, undated, but distributed in April, 1983, Information Supplement to Section 3.1, Utah Air Conservation Regulations.

2. State of Utah, Department of Health, Division of Environmental Health, 1982, Utah Air Conservation Regulations, Revision of September 28, 1982.

3. U.S. Department of Commerce, 1973-1982, Monthly and Annual Climatological Data for Utah.

4. U.S. Environmental Protection Agency, 1977, Compilation of Air Pollutant Emission Factors, 3rd Edition, including Supplement 1-7, EPA Publication AP-42.

5. U.S. Environmental Protection Agency, Dec., 1979, "Dear Colleague" Letter REF: 8AH-A, containing "Compilation of Past Practices and Interpretations by EPA Region VIII on Air Quality Mining."

6. Utah Power & Light Co., 1979, Wilberg Mine Permit, Cottonwood Portal Modification.

EXHIBIT 11-1

DAILY AND HOURLY WIND DIRECTION AND VELOCITY

IN RILDA CANYON DURING

THE PERIOD 12/77 THROUGH 4/78

Courtesy of

Utah Power & Light Company

Salt Lake City, Utah

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILDA STATION

DATA FOR DECEMBER 1977 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	00	01	02	03	04	05	06	07	08	09	10	11
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15	212/ .9	207/ .9	212/ 1.3	214/ 1.3	211/ .9	213/ 1.3	206/ .9	198/ .9	193/ .9	144/ 1.3	158/ 1.3	92/ 1.3
16	230/ 1.8	218/ 1.3	231/ 1.8	224/ 1.3	228/ 1.3	235/ 1.3	225/ 1.3	234/ 1.3	224/ 1.3	205/ 1.3	240/ 1.3	239/ 1.8
17	235/ .9	221/ 1.3	218/ 1.3	228/ 1.3	232/ 1.3	230/ 1.3	237/ 1.3	237/ 1.3	228/ 1.3	232/ .9	232/ .9	164/ .9
18	263/ .9	86/ 1.3	58/ 1.3	139/ 1.3	179/ 1.3	90/ 1.3	195/ .9	267/ .4	134/ 1.3	239/ 1.3	237/ 1.8	235/ 1.8
19	223/ .9	251/ .9	253/ 1.3	223/ .9	221/ .9	218/ 1.3	246/ .9	251/ .4	239/ 1.3	242/ .9	232/ .9	230/ .4
20	217/ .9	229/ .9	226/ .9	234/ .4	264/ .9	250/ .9	241/ 1.3	243/ 1.3	234/ .9	223/ .9	220/ 1.8	220/ 1.3
21	229/ 2.2	220/ 2.2	234/ 2.2	233/ 2.2	235/ 2.2	234/ 2.2	235/ 2.2	234/ 2.2	233/ 2.2	234/ 1.3	233/ .9	235/ .9
22	194/ .9	147/ 1.3	134/ 1.3	224/ .9	162/ 1.8	196/ 1.3	219/ 1.3	152/ 1.3	191/ .9	136/ .9	49/ 1.8	55/ 1.8
23	226/ .4	221/ .4	215/ .9	226/ .9	216/ .9	217/ .9	221/ .4	215/ .9	224/ .9	216/ .9	229/ .4	239/ .4
24	213/ .4	213/ .4	222/ .9	232/ 2.2	234/ 2.2	233/ 2.7	236/ 2.2	224/ 1.3	217/ 1.8	221/ .9	232/ 1.8	232/ 1.8
25	147/ .9	224/ .9	219/ .9	219/ .9	212/ .9	205/ .9	193/ .9	191/ .9	214/ .9	209/ 1.3	228/ .9	232/ 1.3
26	209/ .9	217/ .9	218/ .9	221/ .9	206/ .9	212/ .4	217/ .9	204/ .4	215/ .9	232/ .9	243/ .9	241/ 1.3
27	231/ .9	231/ .9	235/ .9	234/ .9	236/ .9	208/ .9	216/ .9	176/ .9	178/ .9	213/ .9	139/ 1.3	43/ 2.2
28	214/ .9	52/ 1.3	105/ .9	89/ .9	121/ 1.3	167/ .9	143/ .9	220/ .9	201/ .9	221/ .9	179/ .9	342/ 1.3
29	164/ .9	180/ .9	218/ .9	217/ .4	205/ .4	210/ .9	214/ .4	233/ .4	219/ .9	219/ .4	230/ .4	302/ .4
30	125/ 1.3	134/ 1.3	218/ .9	231/ .9	226/ 1.3	230/ 1.8	218/ 1.3	230/ .4	224/ .9	219/ .9	233/ .9	221/ .4
31	244/ 1.8	235/ .4	228/ 1.8	226/ 1.3	219/ .9	210/ .9	229/ .9	220/ .9	224/ .9	229/ .4	218/ .9	120/ 1.3
TOTAL OBSERVATIONS PER HOUR	17	17	17	17	17	17	17	17	17	17	17	17

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILBA STATION

DATA FOR DECEMBER 1977 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	12	13	14	15	16	17	18	19	20	21	22	23	RESULTANT DIR/VEL
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14								182/ 1.3	209/ .9	220/ .9	221/ .4	211/ 1.3	205/ 1.0
15	54/ 2.2	73/ 2.2	131/ 1.8	191/ 2.2	236/ 1.8	224/ 1.8	235/ 1.8	228/ 1.3	214/ 1.8	216/ 1.8	216/ 1.3	228/ 1.3	196/ .9
16	225/ 2.2	235/ 2.2	231/ 2.2	236/ 1.8	220/ 1.3	223/ .4	228/ 1.3	221/ .9	250/ .4	231/ .9	234/ 1.3	232/ 1.3	229/ 1.4
17	52/ 1.8	47/ 2.2	37/ 1.8	46/ 1.8	74/ 1.3	69/ 1.3	316/ .9	166/ .9	126/ .9	142/ .9	62/ 1.3	92/ .9	167/ .2
18	235/ 1.8	222/ 1.8	232/ 1.3	216/ 1.3	233/ 1.3	233/ 1.8	222/ .9	232/ .9	221/ .4	226/ .9	222/ .4	223/ .4	213/ .8
19	224/ .4	234/ .9	237/ .9	234/ 1.3	235/ .9	230/ .9	219/ .9	215/ .4	201/ .4	215/ .4	225/ .4	225/ .4	232/ .8
20	232/ 2.2	234/ 1.3	63/ 1.8	113/ 1.3	209/ .4	213/ .4	221/ .9	225/ .4	211/ 1.8	213/ 1.8	212/ 1.3	214/ 2.2	221/ .9
21	244/ .9	47/ 1.8	54/ 1.8	135/ 1.3	113/ 1.3	192/ .9	170/ .9	181/ .4	190/ .4	189/ .4	177/ .9	204/ .4	219/ 1.0
22	59/ 2.2	159/ 1.8	91/ 2.2	308/ .9	78/ 1.8	91/ 1.3	217/ .9	221/ .9	207/ .9	221/ .4	216/ .4	223/ .4	141/ .6
23	177/ 1.8	86/ 1.8	59/ 1.8	52/ 1.8	142/ 1.3	159/ .9	192/ .9	218/ .9	191/ .4	212/ .9	227/ .4	199/ .4	187/ .5
24	238/ 2.2	243/ 2.2	245/ 2.7	245/ 2.2	235/ 2.2	230/ 1.8	209/ .9	219/ .9	214/ .9	202/ .9	139/ .9	155/ .9	228/ 1.5
25	106/ 1.8	123/ 1.8	44/ 1.3	84/ 1.8	210/ .4	208/ .4	211/ .4	209/ .4	212/ .9	215/ .9	208/ .4	209/ .9	188/ .6
26	53/ 1.8	72/ 1.8	133/ 1.3	82/ 1.3	157/ .9	197/ .4	212/ .4	207/ .4	229/ .4	224/ .4	213/ .4	228/ .9	196/ .4
27	50/ 2.2	53/ 1.8	45/ 2.2	40/ 1.8	53/ 1.8	35/ 1.3	101/ 1.3	80/ 1.3	39/ 1.3	254/ .9	105/ .9	178/ .9	82/ .4
28	40/ 2.2	56/ 2.2	53/ 1.8	36/ 2.2	43/ 1.8	264/ 1.3	326/ .9	172/ 1.3	103/ 1.3	124/ .9	95/ .9	165/ .9	88/ .5
29	78/ 1.3	50/ 1.8	47/ 1.8	259/ 1.3	51/ 1.3	81/ 1.3	113/ .9	199/ .4	126/ 1.3	79/ 1.3	151/ .9	181/ .9	135/ .3
30	158/ 1.3	34/ 1.8	53/ 1.3	66/ 1.8	40/ 1.3	56/ 1.8	98/ 1.3	177/ .9	212/ .9	226/ .9	204/ .4	232/ .9	173/ .3
31	98/ 1.3	42/ 1.8	75/ 1.3	157/ .9	185/ .9	206/ .9	180/ .9	199/ .9	218/ .9	227/ .9	234/ 1.3	239/ .9	206/ .6

TOTAL OBSERVATIONS PER HOUR

12	13	14	15	16	17	18	19	20	21	22	23
17	17	17	17	17	17	17	18	18	18	18	18

TOTAL NUMBER OF HOURLY OBSERVATIONS = 413 TOTAL NUMBER OF POSSIBLE OBSERVATIONS = 744

MAXIMUM WIND SPEED WAS 2.7 MPS AT 233 DEG AND OCCURRED DURING HOUR 0500, 12/24

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILDA STATION

DATA FOR JANUARY 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	00	01	02	03	04	05	06	07	08	09	10	11
1	225/ .9	216/ 1.8	237/ 1.8	235/ 2.2	226/ 1.8	222/ 1.8	219/ 1.8	213/ 1.8	220/ 1.8	215/ 1.8	225/ 1.8	218/ 2.2
2	222/ 2.2	220/ 2.2	222/ 2.2	231/ 2.2	228/ 1.8	223/ 1.8	229/ 1.3	217/ 1.8	226/ 1.3	226/ 1.8	226/ 1.8	228/ 1.3
3	201/ 1.3	220/ .9	209/ .9	205/ .9	217/ .9	206/ .9	204/ .4	209/ .4	212/ .9	198/ .4	213/ .4	223/ .4
4	201/ .9	206/ .9	213/ .9	195/ .9	207/ .4	350/ .9	212/ .4	30/ 1.8	152/ .9	52/ .9	33/ 1.3	99/ 1.3
5	324/ 1.3	73/ 1.3	23/ 1.3	248/ .4	72/ 1.3	160/ 1.3	147/ .9	209/ .4	222/ .4	230/ .4	215/ .4	239/ .4
6	219/ .9	72/ 1.3	262/ .9	54/ 1.8	75/ 1.3	213/ .4	201/ .4	73/ .9	204/ .9	111/ .9	234/ .4	232/ 1.8
7	241/ .4	236/ .9	236/ .9	233/ .9	234/ .9	224/ .4	226/ .4	228/ .4	213/ .4	199/ .4	0/ 0.0	0/ 0.0
8	226/ 2.2	217/ 2.2	236/ 1.8	220/ 2.2	227/ 1.8	234/ 1.3	234/ 2.2	229/ 1.8	232/ 2.2	238/ 1.8	232/ 1.3	232/ .4
9	229/ 1.3	234/ .9	237/ .9	231/ .4	219/ .4	225/ .4	220/ .4	225/ .4	224/ .4	229/ .4	0/ 0.0	227/ .4
10	67/ 1.8	340/ .9	277/ 1.3	167/ 1.3	214/ .9	211/ .9	125/ 1.3	158/ .9	202/ .9	128/ .9	256/ .4	274/ .9
11	212/ 1.3	202/ 1.3	232/ 1.3	227/ 1.3	218/ .9	208/ 1.3	218/ .9	205/ .9	217/ .9	202/ .9	76/ 1.3	38/ 2.2
12	212/ .9	232/ .9	150/ .9	218/ .4	133/ 1.3	129/ .9	222/ .9	218/ .4	209/ 1.3	224/ .4	229/ .9	230/ .9
13	245/ 1.3	171/ 1.8	202/ .9	216/ 1.3	226/ .9	213/ .9	218/ 1.3	216/ .9	252/ .9	226/ 2.2	213/ 1.8	195/ 1.8
14	239/ 1.8	236/ 1.3	238/ 1.8	240/ 1.3	241/ 1.8	241/ 1.3	236/ 1.3	233/ 1.3	223/ .9	228/ .9	219/ .9	265/ .9
15	156/ 1.3	44/ 1.8	97/ 1.8	59/ 1.3	203/ 1.3	280/ .9	97/ 1.3	50/ 1.3	66/ 1.3	68/ .9	90/ .9	43/ 1.8
16	187/ .9	208/ .9	203/ .9	84/ 1.3	178/ .9	177/ .9	221/ .9	210/ .4	209/ .4	228/ .4	195/ .4	48/ 1.3
17	187/ 1.3	222/ .4	224/ .9	224/ .9	224/ .9	205/ .9	214/ .9	151/ 1.3	169/ .4	162/ .9	258/ .9	298/ 1.3
18	225/ 1.3	219/ .9	215/ .4	211/ .9	218/ .4	207/ .9	213/ .9	213/ .9	204/ .9	217/ .4	236/ .9	244/ 1.3
19	237/ 1.8	239/ 1.8	239/ 2.2	239/ 1.3	231/ 1.3	224/ .9	226/ .9	226/ .9	0/ 1.3	219/ .4	333/ .4	62/ .9
20	226/ 1.3	225/ .9	229/ 1.3	238/ 1.3	179/ 1.3	213/ .9	205/ .9	188/ .9	202/ .4	206/ .4	224/ .4	155/ .4
21	236/ .9	236/ .9	231/ .9	229/ .9	227/ .9	227/ 1.3	215/ 1.3	201/ 1.3	232/ .9	223/ .9	246/ .9	239/ .9
22	225/ 2.2	218/ 2.7	222/ 2.7	220/ 2.2	228/ 2.2	224/ 2.2	222/ 2.2	228/ 1.8	226/ 1.8	228/ 1.3	232/ 2.2	232/ .9
23	220/ .9	84/ 1.3	168/ 1.3	219/ .9	223/ .9	192/ .9	225/ .9	241/ .9	252/ .9	252/ .9	249/ 1.8	246/ 1.8
24	257/ 1.8	244/ 1.8	248/ 1.3	237/ 1.3	227/ .9	232/ 1.3	236/ 2.2	251/ 1.8	250/ 1.3	246/ 1.3	243/ 3.6	242/ 3.6
25	254/ 2.7	245/ 2.7	250/ 1.8	243/ 2.7	243/ 2.2	236/ 1.3	225/ 1.3	229/ 1.8	241/ 2.2	248/ 2.2	234/ 2.2	239/ 2.7
26	225/ .9	212/ .9	198/ .9	213/ 1.3	194/ .9	54/ 1.3	79/ 1.3	111/ .9	176/ .9	138/ .4	72/ .4	36/ 1.3
27	227/ 1.3	227/ 1.3	240/ .9	250/ 1.3	245/ 1.3	247/ .9	242/ 1.3	230/ .9	114/ 1.3	193/ .4	230/ .4	238/ .4
28	226/ 1.3	238/ .9	243/ .9	241/ .9	238/ .9	236/ 1.3	236/ 1.3	234/ .9	232/ .9	232/ .9	234/ .9	232/ .9
29	216/ 1.3	213/ .9	211/ .9	213/ .9	210/ .9	208/ .9	224/ .9	214/ .9	217/ .9	223/ .9	223/ .4	181/ .4
30	221/ 1.3	214/ .9	225/ 1.3	220/ .9	231/ .9	224/ 1.3	249/ .9	244/ 1.3	234/ .9	233/ .9	235/ .9	235/ 1.3
31	235/ 1.3	228/ 1.3	232/ 1.3	236/ 1.8	236/ 1.3	243/ .9	233/ .9	236/ .9	235/ .9	230/ .4	230/ .4	244/ .4

TOTAL OBSERVATIONS PER HOUR

00	01	02	03	04	05	06	07	08	09	10	11
31	31	31	31	31	31	31	31	31	31	31	31

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILDA STATION

DATA FOR JANUARY 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	12	13	14	15	16	17	18	19	20	21	22	23	RESULTANT DIR/VEL
1	227/ 1.8	224/ .4	21/ 1.3	24/ 1.3	112/ 1.3	145/ .9	194/ .4	220/ .9	223/ .9	216/ 1.8	213/ 1.8	211/ 1.8	218/ 1.2
2	239/ .9	51/ 2.2	39/ 1.8	27/ 2.2	38/ 1.8	58/ 1.8	48/ 1.8	78/ 1.3	206/ .9	168/ .9	210/ .9	207/ .9	217/ .6
3	25/ 1.3	7/ 1.3	52/ 1.8	39/ 2.2	62/ 1.8	287/ 1.3	118/ 1.3	66/ 1.3	191/ .9	187/ .9	68/ 1.8	164/ 1.3	133/ .2
4	54/ 2.2	51/ 1.8	44/ 1.8	55/ 2.2	75/ 1.8	37/ 2.2	48/ 2.2	216/ .4	220/ .9	42/ 1.8	55/ 1.3	181/ 1.3	63/ .7
5	40/ 1.3	59/ .9	29/ 1.8	37/ 1.8	54/ 1.3	85/ 1.3	228/ .4	208/ .4	206/ .9	214/ .9	213/ .4	206/ .4	73/ .2
6	238/ .9	240/ 1.3	236/ 1.8	245/ 1.8	220/ .9	222/ .4	241/ 2.2	229/ .9	199/ .9	218/ .9	234/ .4	230/ .9	221/ .6
7	70/ 1.8	23/ 2.2	9/ .9	80/ 1.8	235/ 1.3	137/ 1.8	195/ .9	224/ .9	229/ 2.2	234/ 1.8	227/ 2.7	225/ 2.7	218/ .5
8	240/ .9	41/ 2.2	55/ 2.2	13/ 1.8	356/ 1.3	29/ 1.8	155/ 1.3	230/ .9	214/ .9	232/ 1.3	239/ 1.3	235/ .9	234/ .8
9	237/ .9	55/ 1.3	34/ 1.8	66/ 1.8	55/ 2.2	66/ 1.3	141/ 1.3	211/ .9	92/ 1.3	22/ 1.3	62/ 1.3	106/ .9	94/ .2
10	201/ .4	50/ 1.8	57/ 1.3	57/ 1.3	60/ .9	231/ .9	57/ 1.3	186/ .9	217/ .9	215/ .9	211/ .9	213/ .4	150/ .2
11	45/ 1.8	46/ 1.8	62/ 1.3	51/ 1.8	35/ 1.3	36/ 1.8	208/ .9	242/ .9	200/ .4	215/ .4	199/ .4	211/ .4	152/ .1
12	246/ 1.3	240/ 1.3	238/ 1.8	248/ .9	237/ 1.3	231/ 1.3	234/ .9	234/ 1.8	237/ 1.3	240/ 1.3	236/ 1.3	237/ .9	225/ .9
13	177/ 1.3	36/ 2.2	28/ 1.3	41/ 1.3	230/ .9	44/ .9	172/ .4	201/ .4	203/ .9	223/ .4	205/ .9	218/ .4	209/ .6
14	51/ 1.3	62/ 1.3	51/ .9	66/ 1.3	48/ 1.3	37/ 1.3	43/ 1.3	39/ 1.3	61/ 1.3	32/ .9	63/ 1.3	204/ .9	255/ .1
15	67/ 1.3	20/ 1.8	41/ 1.3	46/ 1.3	67/ 1.3	233/ .9	234/ .4	31/ 1.3	225/ .9	234/ .4	202/ .9	197/ .4	68/ .6
16	45/ 2.2	135/ 1.8	50/ 2.2	73/ 1.8	39/ 2.2	55/ 1.3	133/ 1.8	189/ .9	209/ .9	35/ 1.8	287/ .4	167/ .9	187/ .5
17	48/ 1.8	80/ 1.3	48/ 1.8	51/ 1.3	41/ 1.8	219/ .9	231/ 1.3	220/ .9	227/ .9	218/ .9	223/ .9	225/ .4	199/ .3
18	242/ 1.8	251/ .4	34/ 1.3	25/ 1.3	55/ 1.3	223/ .9	221/ .9	211/ .4	242/ .9	225/ 1.3	235/ .9	230/ 1.3	228/ .6
19	38/ 1.8	35/ 1.8	31/ 1.8	31/ 2.7	36/ 1.8	124/ 1.3	40/ 1.3	38/ 1.3	185/ .9	188/ .9	211/ .4	211/ .4	334/ .1
20	51/ 2.2	49/ 1.8	77/ 1.8	61/ 1.3	236/ 1.8	245/ 2.7	239/ 2.2	229/ 1.8	222/ .9	232/ .4	223/ .4	237/ .9	217/ .6
21	249/ 2.2	249/ 1.8	93/ 1.8	47/ 2.2	63/ 1.8	91/ 1.8	182/ 1.3	215/ .9	215/ .9	225/ 1.3	225/ 1.8	220/ 2.7	216/ .7
22	52/ 1.8	41/ 1.8	29/ 1.8	29/ 1.8	43/ 1.3	36/ 1.3	38/ .9	335/ .9	160/ .9	183/ .9	183/ .9	195/ .9	222/ .7
23	247/ 2.7	247/ 1.8	244/ 1.8	249/ 1.8	246/ 2.7	250/ 2.7	248/ 2.2	252/ 2.7	247/ 2.2	247/ 2.2	244/ .4	239/ .9	241/ 1.4
24	248/ 4.0	250/ 3.1	246/ 3.1	255/ 3.1	250/ 3.1	252/ 3.6	247/ 4.0	242/ 2.2	247/ 2.7	240/ 2.7	242/ 2.2	246/ 2.7	246/ 2.4
25	59/ 1.8	73/ 2.2	248/ 1.3	248/ 2.7	44/ 1.8	56/ 1.8	126/ .9	184/ .9	132/ .9	195/ .9	186/ .9	228/ .4	234/ 1.0
26	62/ 1.3	52/ 1.3	33/ 1.8			77/ 1.8	100/ 1.3	223/ .9	262/ .9	231/ .9	217/ .9	223/ .9	120/ .3
27	44/ 1.3	39/ 1.8	48/ 1.3	34/ 1.8	36/ 1.8	52/ 1.8	30/ 1.3	194/ .9	224/ .9	228/ .9	226/ .4	238/ .9	251/ .1
28	235/ .9	59/ 1.3	50/ 1.8	36/ 1.3	35/ 1.8	35/ 1.8	100/ .9	133/ .9	207/ .9	200/ .9	200/ .4	207/ .4	225/ .3
29	61/ 1.3	56/ 1.8	49/ 1.8	38/ 1.3	52/ 1.3	222/ 1.3	141/ 1.3	190/ 1.3	204/ 1.3	190/ 1.3	178/ .4	206/ .4	186/ .4
30	245/ .9	44/ 1.8	42/ 1.8	6/ 1.3	51/ 1.3	11/ 1.3	170/ .9	216/ .9	209/ .9	211/ .9	239/ .4	235/ .4	235/ .4
31	56/ 2.2	54/ 1.3	46/ 1.3	53/ 1.8	46/ 1.8	43/ 1.3	188/ .9	192/ .9	152/ .9	179/ .9	195/ .4	181/ .9	195/ .2

TOTAL OBSERVATIONS PER HOUR

12	13	14	15	16	17	18	19	20	21	22	23
31	31	31	30	30	31	31	31	31	31	31	31

TOTAL NUMBER OF HOURLY OBSERVATIONS = 742 TOTAL NUMBER OF POSSIBLE OBSERVATIONS = 744

MAXIMUM WIND SPEED WAS 4.0 MPS AT 248 DEG AND OCCURRED DURING HOUR 1200, 1/24

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILDA STATION

DATA FOR FEBRUARY 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	00	01	02	03	04	05	06	07	08	09	10	11
1	121/ 1.3	36/ 1.3	49/ 1.8	41/ 1.3	47/ 1.3	11/ 1.3	108/ 1.3	231/ .4	55/ 1.3	152/ .9	193/ .9	101/ .9
2	218/ .4	226/ .4	222/ .4	227/ .4	231/ .9	232/ .4	225/ .4	229/ .4	227/ .4	228/ .4	229/ .4	157/ .9
3	214/ .9	242/ .9	235/ 1.3	182/ .9	229/ .4	227/ .9	206/ .9	215/ .4	222/ .9	237/ .9	225/ .4	300/ .4
4	232/ .4	230/ 1.3	218/ 1.3	228/ 1.8	223/ 1.3	239/ .9	225/ 1.3	237/ 1.3	241/ .4	223/ 1.3	232/ 2.2	258/ 1.3
5	220/ .9	214/ .4	220/ .4	216/ .9	189/ .9	215/ .9	263/ .9	224/ .4	166/ .9	285/ .9	149/ .9	122/ .9
6	42/ 1.3	124/ .9	140/ .9	199/ 1.3	59/ .9	159/ .9	215/ .9	85/ 1.3	92/ 1.3	157/ .4	230/ .9	87/ 1.3
7	167/ .9	209/ .4	207/ .4	211/ .4	213/ .4	210/ .4	210/ .4	217/ .4	217/ .4	179/ .4	85/ .9	302/ .9
8	189/ .4	193/ .4	159/ .4	181/ .4	224/ .4	220/ 1.3	229/ 2.2	225/ 1.8	224/ 1.8	234/ 1.8	231/ 1.3	230/ 1.8
9	223/ 2.2	226/ 2.2	221/ 2.2	231/ 2.2	228/ 2.2	231/ 2.2	233/ 2.2	232/ .9	230/ .9	228/ .9	221/ .9	211/ .4
10	135/ .9	292/ .9	194/ .9	220/ .9	155/ .9	170/ .9	189/ .9	187/ .4	215/ .4	215/ .4	164/ .4	141/ .4
11	123/ .9	199/ .4	74/ .4	60/ .4	36/ .4	63/ .4	165/ .4	141/ .4	152/ .4	193/ .4	179/ .4	222/ .4
12	249/ .4	232/ 1.3	241/ .9	234/ 1.3	234/ 1.3	234/ .9	238/ .9	231/ .9	226/ .9	233/ .4	246/ .4	237/ .9
13	229/ 2.2	241/ 1.3	232/ 1.8	234/ 2.2	232/ 2.2	237/ 2.2	227/ 2.2	227/ 2.2	225/ 2.2	230/ 2.2	230/ 2.2	234/ 1.8
14	260/ .9	236/ 1.8	211/ 1.8	211/ 1.8	220/ 1.8	213/ 1.3	227/ 2.2	218/ 2.2	218/ 2.2	230/ 1.8	223/ 1.8	227/ 1.8
15	228/ .9	225/ 1.3	218/ 2.2	211/ 2.2	222/ 1.8	222/ 1.8	212/ 2.2	224/ 1.8	212/ 1.8	221/ 1.3	221/ 1.3	162/ .4
16	219/ .9	222/ .9	235/ .9	229/ .4	237/ 1.3	236/ .9	239/ .9	249/ .9	257/ .9	244/ 1.3	238/ 1.8	241/ 2.2
17	210/ .9	226/ .9	218/ .9	225/ .9	219/ .9	226/ .9	223/ .4	209/ .4	192/ .9	218/ .9	230/ .9	216/ .9
18	237/ 1.8	239/ 1.8	228/ 2.7	225/ 2.7	225/ 2.2	216/ 2.2	216/ 2.2	225/ 1.8	216/ 1.3	223/ 2.2	235/ 2.2	242/ 1.8
19	235/ .9	249/ .9	253/ .4	258/ .9	253/ .9	241/ 1.3	245/ 2.2	240/ 1.8	242/ 2.2	240/ 2.2	237/ 2.2	237/ 3.6
20	239/ 1.3	237/ 1.8	232/ 2.2	242/ 2.2	240/ 2.2	242/ 2.7	238/ 2.2	241/ 2.2	241/ 2.2	241/ 2.2	239/ 3.1	239/ 2.7
21	250/ .9	227/ .9	213/ 1.3	209/ 2.2	223/ 2.2	219/ 2.2	212/ 2.7	210/ 2.2	215/ 2.2	222/ 2.2	225/ 2.2	234/ 1.8
22	234/ 2.2	228/ 2.7	219/ 2.7	218/ 2.7	214/ 2.7	210/ 2.7	213/ 3.1	200/ 3.6	204/ 3.1	211/ 3.1	217/ 2.7	237/ 1.8
23	215/ 2.2	215/ 2.2	217/ 2.2	214/ 2.7	212/ 2.7	214/ 2.2	211/ 2.7	208/ 2.2	215/ 2.2	217/ 2.2	226/ 2.2	238/ 1.8
24	235/ 1.3	233/ 1.8	234/ .9	231/ .9	225/ .9	214/ .9	215/ .9	214/ .9	215/ .9	223/ .9	236/ .9	239/ .4
25	227/ 1.3	229/ 2.2	221/ 2.2	223/ 1.8	229/ 1.8	224/ 2.2	223/ 1.3	225/ 1.3	228/ .9	236/ .9	232/ .4	232/ .4
26	223/ .4	217/ .4	213/ .4	218/ .4	214/ .4	229/ .4	218/ .4	215/ .4	220/ .4	214/ .4	203/ .4	197/ .4
27	219/ .9	215/ .9	201/ .9	208/ .9	199/ .9	215/ .9	220/ .4	215/ .4	201/ .4	213/ .4	129/ .4	48/ .4
28	167/ .9	218/ .4	212/ .4	196/ .4	204/ .4	214/ .4	209/ .4	228/ .4	229/ .4	229/ .4	232/ .4	225/ .4
29												
30												
31												
TOTAL OBSERVATIONS PER HOUR	28	28	28	28	28	28	28	28	28	28	28	28

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILDA STATION

DATA FOR FEBRUARY 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	12	13	14	15	16	17	18	19	20	21	22	23	RESULTANT DIR/VEL
1	69/ 1.3	52/ .9	39/ 1.3	31/ 1.3	50/ 1.3	45/ 1.3	179/ .9	178/ .4	193/ .9	173/ .9	200/ .9	225/ .4	74/ .6
2	48/ 1.3	100/ .9	82/ 1.3	36/ 1.3	97/ .9	133/ 1.3	47/ .9	78/ .9	212/ .9	173/ .9	185/ .9	192/ .9	152/ .3
3	56/ 1.3	49/ 1.3	49/ 1.3	40/ .9	48/ 1.3	13/ .9	74/ .9	28/ .9	166/ .4	171/ .4	192/ .4	211/ .4	182/ .1
4	44/ 1.3	65/ 1.3	65/ 1.3	62/ 1.3	60/ 1.3	71/ 1.3	60/ 1.3	207/ .4	214/ .9	207/ .9	214/ .9	214/ .9	213/ .4
5	139/ 1.3	156/ 1.3	28/ 1.3	107/ .9	77/ .9	230/ .9	110/ .4	115/ .9	180/ .4	134/ .9	241/ .4	125/ .9	166/ .5
6	136/ .9	108/ 1.3	37/ 1.3	55/ 1.3	41/ .9	38/ .9	255/ .9	227/ .9	208/ .4	203/ .4	202/ .4	132/ .9	113/ .4
7	65/ 1.3	48/ 1.3	53/ 1.3	41/ 1.3	54/ 1.3	28/ 1.3	348/ .9	144/ .4	189/ .9	73/ .9	140/ .4	136/ .4	83/ .2
8	236/ 2.2	234/ 2.2	230/ 2.2	231/ 2.2	234/ 2.2	228/ 1.8	224/ 1.8	215/ .9	211/ .4	219/ .9	227/ .9	213/ 1.8	225/ 1.4
9	184/ .9	91/ .9	38/ .9	32/ .9	33/ 1.3	25/ .9	66/ .9	50/ .9	28/ .9	22/ .9	84/ .9	234/ .4	225/ .5
10	251/ .9	62/ .9	139/ .9	167/ .9	81/ .9	90/ .9	328/ .4	300/ .4	153/ .4	144/ .4	230/ .4	76/ .4	168/ .3
11	235/ .4	231/ .4	52/ .9	48/ .9	110/ .9	190/ .4	205/ .4	229/ .9	232/ .4	223/ .4	231/ .4	225/ .4	162/ .2
12	319/ .9	39/ .9	46/ 1.3	58/ .9	58/ 1.3	54/ 1.3	49/ .9	112/ .9	215/ .4	227/ .9	225/ 1.3	230/ 1.3	235/ .3
13	238/ .9	59/ 1.3	53/ 1.3	40/ 1.8	43/ 1.3	148/ .9	222/ .9	180/ .4	214/ .4	214/ .4	227/ .9	225/ .4	228/ 1.0
14	238/ 1.3	250/ .9	243/ 1.8	241/ 1.8	234/ 1.3	228/ 1.3	216/ 1.3	233/ .9	240/ .4	227/ .9	229/ .9	223/ .9	227/ 1.4
15	45/ 1.3	52/ 1.3	43/ 1.3	32/ 1.3	41/ 1.3	44/ 1.3	30/ .9	56/ .9	77/ .9	213/ .4	227/ .4	218/ .4	209/ .4
16	246/ 2.2	244/ 2.2	246/ 2.2	243/ 2.2	243/ 2.2	241/ 2.2	238/ 2.2	224/ 1.3	221/ .9	214/ .9	207/ .4	218/ .9	238/ 1.4
17	238/ 1.3	240/ 1.3	241/ 1.8	239/ 2.2	237/ 2.2	238/ 1.8	246/ 1.8	230/ 1.3	230/ 1.8	236/ 1.3	238/ 1.8	230/ 1.3	231/ 1.2
18	243/ 2.2	236/ 2.2	239/ 2.2	240/ 2.2	238/ 2.7	236/ 2.7	239/ 2.2	237/ 2.2	235/ .4	238/ .4	197/ .9	199/ .9	231/ 1.9
19	247/ 4.5	246/ 3.6	242/ 3.1	245/ 2.7	248/ 2.7	246/ 3.1	238/ 3.1	234/ 2.7	235/ 2.7	231/ 2.2	227/ 2.2	230/ 2.2	241/ 2.3
20	244/ 3.1	246/ 2.2	242/ 2.7	244/ 2.7	242/ 2.2	235/ 2.2	242/ 1.8	232/ 1.3	230/ .9	232/ .4	237/ .4	239/ .4	240/ 2.0
21	172/ 1.3	41/ 1.3	39/ 1.3	37/ 1.3	49/ 1.3	92/ .9	221/ .4	214/ .9	226/ .9	210/ 1.3	208/ 2.2	218/ 2.2	214/ 1.1
22	45/ 1.3	49/ 1.3	61/ 1.3	65/ 1.3	70/ 1.3	72/ .9	161/ .9	210/ .4	212/ .4	228/ .4	214/ 1.8	209/ 1.8	208/ 1.3
23	227/ .9	35/ 1.3	34/ 1.3	31/ 1.3	39/ 1.3	48/ .9	52/ .9	210/ .4	207/ .4	208/ .4	198/ .4	230/ .4	215/ 1.0
24	50/ .9	53/ 1.3	46/ 1.3	44/ 1.3	18/ 1.3	42/ 1.3	70/ .9	124/ .4	204/ .4	206/ .4	223/ .4	216/ .4	219/ .2
25	59/ 1.3	52/ 1.3	54/ 1.3	58/ 1.8	75/ .9	51/ .9	151/ .9	231/ .9	177/ .9	209/ .4	216/ .4	0/ 0.0	212/ .5
26	51/ .4	49/ .9	47/ .9	31/ 1.3	33/ .9	31/ 1.3	1/ .9	268/ .4	187/ .4	213/ .4	211/ .4	211/ .4	233/ .0
27	52/ .9	270/ .9	55/ .9	41/ .9	231/ .4	172/ .4	233/ .4	220/ .4	227/ .4	225/ .4	209/ .4	199/ .4	207/ .3
28	150/ .4	66/ .9	41/ 1.3	74/ .9	84/ .9	106/ .9	358/ .4	69/ .4	93/ .4	196/ .4	94/ .4	50/ .4	134/ .2
29													
30													
31													

TOTAL OBSERVATIONS PER HOUR

12	13	14	15	16	17	18	19	20	21	22	23
28	28	28	28	28	28	28	28	28	28	28	28

TOTAL NUMBER OF HOURLY OBSERVATIONS = 672 TOTAL NUMBER OF POSSIBLE OBSERVATIONS = 672

MAXIMUM WIND SPEED WAS 4.5 MPS AT 247 DEG AND OCCURRED DURING HOUR 1200. 2/19

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILDA STATION

DATA FOR MARCH 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	00	01	02	03	04	05	06	07	08	09	10	11
1	61/ .9	61/ .9	176/ .4	293/ .4	286/ .9	179/ .9	249/ .9	212/ .4	201/ .4	213/ .4	222/ .4	99/ .4
2	201/ .4	191/ .4	201/ .4	236/ .4	215/ .4	199/ .4	176/ .9	215/ .4	208/ .4	17/ .4	31/ .4	43/ .4
3	217/ .4	44/ .4	59/ .4	71/ .4	193/ .9	75/ .9	75/ .9	43/ .4	25/ .4	53/ .4	42/ .4	29/ .9
4	231/ .4	222/ .4	230/ .9	230/ .4	212/ .4	209/ .4	219/ .4	233/ .4	234/ .4	222/ .4	0/ 0.0	22/ .9
5	124/ .4	215/ .9	209/ .9	223/ .9	223/ .9	212/ .9	214/ .9	233/ .9	48/ .9	49/ .9	5/ .9	38/ .9
6	212/ .9	203/ .9	206/ 1.3	214/ .9	226/ .9	226/ .9	220/ .9	218/ .9	207/ .9	226/ .9	241/ .9	234/ 1.3
7	251/ .9	228/ .9	232/ .9	232/ .9	236/ .9	234/ .9	236/ 1.3	231/ .9	231/ 2.2	228/ 1.3	228/ 1.3	237/ .4
8	226/ .9	217/ .9	217/ 2.2	217/ 1.3	224/ 1.8	224/ 1.3	225/ .9	225/ .9	222/ .9	232/ .9	232/ .9	234/ .4
9	238/ .4	234/ .4	235/ .4	236/ .9	232/ .9	228/ .9	233/ .9	236/ .9	235/ .9	238/ .9	241/ .9	58/ 1.3
10	289/ .4	207/ .4	203/ .4	208/ .4	221/ .4	240/ .9	217/ .4	225/ .4	214/ .4	221/ .4	245/ .9	246/ .4
11	209/ .4	209/ .4	217/ .4	210/ .4	222/ .4	232/ .4	221/ .4	223/ .4	228/ .4	250/ .9	262/ .9	45/ .9
12	36/ 1.3	20/ .9	184/ .4	308/ .4	215/ .4	215/ .9	224/ .4	229/ .4	218/ .4	206/ .4	7/ .9	31/ 1.8
13	213/ .4	220/ .4	211/ .4	196/ .4	213/ .4	212/ .4	212/ .4	0/ 0.0	219/ .4	0/ 0.0	230/ .4	0/ 0.0
14	86/ .9	222/ .4	178/ .4	212/ .4	203/ .4	234/ .4	239/ .4	221/ .9	233/ .4	0/ 0.0	246/ .9	239/ .9
15	250/ .4	246/ .4	220/ .4	223/ .4	223/ .4	247/ .4	245/ .4	238/ .4	234/ .4	119/ .9	52/ 1.3	41/ .9
16	214/ .4	210/ .4	245/ .4	234/ .4	229/ .4	237/ .4	240/ .9	235/ .9	236/ .4	227/ .4	0/ 0.0	0/ 0.0
17	211/ .9	204/ 1.3	216/ 1.3	214/ 1.3	226/ 1.3	221/ 1.8	215/ 1.8	217/ 1.3	215/ .9	218/ 1.8	0/ 0.0	0/ 0.0
18	229/ .9	230/ .9	228/ 1.3	224/ .9	225/ .4	228/ .9	231/ .4	234/ .4	230/ .4	238/ .4	0/ 0.0	0/ 0.0
19	232/ .4	231/ .9	233/ .4	237/ .4	234/ .4	210/ .4	228/ .4	230/ .4	234/ .4	229/ .4	233/ .4	242/ .4
20	211/ .4	204/ 1.3	211/ .9	235/ .4	221/ .9	221/ .4	224/ .4	213/ .4	0/ 0.0	0/ 0.0	0/ 0.0	241/ .9
21	221/ 1.3	221/ 1.3	224/ 1.8	222/ .9	211/ 1.3	213/ .9	216/ .9	219/ 1.3	217/ 1.3	224/ 1.8	236/ .9	31/ 1.3
22	213/ 1.3	227/ 2.2	211/ 1.8	216/ .9	219/ 1.3	205/ .9	210/ 1.3	205/ 2.7	208/ .4	215/ .9	222/ 2.2	238/ 2.7
23	237/ 2.2	220/ 2.2	206/ .9	219/ 1.8	211/ 1.8	225/ 1.3	215/ .9	226/ 1.8	202/ 2.2	203/ .9	245/ 1.3	39/ 1.3
24	230/ 2.7	216/ 1.8	228/ .9	226/ 1.3	199/ .9	115/ 1.8	183/ 1.3	226/ 2.2	235/ 3.6	229/ 3.1	234/ 3.1	239/ 3.6
25	212/ 2.2	221/ 3.1	217/ 3.1	222/ 2.7	215/ 3.1	203/ 3.1	206/ 2.2	218/ 2.7	211/ 4.0	215/ 4.0	230/ 4.0	239/ 2.7
26	220/ 4.0	225/ 4.9	213/ 4.5	225/ 3.6	216/ 4.5	211/ 3.6	223/ 4.9	211/ 4.5	206/ 4.0	213/ 4.5	225/ 4.5	230/ 3.1
27	215/ 2.7	222/ 3.6	213/ 3.1	220/ 2.7	218/ 2.7	212/ 4.0	212/ 4.5	212/ 4.5	218/ 4.5	210/ 4.9	218/ 4.5	232/ 3.1
28	218/ 4.5	218/ 4.9	211/ 4.5	219/ 5.4	221/ 5.4	224/ 4.9	219/ 4.5	220/ 2.2	217/ 2.7	222/ 2.7	223/ 2.7	239/ 4.8
29	213/ 4.5	206/ 4.9	202/ 4.0	204/ 4.5	207/ 4.9	207/ 4.9	207/ 4.5	210/ 4.9	218/ 4.9	220/ 4.5	225/ 5.4	234/ 5.4
30	225/ 4.5	219/ 4.5	222/ 4.9	213/ 4.9	213/ 5.4	220/ 5.4	216/ 4.9	212/ 4.9	219/ 5.4	227/ 4.9	229/ 4.9	45/ 3.1
31	216/ 2.2	225/ 2.2	232/ 1.8	227/ 2.2	222/ 4.5	203/ 1.3	215/ 1.8	219/ 1.3	231/ 2.2	240/ 2.2	237/ 1.3	354/ 1.8
TOTAL OBSERVATIONS PER HOUR	31	31	31	31	31	31	31	31	31	31	31	31

UTAH POWER AND LIGHT WIND DATA 05/11/78

U3 - RILDA STATION

DATA FOR MARCH 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	12	13	14	15	16	17	18	19	20	21	22	23	RESULTANT DIR/VEL
1	305/ .9	37/ .9	338/ .9	76/ .9	39/ .9	53/ .9	85/ .4	62/ .4	67/ .9	211/ .4	204/ .4	38/ .9	49/ .1
2	58/ .9	32/ .9	39/ .9	48/ .9	36/ .9	68/ .9	47/ .9	33/ .4	212/ .4	214/ .4	198/ .4	20/ .4	73/ .1
3	38/ .9	43/ 1.3	67/ .9	231/ .4	220/ .4	225/ .4	155/ .4	88/ .4	168/ .4	208/ .4	211/ .4	206/ .4	78/ .2
4	39/ .9	60/ .4	157/ .4	27/ .9	128/ .9	88/ .4	344/ .9	66/ .4	69/ .4	88/ .4	243/ .4	190/ .4	174/ .1
5	35/ 1.3	40/ 1.3	49/ .9	35/ .9	86/ .9	221/ .9	41/ .9	319/ .4	81/ .4	137/ .4	111/ .4	92/ .9	73/ .2
6	252/ 1.8	247/ .9	247/ .9	242/ .9	242/ .9	240/ .4	244/ .9	247/ .4	244/ .4	244/ .4	239/ .4	239/ .4	231/ .8
7	42/ 1.3	37/ 1.3	31/ 1.8	40/ 1.3	24/ 1.3	32/ .9	216/ .4	207/ .4	219/ .4	194/ .4	284/ .4	202/ .4	243/ .3
8	51/ 1.8	42/ 1.8	42/ 1.8	32/ 1.8	63/ 1.3	44/ 1.3	62/ .9	209/ .4	209/ .4	232/ .4	223/ .4	0/ 0.0	214/ .2
9	35/ 1.3	35/ .9	307/ .9	46/ 1.3	28/ 1.3	75/ .9	213/ .4	0/ 0.0	0/ 0.0	226/ .4	0/ 0.0	0/ 0.0	270/ .1
10	255/ 1.3	253/ 1.8	253/ 1.3	251/ 1.3	244/ .4	241/ .4	248/ .4	241/ .4	227/ .4	239/ .4	0/ 0.0	216/ .4	238/ .6
11	36/ 1.3	44/ 1.8	51/ 1.8	63/ 1.8	66/ 1.8	59/ 1.8	50/ 1.3	32/ 1.3	151/ .9	206/ .4	47/ .9	342/ .9	52/ .4
12	56/ 1.8	70/ 1.8	47/ 2.2	63/ 1.8	234/ .9	248/ .9		224/ .9	199/ .4	199/ .4	0/ 0.0	0/ 0.0	49/ .2
13	252/ .4	231/ .4	207/ .9	215/ .4	233/ .9	189/ .9	213/ .9	218/ .4	234/ .9	222/ .4	169/ .4	69/ .9	213/ .4
14	248/ 2.2	239/ 2.2	236/ 2.2	234/ .9	237/ 2.2	232/ 1.8	227/ 1.8	234/ .9	230/ .9	234/ 1.3	230/ .9	0/ 0.0	232/ .9
15	50/ 1.8	255/ 1.3	248/ 2.2	245/ .9	248/ .9	245/ 1.8	252/ 2.2	242/ 2.2	235/ 1.3	226/ 1.3	207/ .4	55/ .4	243/ .6
16	61/ 1.8	42/ 1.8	49/ 1.3	52/ 1.3	40/ 1.3	47/ .4	225/ .4	220/ .4	216/ .4	227/ .4	218/ 1.3	220/ 1.3	215/ .1
17	43/ 1.3	73/ .9	50/ .9	45/ 1.3	36/ 1.3	89/ .9	103/ .4	216/ .4	204/ .4	218/ .4	232/ .9	227/ 1.3	207/ .5
18	57/ 1.8	45/ 1.3	34/ .9	48/ .9	44/ .9	95/ .9	60/ .4	0/ 0.0	189/ .4	201/ .4	237/ .4	225/ .4	201/ .1
19	83/ .9	115/ 1.3	35/ .4	45/ 1.8	47/ .9	68/ 1.8	79/ 1.3	212/ .4	224/ .4	212/ .4	211/ .4	202/ .4	150/ .1
20	80/ .4	241/ .9	243/ .4	231/ .4	240/ .4	235/ 1.3	217/ .4	0/ 0.0	0/ 0.0	0/ 0.0	214/ 1.3	216/ .9	222/ .5
21	44/ 2.2	21/ 2.2	49/ 2.2	54/ 2.7	45/ 2.2	216/ .9	107/ 1.3	205/ .9	215/ 1.3	227/ 2.2	213/ .9	157/ 1.3	198/ .3
22	173/ 1.3	42/ 2.2	92/ 1.3	227/ .9	230/ 1.3	233/ 2.2	49/ 1.3	74/ .9	196/ .4	77/ 1.8	201/ 1.3	218/ 1.8	207/ .9
23	47/ 2.2	33/ 3.1	40/ 1.8	248/ 1.8	234/ 2.2	232/ 1.8	220/ 3.1	208/ 4.0	232/ 2.7	220/ 1.8	223/ 1.3	230/ 2.2	224/ 1.2
24	238/ 4.0	243/ 3.6	242/ 4.0	235/ 3.1	236/ 1.8	243/ 3.1	230/ 3.1	230/ 3.6	219/ 2.7	212/ 1.3	197/ 1.3	204/ 1.3	228/ 2.3
25	59/ 2.7	52/ 2.7	54/ 2.7	55/ 3.6	53/ 4.9	97/ 2.7	214/ 2.7	203/ 2.2	215/ 1.8	218/ 2.7	229/ 3.1	220/ 3.6	206/ 1.5
26	51/ 3.6	54/ 4.9	47/ 4.9	44/ 3.6	49/ 4.9	45/ 4.0	54/ 3.1	103/ 1.3	176/ 1.3	211/ 3.1	220/ 3.1	204/ 2.7	203/ 1.3
27	45/ 3.6	46/ 4.5	40/ 4.5	48/ 4.0	65/ 4.5	59/ 4.9	54/ 3.1	83/ 2.7	172/ 2.2	202/ 2.2	221/ 2.2	211/ 3.6	198/ 1.1
28	248/ 2.7	236/ 1.8	232/ 1.8	226/ 1.8	152/ 2.7	231/ 3.1	211/ 3.1	181/ 2.2	212/ 3.1	222/ 2.7	213/ 3.1	206/ 3.1	218/ 3.2
29	64/ 4.0	55/ 4.5	88/ 5.4	51/ 4.9	59/ 4.0	162/ 3.6	57/ 3.6	72/ 3.1	191/ 2.7	224/ 2.2	227/ 2.7	223/ 3.6	192/ 2.0
30	65/ 4.0	52/ 4.9	37/ 4.5	31/ 4.5	44/ 4.5	36/ 4.0	58/ 3.6	136/ 2.7	170/ 2.2	206/ 2.2	217/ 2.2	220/ 2.7	204/ 1.3
31	43/ 4.9	52/ 4.9	41/ 4.0	43/ 4.0	46/ 4.9	95/ 3.6	145/ 2.2	182/ 2.2	180/ 1.8	178/ 2.2	211/ 2.2	176/ 1.8	161/ .5

TOTAL OBSERVATIONS PER HOUR

12	13	14	15	16	17	18	19	20	21	22	23
31	31	31	31	31	31	30	31	31	31	31	31

TOTAL NUMBER OF HOURLY OBSERVATIONS = 743 TOTAL NUMBER OF POSSIBLE OBSERVATIONS = 744

MAXIMUM WIND SPEED WAS 5.4 MPS AT 219 DEG AND OCCURRED DURING HOUR 0300, 3/28

HUNTINGTON CANYON WIND DATA 08/04/78

RILDA CANYON (U3)

DATA FOR APRIL 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	12	13	14	15	16	17	18	19	20	21	22	23	RESULTANT DIR/VEL
1	79/ 4.8	203/ 2.7	247/ 2.2	235/ 2.7	239/ 2.7	162/ 2.7	143/ 3.6	185/ 2.2	196/ 1.8	217/ 1.3	198/ 1.3	207/ 1.3	155/ 1.3
2	62/ 3.6	163/ 2.7	202/ 2.7	235/ 2.2	104/ 2.2	230/ 2.2	237/ 1.3	223/ 1.3	218/ 1.8	218/ 1.8	211/ 1.3	214/ 1.3	281/ .9
3	59/ 4.5	56/ 4.5	55/ 4.0	57/ 4.9	68/ 3.6	355/ 2.7	86/ 4.0	85/ 3.1	115/ 4.5	131/ 3.6	191/ 1.8	209/ 1.3	96/ .9
4	37/ 3.6	51/ 4.0	62/ 3.6			40/ 2.2	57/ 2.7	216/ 1.3	217/ 1.8	215/ 1.8	222/ 1.3	204/ 1.3	159/ .2
5	242/ 6.7	246/ 5.4	249/ 6.3	242/ 4.9	239/ 4.0	242/ 4.0	242/ 2.2	225/ 1.3	223/ 1.3	225/ 1.8	220/ 2.2	216/ 1.8	236/ 3.1
6	58/ 4.0	38/ 4.5	34/ 3.1	46/ 4.5	50/ 4.5	34/ 3.6	44/ 3.1	45/ 2.7	69/ 2.7	83/ 2.2	84/ 2.2	141/ 1.8	53/ .6
7	44/ 4.0	40/ 5.4	38/ 4.9	59/ 3.6	76/ 3.1	161/ 2.7	171/ 2.2	76/ 3.1	46/ 2.7	53/ 2.7	49/ 2.7	150/ 2.2	71/ 1.7
8	84/ 3.6	242/ 3.1	256/ 3.6	230/ 2.2	235/ 3.6	226/ 2.2	230/ 1.3	64/ 2.7	62/ 3.1	202/ 1.3	214/ 1.8	202/ 2.2	132/ .5
9	244/ 3.6	47/ 4.5	125/ 2.7	67/ 2.7	203/ 1.8	181/ 2.2	219/ 1.3	236/ 1.8	230/ 1.3	214/ 1.8	227/ 2.2	213/ 2.2	225/ 2.1
10	248/ 4.9	243/ 4.9	246/ 5.4	239/ 5.4	244/ 5.4	230/ 4.9	239/ 4.9	234/ 4.5	239/ 4.5	237/ 4.5	241/ 4.5	239/ 4.5	244/ 4.4
11	57/ 4.9	212/ 3.1	241/ 1.8	233/ 2.7	236/ 4.5	225/ 4.9	191/ 4.5	224/ 2.2	192/ 1.3	223/ 2.7	234/ 3.6	232/ 4.5	222/ 1.9
12	228/ 2.2	232/ 3.6	235/ 4.5	230/ 4.9	236/ 4.5	231/ 4.5	224/ 3.1	215/ 1.3	224/ 1.3	216/ 1.3	218/ 2.7	214/ 3.6	222/ 1.9
13	38/ 3.1	146/ 3.6	39/ 4.0	231/ 1.3	220/ 1.8	220/ 1.8	218/ 1.8	200/ 1.5	224/ 2.7	229/ 2.7	208/ 1.8	220/ 1.8	218/ 1.3
14	46/ 3.1	247/ 1.8	254/ 2.7	240/ 1.8	228/ 1.3	250/ 1.8	259/ 1.8	213/ 1.3	211/ 1.3	199/ 1.3	216/ 1.3	206/ 2.7	232/ 1.3
15	48/ 3.6	79/ 4.0	44/ 4.5	235/ 4.5	235/ 4.5	235/ 1.3	200/ 1.8	186/ 1.3	197/ 1.8	139/ 2.7	160/ 2.7	209/ 1.8	221/ 1.8
16	223/ 1.8	192/ 4.5	242/ 2.2	235/ 3.1	237/ 2.2	235/ 1.3	245/ 1.3	205/ 1.8	227/ 3.1	178/ 1.8	216/ 1.3	206/ .9	79/ .4
17	240/ 4.5	240/ 4.9	234/ 4.9	237/ 4.9	242/ 4.5	240/ 4.5	241/ 4.5	237/ 4.5	233/ 4.5	233/ 4.9	231/ 4.9	225/ 4.9	235/ 3.9
18	130/ 3.1	192/ 1.8	226/ 2.2		237/ 6.3	237/ 3.1	224/ 2.2	212/ 1.8	215/ 1.8	206/ 2.7	211/ 2.7	209/ 2.7	211/ 1.4
19	54/ 2.7	52/ 2.7	45/ 2.7	55/ 2.2	57/ 2.2	48/ 2.7	79/ 2.2	126/ 2.2	192/ 1.3	211/ 1.3	220/ 1.8	216/ 2.7	190/ .9
20	51/ 2.7	52/ 2.7	49/ 2.7	58/ 2.7	41/ 3.1	33/ 3.1	56/ 2.7	214/ 1.3	227/ 1.3	208/ 1.8	193/ 1.8	214/ 1.8	213/ 1.1
21	236/ 5.8	238/ 4.5	230/ 4.5	234/ 3.6	231/ 4.5	240/ 4.0	230/ 4.5	230/ 2.7	229/ 2.7	217/ 1.8	205/ 1.8	225/ 2.2	229/ 3.4
22	239/ 3.6	241/ 4.5	245/ 5.4	242/ 3.6	232/ 3.1	224/ 3.1	226/ 2.2	223/ 1.8	204/ 1.8	217/ 1.8	217/ 1.3	214/ 1.3	235/ 3.2
23	52/ 2.2	229/ 3.1	229/ 3.1	224/ 2.2	219/ 1.8	231/ 1.3	228/ .9	231/ 1.3	221/ .9	176/ 1.3	211/ 1.3	218/ 3.1	223/ 1.8
24	58/ 4.0	51/ 4.5	55/ 4.0	55/ 4.5	53/ 3.6	50/ 3.6	43/ 4.0	53/ 4.5	62/ 4.0	200/ 1.8	221/ 2.2	223/ 2.2	180/ .8
25	66/ 2.7	74/ 4.5	61/ 2.2	45/ 2.7	43/ 3.6	44/ 3.1	56/ 1.8	143/ 1.8	186/ .4	214/ 1.3	220/ 1.8	199/ 1.3	221/ 1.0
26	45/ 3.6	40/ 3.6	38/ 3.6	56/ 3.6	37/ 4.0	138/ 3.6	233/ 1.3	207/ 1.3	233/ 1.3	233/ 1.8	237/ 1.8	232/ 1.3	113/ .6
27	240/ 1.8	230/ 1.3	253/ 1.3	248/ 1.3	227/ 1.8	236/ 4.5	236/ 1.3	222/ .9	226/ 1.3	219/ .9	209/ .9	214/ .9	230/ 1.8
28	229/ 1.3	229/ 1.3	241/ 1.8	237/ 1.3	230/ 1.3	237/ 1.3	226/ .9	203/ .9	220/ 1.8	222/ .9	220/ .9	206/ .9	225/ 1.3
29	46/ 4.9	229/ 1.3	234/ 1.3	234/ 1.3	242/ 1.3	147/ 2.2	49/ 2.2	71/ 1.8	121/ 1.8	203/ .9	210/ .9	220/ 1.3	205/ .9
30	244/ 1.8	246/ 1.8	229/ 1.3	217/ 1.8	223/ .9	229/ .9	224/ .9	160/ 1.8	45/ 3.1	37/ 3.1	39/ 3.1	197/ .9	184/ .5
31													

TOTAL OBSERVATIONS PER HOUR

12	13	14	15	16	17	18	19	20	21	22	23
30	30	30	28	29	30	30	30	30	30	30	30

TOTAL NUMBER OF HOURLY OBSERVATIONS = 717 TOTAL NUMBER OF POSSIBLE OBSERVATIONS = 720

MAXIMUM WIND SPEED WAS 6.7 MPS AT 242 DEG AND OCCURRED DURING HOUR 1200, 4/ 5

HUNTINGTON CANYON WIND DATA 08/04/78

RILDA CANYON (U3)

DATA FOR APRIL 1978 WIND DIRECTION (DEG) AND VELOCITY (MPS)

DAY \ HOUR	00	01	02	03	04	05	06	07	08	09	10	11
1	143/ 3.6	137/ 2.7	171/ 2.7	195/ 1.8	98/ 3.1	145/ 4.0	195/ 1.3	205/ 1.3	213/ 1.3	43/ 3.1	68/ 3.6	40/ 4.5
2	228/ 1.3	225/ 1.3	211/ 1.3	214/ 1.3	209/ 1.3	218/ 1.3	202/ 1.3	192/ 1.3	221/ 1.8	258/ 1.8	48/ 2.7	52/ 3.6
3	224/ 1.8	219/ 1.3	214/ 1.3	226/ 1.3	226/ 1.3	233/ 1.8	221/ 1.3	226/ 1.3	228/ 1.3	235/ 1.3	239/ 1.8	59/ 2.7
4	222/ 2.2	232/ 1.8	227/ 1.8	222/ 1.8	222/ 1.8	224/ 1.8	224/ 1.8	219/ 1.8	223/ 1.3	221/ 1.3	57/ 3.1	55/ 4.0
5	238/ 2.2	244/ 3.1	240/ 2.7	229/ 2.7	227/ 3.1	228/ 2.7	193/ 2.2	208/ 1.8	223/ 2.2	235/ 3.6	245/ 3.6	251/ 4.0
6	233/ 2.7	231/ 3.1	231/ 4.0	234/ 2.2	223/ 1.8	219/ 2.7	229/ 3.1	232/ 3.1	235/ 3.6	238/ 2.7	35/ 4.0	52/ 2.7
7	202/ 1.8	204/ 1.8	207/ 1.8	198/ 1.8	208/ 2.2	59/ 2.7	59/ 2.7	60/ 2.7	116/ 2.2	42/ 2.7	45/ 2.2	48/ 3.1
8	122/ 2.2	56/ 2.2	96/ 2.7	151/ 2.2	56/ 2.7	47/ 2.7	50/ 2.7	191/ 2.2	218/ 2.2	279/ 1.3	49/ 2.7	55/ 3.1
9	234/ 2.7	224/ 2.7	227/ 2.2	236/ 3.1	226/ 3.6	225/ 3.6	222/ 4.0	226/ 3.6	232/ 4.9	247/ 3.6	244/ 4.5	243/ 3.1
10	222/ 2.7	232/ 2.7	238/ 3.6	253/ 3.1	254/ 2.7	252/ 5.4	258/ 4.9	263/ 4.9	253/ 4.9	247/ 4.5	245/ 4.9	241/ 4.5
11	241/ 4.5	224/ 3.1	226/ 3.1	212/ 2.7	214/ 2.2	230/ 1.8	211/ 1.8	220/ 2.2	238/ 2.2	240/ 2.2	57/ 4.9	48/ 4.9
12	240/ 4.0	221/ 2.2	158/ 2.7	219/ 3.1	221/ 2.7	235/ 2.7	221/ 3.6	216/ 2.2	158/ 2.2	41/ 4.0	48/ 4.9	43/ 4.0
13	234/ 3.6	225/ 3.1	235/ 3.1	236/ 3.1	229/ 2.7	215/ 3.6	225/ 2.7	221/ 3.1	238/ 2.2	37/ 2.2	38/ 3.1	92/ 2.2
14	226/ 2.2	229/ 2.2	228/ 1.8	234/ 2.2	223/ 2.7	224/ 2.2	227/ 2.7	230/ 2.2	229/ 3.1	239/ 3.6	49/ 4.0	45/ 4.9
15	229/ 2.2	236/ 3.1	231/ 3.6	231/ 3.6	224/ 3.6	243/ 3.1	231/ 3.6	228/ 4.5	230/ 4.5	237/ 4.5	246/ 4.0	52/ 2.2
16	205/ 2.2	98/ 2.7	131/ 2.7	46/ 3.6	44/ 3.1	49/ 4.5	33/ 4.5	29/ 4.9	32/ 4.9	58/ 4.5	24/ 4.0	213/ 1.8
17	179/ 1.3	212/ 1.8	234/ 2.7	241/ 2.7	234/ 3.1	235/ 2.7	235/ 3.1	233/ 3.1	233/ 3.6	236/ 4.5	236/ 4.0	239/ 4.5
18	226/ 4.5	221/ 2.2	198/ 1.8	196/ 1.8	216/ 1.8	219/ 1.8	212/ 1.3	207/ 1.3	251/ .9	53/ 2.7	50/ 4.0	38/ 4.9
19	218/ 3.1	219/ 2.7	219/ 3.1	208/ 3.6	208/ 3.1	209/ 3.6	214/ 3.6	209/ 3.6	222/ 4.0	229/ 4.0	47/ 2.7	50/ 2.2
20	229/ 2.7	219/ 3.6	219/ 3.6	221/ 3.6	221/ 3.6	216/ 4.0	212/ 4.5	212/ 4.5	219/ 4.0	228/ 3.6	244/ 4.0	41/ 2.7
21	214/ 2.7	216/ 2.2	214/ 1.8	204/ 1.8	216/ 1.8	216/ 2.2	221/ 2.2	176/ 2.7	239/ 5.4	239/ 6.3	239/ 5.8	235/ 5.8
22	235/ 3.1	233/ 2.7	235/ 3.6	237/ 4.5	235/ 3.6	242/ 3.6	239/ 4.5	237/ 4.0	235/ 3.1	242/ 3.6	242/ 3.6	237/ 3.6
23	206/ 1.8	216/ 2.2	221/ 1.8	216/ 2.7	224/ 2.7	226/ 2.7	229/ 3.1	227/ 3.1	224/ 3.1	236/ 3.1	237/ 2.7	43/ 2.2
24	218/ 4.0	218/ 4.5	216/ 4.0	212/ 4.5	212/ 4.9	217/ 4.9	215/ 4.5	212/ 4.5	215/ 4.5	227/ 4.5	246/ 2.7	55/ 3.6
25	232/ 2.7	232/ 3.1	234/ 2.7	232/ 2.7	234/ 3.1	239/ 4.5	234/ 4.9	223/ 4.5	234/ 4.5	232/ 4.5	232/ 3.6	48/ 2.7
26	210/ 1.3	222/ 1.3	183/ 2.7	87/ 3.1	78/ 4.0	157/ 2.7	222/ 1.8	220/ 1.8	143/ 2.7	41/ 2.7	269/ 1.3	195/ 1.8
27	241/ 1.8	242/ 1.8	242/ 1.8	236/ 2.2	237/ 2.7	233/ 2.2	189/ 2.2	199/ 2.2	230/ 2.7	231/ 3.1	227/ 1.8	223/ 1.3
28	220/ 1.3	222/ 1.3	218/ 1.3	223/ 1.3	211/ 1.3	219/ 1.3	217/ 1.3	224/ 1.3	227/ 1.3	227/ 1.3	243/ 1.3	237/ 1.3
29	211/ 1.8	228/ 1.3	215/ 1.8	213/ 1.8	214/ 2.2	217/ 2.2	210/ 1.3	225/ 3.1	223/ 4.0	228/ 2.2	234/ 2.2	64/ 3.1
30	227/ 1.3	63/ 2.7	88/ 2.7	141/ 2.7	215/ 1.3	224/ 1.8	111/ 3.1	221/ 1.3	232/ 1.8	243/ 1.8	235/ 1.8	246/ 1.3
31												

TOTAL OBSERVATIONS PER HOUR

00	01	02	03	04	05	06	07	08	09	10	11
30	30	30	30	30	30	30	30	30	30	30	30

CHAPTER XII

GEOTECHNICAL

Prepared for

West Appa Coal Company

Price, Utah

Prepared by

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West Appa Coal Company

Aurora, Colorado

April 1983

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LIST OF FIGURES, TABLES, AND PLATES FOR CHAPTER XII

CHAPTER XII

GEOTECHNICAL

12.1 SCOPE

The geotechnical analyses performed during the 1982 exploration program will be presented for the Rilda Canyon property. As the property is not operating, relatively few samples are available due to the extremely high cost of obtaining samples and restrictions placed on drilling by the Manti LaSal National Forest. All available information used to determine the following conclusions will be presented.

12.2 METHODOLOGY

The following geotechnical description is based upon a room and pillar mining plan followed by longwall retreat for both the Blind Canyon and Hiawatha seams. The mining plan was designed with information collected from the 1982 drilling program, geotechnical testing and inspection of cores, geophysical logging, two lineation analyses, an environmental deposition study, very low frequency electromagnetic surveys and two seismic profile lines.

The information obtained from the above studies was used to determine coal pillar sizes, barrier pillar design, directions of retreat for the longwall panels, and the composition of the immediate roof during room and pillar development. The subsidence effects were then calculated for critical area across the property and a control and mitigation plan was devised.

12.3 UNDERGROUND MINE DESIGN

Access to the underground reserves in Rilda Canyon will be via three drift entries in the Hiawatha Seam as shown on Plate 3-11. One continuous miner section will perform the development work to the slope and raise locations, the generated access to the Blind Canyon Seam, and continue mining in the Hiawatha Seam until the completion of the slopes. The room and pillar advances will continue until the first longwall panel has been developed in year 3 as shown on Plate 3-12. As the longwall retreats the miner section will continue developing panels. In year 23 the miner section will be moved to the Hiawatha Seam for room and pillar advance. As the reserves in the upper seam are exhausted, both miner sections and possibly the longwall will be moved to the Hiawatha Seam. Longwall potential is dependent upon the results of additional drilling to the Hiawatha Seam from the Blind Canyon, the coal heights encountered as the property is cross-sectioned by development mining

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TABLE 12-1

ACTUAL GEOTECHNICAL TESTING

TEST	HOLE R1 BLIND CANYON			HOLE R3 BLIND CANYON			HOLE R5 BLIND CANYON			HOLE R5 HIAWATHA			HOLE WA-HM-BC-1 BLIND CANYON			TOTALS
	R*	C**	F***	R	C	F	R	C	F	R	C	F	R	C	F	
Uniaxial Compressive	1	1	1	1	1	2	1	2	2	3	3	2	2	2	0	25
Elastic Modulus	0	1	0	0	1	0	1	2	2	2	3	2	0	2	0	16
Triaxial Compressive	1	1	2	1	1	2	1	0	1	4	2	2	0	0	0	18
Direct Shear	0	0	0	0	4	0	0	0	0	0	3	0	0	0	0	7
Brazilian Tensile	2	2	2	2	2	2	3	2	2	7	6	7	2	0	0	41
Bulk Density	2	2	2	2	2	2	3	4	3	7	6	6	2	2	0	45
Slake Potential	1	0	1	1	0	1	1	0	1	2	0	2	1	0	0	11
TOTALS:	7	7	9	7	11	9	10	10	11	25	23	21	7	6	0	163

R* = Roof
C** = Coal
F*** = Floor

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depth as the Star Point Sandstone is encountered. No problems relative to squeezing, bearing capacity or mine equipment operation will exist.

Two independent lineament studies were undertaken, one by Norwest and the other by McCabe, to help predict mining conditions due to the influence of regional structure from the Flat Canyon anticline and Pleasant Valley Fault system as described in Chapter 6. The lineaments have been placed on Plate 12-1 so that entry development for mine planning will avoid lineament intersections, areas of probable roof control problems. In areas where lineaments are crossed, they are done so at high angles.

12.3.2 Coal Pillar Design

Coal pillar design is dependent upon mining techniques, coal strengths, depth of overburden, entry and pillar geometry, mining sequence in multiple seam areas, roof and floor bearing and slaking characteristics and estimated design life. Pillar design will change across the Rilda Canyon property as mine design incorporates both longwall and continuous miner room and pillar extraction techniques. As the mining techniques and physical characteristics change across the property, the pillar design of each area will be described and calculated from the combination of the above operating characteristics into a worse case.

A property barrier pillar is required by Utah mining regulations as another property is approached. The following table includes the worse case or largest pillar required around the property's perimeter based upon the ensuing formula:

Width = 2* coal thickness to be extracted in feet + 4* overburden in feet to the top of the lowest coal seam ÷ 100 + 10 feet.

values will be compared to the gravity induced vertical stress component. The minor or lateral stress is perpendicular to the major stress and of equal magnitude as Poisson's number approaches 2 for coals deeper than 1300 feet as confirmed by Phillips (1944).

Several areas during the mine development will not strictly adhere to the argument that the magnitude of the major stress component is equal to 1.1 PSI multiplied by the overburden depth. The load may be transferred across an opening of limited width outward to both sides of the rib by a pressure arch that forms in the strata leaving a distressed zone in the roof strata. The minimum value of the maximum width is equal to .15 times the overburden depth plus 60 feet. The total width of the developed panels should be restricted to 75% of the value calculated. This distressed zone above the coal is believed to be twice the width of the pressure arch. The magnitude of the major stress component will then be a factor of arch width rather than depth.

Two pillar formulas will be used to relate pillar strength to its geometry and structural composition. Holland, Grumwald and Gaddy found that:

Pillar strength in PSI = strength of cubic specimen * (end dimension cube in inches)$^{1/2}$ * (length of pillar in inches) ÷ thickness in inches

The above calculation should be valid for length to thickness ratios for pillars from 1:1 to 12:1. For values greater than 12:1 the pillars can ordinately be regarded to bear about any load they become subject to. Obert and Skelly have determined a second relationship that:

Pillar strength in PSI = strength of sample in PSI * [0.78 + .22 (width to height of pillar)] ÷ [0.78 + .22 (width to height of sample)]

No corrections need to be applied to any of the above values due to the coal seam's attitude as dip ranges from 1 to 3 degrees.

Wilson and Ashwin hypothesize that a pillar flanked on both sides by gobs contains a yield zone around the edges and a core in the center enclosed by the yield zone. The theory is based upon the fact that through stress redistribution the maximum abutment pressure occurs at the ribs closest to the pillar lines and decrease with distance from the pillar line. The vertical stress is very low at the ribs and increases rapidly to a maximum yield stress 10 to 30 feet from the ribs. The pillar core is relatively undisturbed and the strength of the core increases because of the confining constraints rendered by the yield zone. The vertical stress at seam level is estimated to be:

$\frac{\Delta}{\sigma}$ = vertical stress PSI = [6.94 x 10^{-3} * density * depth of overburden + support stress due to bolting in PSI] [(1+SIN internal fraction angle) ÷ (1-SIN internal fraction angle)] + confining stress at edge of pillar in PSI ≈ 4 (1.1 * depth of overburden + support stress)

The vertical and horizontal stresses are equal to the hydrostatic condition as Poisson number equals 2 for most of the Rilda Canyon reserve (depth over 1300 feet). The distance into the pillar in feet to the edge of the confined core is:

y = distance in feet = pillar height in feet * ln ($\frac{\Delta}{\sigma}$÷ [bolting stress + confining stress]) ÷ (TAN B) 1/2 (TAN B-1)

where TANB = 1+SIN interval function angle ÷ 1-SIN interval function angle.

The load carrying capacity of the pillar if 2 y < pillar width then:

L = load in tons = (7.2 x 10^{-2}(V)[P^2 - 2PY + Y/3 Y^2]

where P is the pillar dimension.

Based upon the Seegmiller test results, the above formulas may be reduced for the Rilda Canyon property to the following:

$$v = [(6.94 \times 10^{-3})\ (158.9)\ (H) + 0]\ \frac{1+SIN40}{1-SIN40} + 1.1 =$$

5.074 H + 1.1

y = (m) (ln(5.072 H + 1.1) ÷ 1.1)) / 7.72
H = depth of overburden
m = seam height extracted in feet

The pillar is sufficient if the load capacity calculated above is greater than or equal to the tributary area loading.

Continuous miner development in the Blind Canyon Seam will proceed from east to west approximately 116 feet south of the properties northern boundary as shown on Plate 12-1. Success has been experienced in adjacent mines using 100- x 100-foot centers for pillar design with 18-foot entries using 2 entries for intake air, 2 entries for return air and 1 entry for the belt. The maximum overburden of 1500 feet is experienced with 9 feet of coal towards the western boundary. A roadway working height of at least 8 feet will be maintained wherever possible so that two feet of coal will be left in place in all areas where the coal seam is greater than 10 feet thick and 1.5 feet of coal will be left in areas down to a seam height of 9 feet for main entry development to reduce the probability of roof dilution due to the relatively high slaking potential. Pillar design includes:

(1) Pressure arch width = .15 (1500) + 60 = 285 feet
Panel width = 4 (100) + 20 = 420 feet
Pillar subject to hydrostatic load as 420 ft > (285 ft)(.75)

(2) Gaddy-Holland - length to thickness 82 ft/8 ft = 10.3 ratio valid, pillar strength = (1960 PSI) $(2.97 \text{ in})^{1/2}$ $(82 \times 12 \text{ in})^{1/2}$ (9-1)(12) = 1104 PSI

Obert-Skelley - pillar strength = (1960 PSI) (0.78 +

$$.22 \left(\frac{82 \text{ ft}}{8 \text{ ft}}\right))/(0.78 + .22 \left(\frac{1 \text{ in.}}{1 \text{ in.}}\right)) = 5950 \text{ PSI}$$

Tributary Area Load = (1.1 PSI/Ft) (1500 Ft) (100 ft x 100 ft)/(82 ft x 82 ft) = 2450 PSI = (1.1 PSI/Ft) (1500 ft) $(100 \text{ ft})^2$ $(12 \text{ ft})^2$ / 2000 #/ton = 1,188,000 tons.

Wilson - v = 5.072(1500 ft) - 1.1 = 7609 PSI

$$y = (8 \text{ ft})(\ln \frac{7609}{1.1})/7.72 = 9.2 \text{ ft} \quad 2y < P \text{ as } 18' < 82'$$

$$L = (7.2 \times 10^{-2})\ (7609)\ (82^2 - 2\ (82)\ (9.2) + \frac{Y}{3}\ (9.2)^2) = 2{,}918{,}963 \text{ Tons}$$

(3) Factor of Safety

F.S. = (GADDY+OBERT) ÷ 2/TAL = (1104 PSI + 5950 PSI) - 2/2450 PSI = 1.4
F.S. = Wilson/TAL = 2918963 Tons/1188000 Tons = 2.5

The factor of safety is greater than 1 which is sufficient but the range of 1.4 to 2.5 is low due to the poor uniaxial test values obtained from the exploration program. To reiterate, the Rilda Canyon reserve is surrounded by operating properties with similar conditions so that satisfactory mining results are expected. As the property is traversed during development, additional samples wlll be tested to improve these results. If a more typical value of 2200 PSI is used for uniaxial compression the factor of safety range improves to a range from 1.9 to 2.5.

A set of 5 main entries will be driven to the south 250 feet east of the 36-31 section line in the Blind Canyon Seam, refer to Plate 12-1. This area was selected for the entries to minimize overburden depth (between two 2000-foot cover lines), keep coal heights just inside the operating range and to avoid the 3 lineament intersections, placing them in a barrier pillar.

The maximum overburden reaches 2000 feet with 6.5 feet of coal planned for removal. Between one to two feet of top coal will be left in place except for the last 1000 feet of development as the seam height reduces to 7.5 feet. Pillar designs include:

(1) Pressure arch width = 0.15 (2000 ft) + 60 ft = 360 ft.
Panel width = 4 (100) + 20 = 420 ft.
Pillar subject to hydrostatic load as 420 ft > 360 ft (.75)

(2) Gaddy Holland length to thickness = 82 ft/6.5 ft = 12.6 just outside valid region
pillar strength = (1960 PSI) $(2.97 \text{ in})^{1/2}$ (82 ft x 12 in/ft)$^{1/2}$ (6.5 ft) (12 in/ft) = 1360 PSI

Obert & Skelley - pillar strength = (1960 PSI)

$$(0.78 + .22\ (\frac{82\ \text{ft.}}{65\ \text{ft.}})\ )/(0.78 + .22\ (\frac{1\ \text{in.}}{1\ \text{in.}})\ ) = 6970\ \text{PSI}$$

Tributary Area Load = (1.1 PSI) (2000 ft) $(100\ \text{ft})^2/\ (82\ \text{ft})^2$ = 3270 PSI = (1.1 PSI) (2000 ft) $(100\ \text{ft})^2\ (12)^2$/2000 #/Ton = 1,584,000 Tons

Wilson - v = 5.072 (2000 ft) + 1.1 = 10145 PSI

$$y = (6.5\ \text{ft})\ (\ln \frac{10145}{1.1})/7.72 = 7.7\ \text{ft.} \quad 2y < P \text{ yes}$$

15.4 ft < 82 ft

$$L = (7.2\text{x}10^2)\ (10145\ \text{PSI})(82\ \text{ft}^2 - 2(82\ \text{ft})$$

$$(7.7\ \text{ft}) + \frac{4}{3}\ (7.7\ \text{ft})^2) = 4046823\ \text{Tons}$$

(3) Factor of Safety
F.S. = (Gaddy + Obert) ÷ 2/TAL = (1360+6970PSI) ÷ 2/3270 = 1.3

F.S. = Wilson/TAL = 4046823 Tons/1584000 Tons = 2.6

Again the factor of safety is greater than 1 which is sufficient but the range of 1.3 to 2.6 is low. The lower seam height is acceptable in the southern 1000 feet of the main development as the longwall supports used in Section 36 will have a collapsed height of 4.5 to 5.0 feet and the estimated life is 2 to 3 years rather than 15 to 20 as for the northern mains. This last 1000 feet of development will deserve additional attention as mining progresses because the factor of safety is relatively low, top coal will not be left in place increasing the possibility of air slaking as the potential is high and in this area the sandstone paleochannel in the roof comes within 2 feet of the coal seam (interfingering of roof strata).

Longwall headgate and tailgate entry development will occur in Section 36. Two entry development has successfully been used at the Deer Creek Mine and West Appa anticipates its approval in Rilda Canyon from MSHA. The pillars will be driven on 80-foot centers with 18-foot-wide entries. Geometry of the reserve in this area ranges from 2350 feet of overburden and 6 feet of coal, 2100 feet of overburden and 8 feet of coal to 5.5 feet of coal and 1400 feet of overburden. Pillars in this area will be designed to yield as follows:

(1) Pressure arch width = (.15) (2350 ft) + 60 ft = 413 ft
= (.15) (2100 ft) + 60 ft = 375 ft
= (.15) (1400 ft) + 60 ft = 270 ft

panel width if MSHA approves = 80 ft + 20 ft = 100 ft

panel width for 3 entries = 2 (80 ft) + 20 ft = 180 ft

100 ft (or even 180 ft if required) < .75 (270) = 203 ft, design for pressure arch followed by yield

(2) Gaddy Holland length to thickness 62 ft/6 ft = 10.3

pillar strength = $(1960 \text{ PSI})(2.97 \text{ in})^{1/2}(62 \times 12)^{1/2}/(6)(12) = 1280$ PSI

Obert & Skelly

pillar strength = (1960)(.78 + .22 (62/6))

$(0.78 + 0.72 (\frac{1 \text{ in}}{1 \text{ in}})) = 5980$ PSI

Tributary Area Load = $(1.1)(413 \text{ ft}(2)(80 \text{ ft})^2/(62 \text{ ft})^2 = 1512$ PSI
$= (1.1)(413)(2)(80^2)(12^2)/2000 = 418{,}690$ Tons

Wilson

v = 5.072 (413)(2)+1.1 = 4191 PSI

$y = (6 \text{ ft}) \ln \frac{4191}{1.1}/7.72 = 6.41$ ft 2y < P yes
12.8 < 62'

$L = (7.2\text{x}10^{-2})(4191)(62^2-2(62)(6.4)+4/3(6.4^2)$
= 936,944 Tons

F.S. = Gaddy + Obert = (1280 + 5980) ÷ 2/1512 = 2.4
F.S. = Wilson = 936,944/418,690 = 2.2

tributary area load, equation modified for excessive coal removal = $((1.1 \text{ PSI})(2350 \text{ ft})(144 \text{ in}^2/\text{Ft}^2)/2000\#/\text{ton})(62 \text{ ft} + .3(2350 \text{ ft}))(62 \text{ ft})$
= 8,850,750 tons
$= (8{,}850{,}750 \text{ tons})(2000 \#/\text{ton})/(62 \text{ ft} \times 12^2) =$ 31,979 PSI

Wilson after longwall

$v = (5,072)(2350) + 1.1 = 11,920$ PSI

$y = (6 \text{ ft}) \ln (\frac{11920}{1.1})/7.72 = 7.22 \text{ ft} < 2P$ yes 162

$L = (7.2 \times 10^{-2})\ (11920)\ (62^2 - 2(62)(7.2) + 4/3\ (7.2)^2) = 2,592,159$ tons

F.S. after longwall = (1280+5980/2)/31979 = 0.11
F.S. after longwall = 2,592,159/8,850,750 = 0.29

From the above the pillars are adequate for factors of safety during development under the pressure arch and yield after the longwall retreats as the factor of safety becomes less than 1.

The remainder of the coal in Sections 31 and 32 not incorporated on the main entry development will be removed by longwall techniques. As previously described, two entries on 80-foot centers with 18-foot width will serve as the headgate and tailgate entries. Overburden ranges from 1400 feet to 2300 feet as in Section 36 so that the pressure arch theory is valid. Twenty-one hundred feet of overburden covers 13 feet of coal in the following pillar design:

Gaddy & Holland-length to thickness 62 ft/13 ft = 4.8
pillar strength = $(1960 \text{ PSI})\ (2.97 \text{ in})^{1/2}\ (62 \times 12)^{1/2} / (13 \times 12) = 591$ PSI

Obert & Skelly pillar strength = $(1960 \text{ PSI})\ (.78 + .22\ (62 \text{ ft}/13 \text{ ft}/(0.78 + 0.22\ (\frac{1 \text{ in}}{1 \text{ in}})) = 3585$ PSI

tributary area load = 1512 PSI as before
= 418,690 tons as before

Wilson

$v = 4191$ as before

$y = 13 \text{ ft} \ln (4191/1.1)/7.72 = 13.9 \text{ ft}, 2y < P$ yes 28 < 62

$L = (7.2 \times 10^{-2})(4191)(62^2 - 2(62)(13.9) + 4/3\ (13.9)^2) = 717,570$ tons

F.S. = Gaddy & Obert = (591 + 3585 PSI)/2/1512 PSI = 1.4
F.S. = Wilson = 717,570 tons/418,690 tons = 1.7

The pillars are adequate with factors of safety over 1 and will fail as previously shown after the longwall passes.

Two barrier pillars are required between the main entries and the longwall retreat areas. Three formulas will be used in determining the recommended width as presented below:

(1) The Ashley Formula
width = 20 ft + 4* total bed thickness + 0.1* overburden depth

(2) The pressure arch
width = [.15* overburden + 60 + width of entries] ÷ 2

(3) Belinski and Borecki formula
width = (5)(log estimated convergence) ÷ (.09) (log e)

The barrier pillar along the line between Sections 36 and 31 acts to isolate the abutment pressure effects from mining in Section 36 to the other areas, protects the southern mains for future use and will act as a fire wall if necessary. Two thousand feet of overburden and 8.5 feet of coal is used to determine the required width of 350 feet.

(1) W = 20 + 4(8.5) + 0.1 (2000) = 254 ft
(2) W = (-15(2000)+ 60 + 420) - 2 = 390 ft
(3) W = (5) (log 200 millimeters)/(.09)(log e)
= 294 ft

average plus 10% = 350 ft.

as thickness of overburden approaches 2000 ft convergence ranges from 200-200 millimeters

The second barrier pillar along the east-west main entries will be designed for the Hiawatha Seam so that the barrier pillars between seams will directly align. Since interburden ranges from 55 to 72 feet along these areas the pressure arch is still essentially vertical. Fifteen hundred feet of overburden and 26 feet of coal is used to determine the required width of 330 feet.

(1) Width = 20+4(26) + 0.1 (1500) = 274 ft.
(2) W = (.15(1500) + 60 +420) - 2 = 353 ft.
(3) W = (5)(log 150)/(.09) log e = 278 ft.
as thickness of overburden reaches 1500 feet commence ranges from 60-150 millimeters

average plus 10% = 330 ft.

A set of 5 main entries will be driven from east to west in the Hiawatha Seam along the northern property boundary directly underneath the entries in the Blind Canyon Seam with all pillars being superimposed. One hundred-foot centers for pillars with 18-foot roadways will be maintained as overburden reaches 1570 feet with 11.3 feet of coal. Pillar designs include:

(1) Pillar subject to hydrostatic load as in Blind Canyon Seam.
(2) Gaddy and Holland - length to thickness ratio 82 ft/ 9.3 ft = 8.82 valid
pillar strength = $(1650 \text{ PSI})(2.97 \text{ in})^{1/2}(82 \times 12)^{1/2} / (9.3)(12)$ = 799 PSI

(3) Obert and Skelly

pillar strength = (1650 PSI) (0.78 + .22(82 ft/9.3 ft))/((0.78) + .22(1/1)) = 4488 PSI

Tributary Area Load = (1.1 PSI/Ft) (1570 ft)(100 ft)^2 /(82 ft)^2 = 2568.4 PSI

= (1.1 PSI/Ft) (1570 ft) (100 ft)^2(12 in)^2/(2000#/ton) = 1,243,440 tons

Wilson

v = 5.072(1750 ft) + 1.1 = 7964 PSI

y = (9.3 ft) ln (7964/1.1)/7.72 = 10.7 ft

L = (7.2x10^{-2}) (7964) (82^2-2(82) (10.7) + 4/3 (10.7)^2) = 2,936,912 tons

(3) Factor of Safety

F.S. = Gaddy & Obert = (799 + 4488/2)/5568 PSI = 1.03

F.S. = Wilson = 2936912/1243440 = 2.4

As described for the Blind Canyon Seam, additional testing of samples is required to readjust the 1650 PSI uniaxial compression value. The factor of safety is very low and questionable. Samples can be obtained during initial development work and from above seam drilling to the lower seam.

The remaining mining plan for the Hiawatha Seam is dependent upon the further geotechnical testing and exploration drilling to confirm the coal heights and strengths. Based upon the information available now, further design is unwarranted.

12.3.3 Roof Span Design

Due to the relatively weak bonding between adjacent strata and the stratigraphic characteristics of the immediate roof, it is assumed that each stratum in the roof behaves as a beam. As the Rilda Canyon reserve is relatively deep (overburden reaching 2350 feet), the two ends of each stratum are assumed to be fixed, rigidly anchored and under a uniform load. The immediate roof of both seams is composed of more than one bed, the composition of which is averaged to be 1.5 feet of coal, 2 feet of claystone, 2.5 feet of siltstone and then followed by at least 10 feet of sandstone (or 1/4 of the entry width).

The first step is to determine the immediate roof beam thickness to see if the sandstone member becomes incorporated based upon the following values and formula:

Bed	Description	Unit Weight tons/ft^2	Thickness D (in)	Elasticity E (PSIx10^6)
1	Coal	.0455	18	0.25
2	Claystone	.0903	24	0.7
3	Siltstone	.0975	30	1.5
4	Sandstone	.0903	120	1.5

$$W = E_1 d_1{}^3 \ (\gamma_1 d_1 + \gamma_2 d_2 + \gamma_n \ d_n)/(E_1 d_1{}^3 + E_2 d_2{}^3 + E_n \ d_n{}^3)$$

Where 1 = .0455x1B = 0.819 PSI

$$\text{Where } 1\text{-}2 = \frac{.25\text{x}10^6\text{x}18^3 \ (.0455\text{x}18+.0903\text{x}24)}{.25+10^6\text{x}18^3+.7\text{x}10^6\text{x}24^3} = 0.391 \text{ PSI}$$

$$\text{Where } 1\text{-}2\text{-}3 = \frac{0.25\text{x}10^6\text{x}18^3 \ (.0455\text{x}18+.0903\text{x}24-.0975\text{x}30)}{.25\text{x}10^6\text{x}18^3+.7\text{x}10^6\text{x}24^3\text{x}1.5\text{x}10^6\text{x}30^3}$$

$$= 0.1669 \text{ PSI}$$

$$\text{Where } 1\text{-}2\text{-}3\text{-}4 = \frac{0.25\text{x}10^6\text{x}18^3 \ (.0455\text{x}18+.0903\text{x}24-.0903\text{x}120)}{.25\text{x}10^6\text{x}18^3+.7\text{x}10^6\text{x}24^3\text{x}1.5\text{x}10^6\text{x}120^3}$$

$$= 0.0092 \text{ PSI}$$

The immediate roof is only composed of the 18-inch coal left in place with a weight factor of 0.819 PSI as the tension zone is usually restricted to one-fourth the entry width or 18 feet/4 = 4.5 feet. The beds within this 4.5-foot zone have been evaluated above. A safe span length will be calculated below having a factor of safety equal to 3:

Cohesion of coal = 150 PSI Hiawatha value lowest

$$\text{Stress allowable} = \frac{150 \text{ PSI}}{\text{factor safety of } 3} = 50 \text{ PSI}$$

L safe = 18 in (2 x 50 PSI/.819 PSI)$^{1/2}$ - 12 = 17 feet

Shear strength = 440 PSI Hiawatha value lowest

$$\text{Shear allowable} = \frac{440 \text{ PSI}}{(\text{factor of safety } 3)(2)} = 73 \text{ PSI}$$

L safe = 4(18 in) (73 PSI)/(3)(.819PSI)(12) = 178 feet

If an entry 18 feet wide is driven with timbering or bolting to keep the unsupported roadway to less than 16 feet a safety factor of 3 is attainable.

12.4 Surface Subsidence Effects of Mining

West Appa Coal is proposing to use longwall mining techniques in the Blind Canyon Seam and very possibly in the Hiawatha Seam. The subsidence effects will be determined for the worse case scenario in which both seams will be mined using longwall as shown on Plates 3-12 and 3-13. All discussions will be directed towards the supercritical conditions (maximum subsidence) rather than the temporary subsidence expected under subcritical and critical analyses.

12.4.1 Subsidence Mechanisms

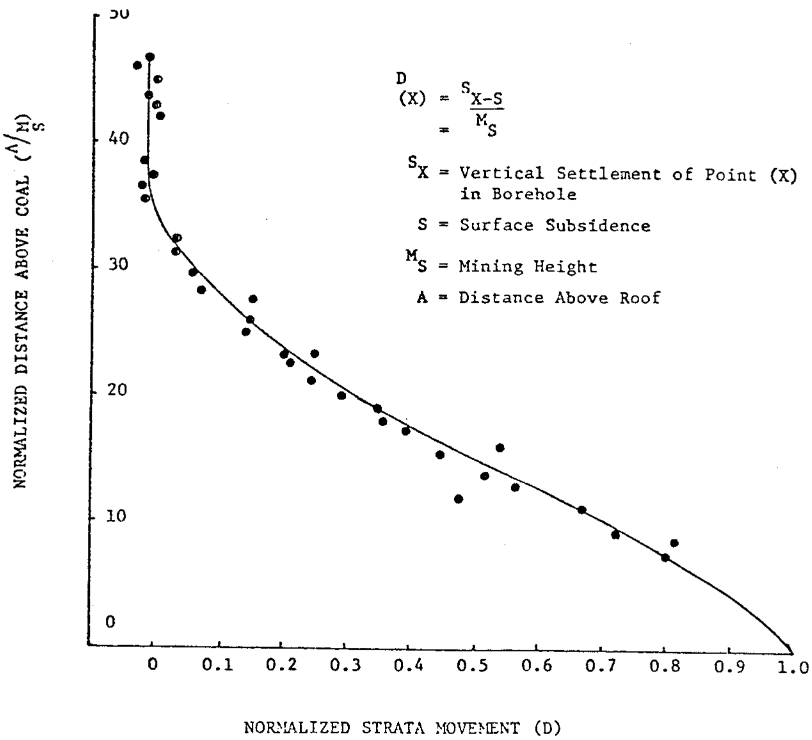
The magnitude of subsidence is a function of coal height, overburden depth, stratigraphy, mining technique, panel widths and distance from barrier pillars. The maximum subsidence experienced for western coal mines according to Peng (1978) ranges from 33% to 65% of the coal height extracted. Gentry and Abel (1976) have cited examples ranging to 70% of the seam height for the Western United States longwall operations. The United Kingdom National Coal Board published a graph (refer to Figure 12-1) illustrating that maximum subsidence ranges from 40% to 68% of the seam height over typical overburden depths similar to that of the Rilda Canyon Reserve. The maximum value may further be reduced for those points near an unmined solid pillar according to Gentry and Abel who reference several United Kingdom studies. Figure 12-2 is a graph of the factors used vs. distance from solid pillars. The Gentry and Abel factors of subsidence of Figure 12-2 and the United Kingdom National Coal Board maximum subsidence graph on Figure 12-1 will be used to estimate the total subsidence over several critical areas.

In addition to the magnitude of subsidence, it is important to evaluate the effects of subsidence upon the springs present on East Mountain. Abel has stated that the following holds true when pillars are extracted allowing subsidence to occur through repeated roof failure.

- 1-3 seam thicknesses above coal - broken and collapsed strata
- 4 seam thicknesses above coal - bedding can be traced
- 4-9 seam thicknesses above coal - bedding becoming easily traced
- >9 seam thicknesses above coal - elastic deflection of beds occurs

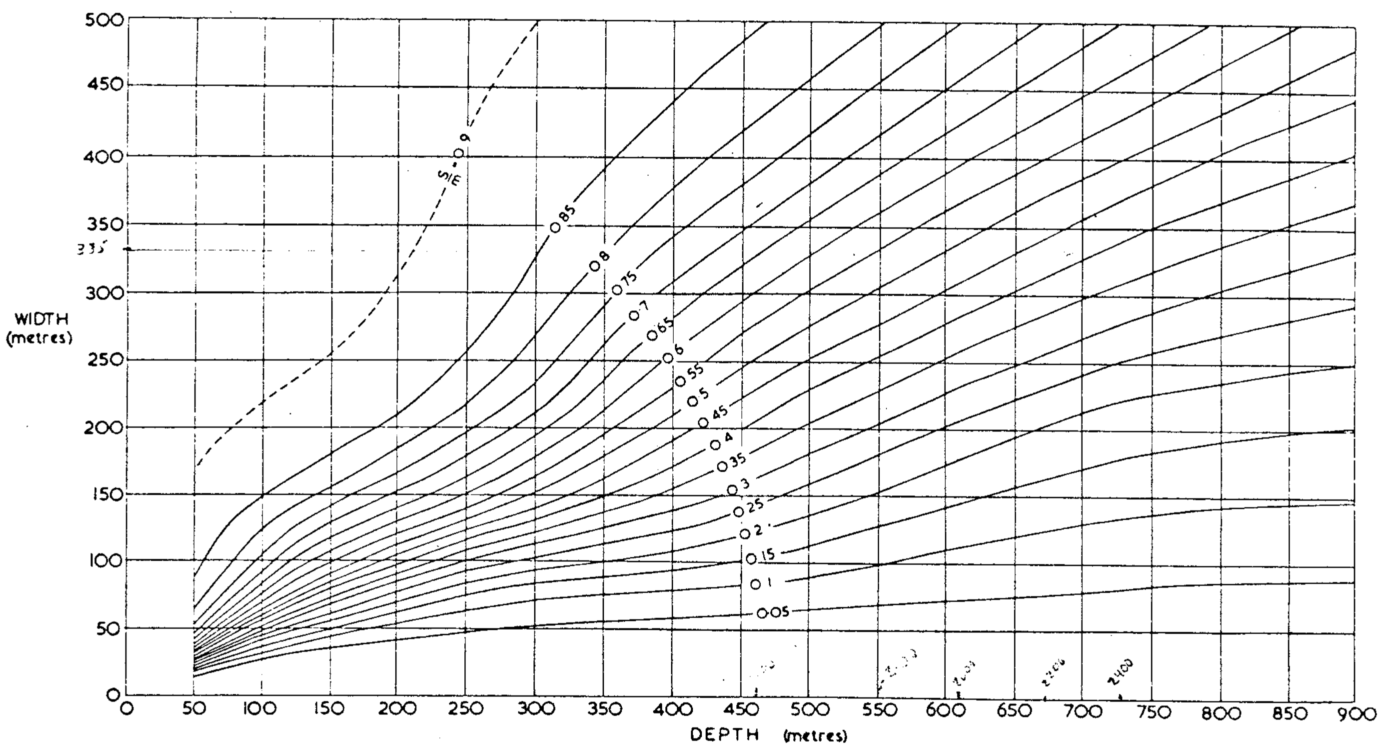
Dahl and Von Schonfeldt have shown that deformation decreases from a maximum of 1 at the seam roof to near 0 approximately 35 times the seam thickness; refer to Figure 12-3.

Fayol (1913) conducted studies on material swell characteristics in which he determined that broken material followed by compaction as the overburden settles occupy 12% more volume than the original in-place material. By comparing the coal height



Vertical settlement of overburden above a longwall panel (after Dahl and Von Schonfeldt)

FIGURE 12-1



Panel Width = 550 ft. or 168 M.

Excessive Case = 2 (panel width) 335

FIGURE 12-2

Relationship of subsidence factor to width and depth of the opening (Courtesy of U.K. National Coal Board)

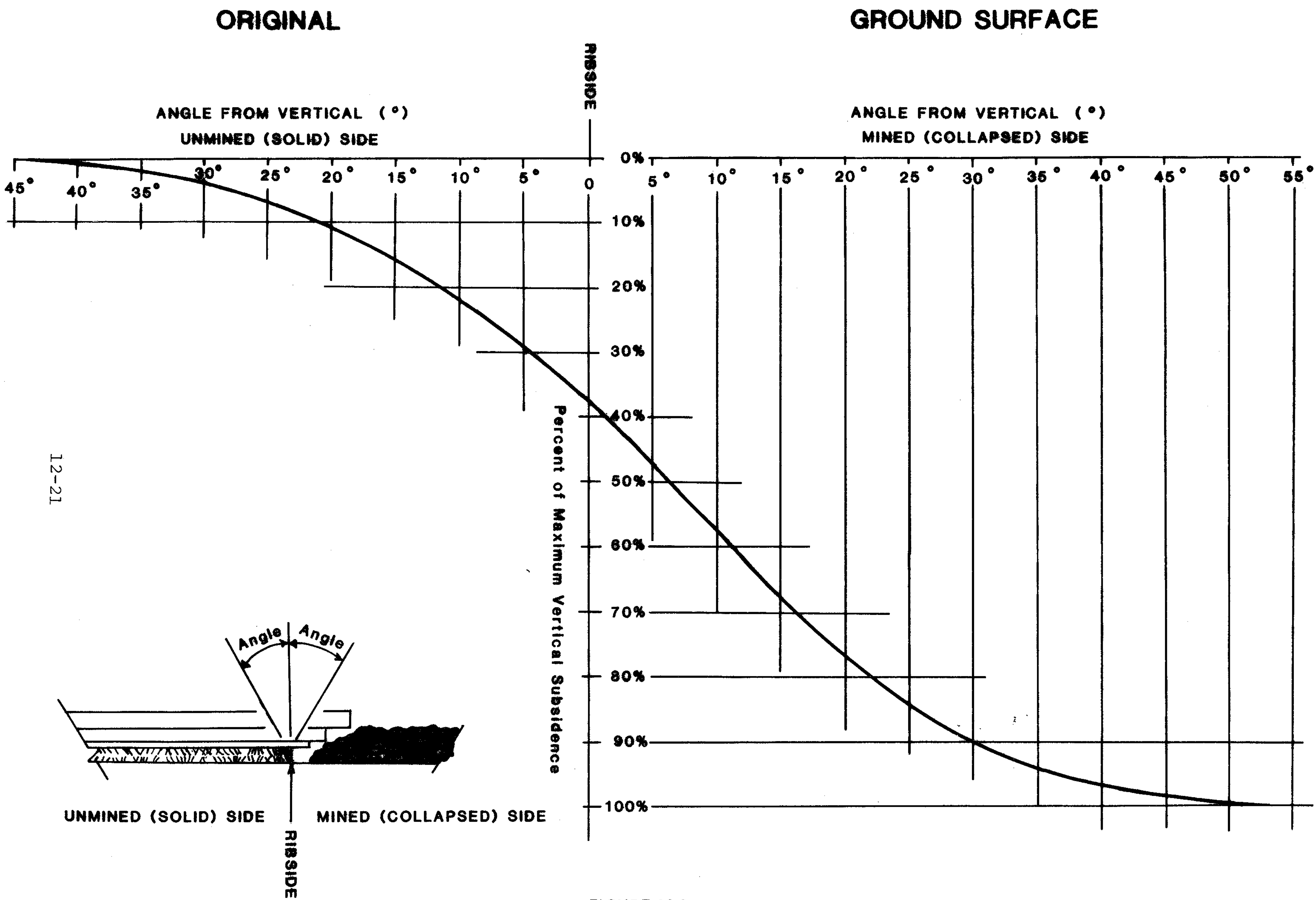


FIGURE 12-3

Approximate Vertical Subsidence Distribution Under Super-critical Conditions magnitude to the stratigraphic section taken from the geophysical logs above the seam and using a 12% swell for the mudstone and siltstone sequences the point of elastic deformation can be approximated. The major sandstone units have been omitted in calculating the swell because as the longwall face advances they will act in larger blocks, tilt and realign rather than break up in smaller pieces (concave tilting followed by convex tilting back to a position parallel to stratification, according to Hoffman, 1956).

12.4.2 Projected Subsidence Effects

The major impacts of subsidence will be discussed below as it affects pertinent structures and the environment of the property. A surface survey has indicated that no structures or dwellings are present on East Mountain except for a 6300 foot 345 KV transmission line owned by Utah Power & Light located within Section 36. Each of the pylons have been located from UP&L survey plots and placed on Plate 12-1. Eleven springs and one seep making up three general spring areas were located by Vaughn Hansen Associates across the property which are shown on Plate 12-1. One undeveloped access road crosses through the middle of Section 36 and a Manti-LaSal National Forest access road cuts across the southeast corner of Section 32. Several fences are present separating grazing areas across East Mountain but are of no significant construction.

On the following table (Table 12-3), the above items will be addressed.

12.4.3 Subsidence Control and Mitigation

The Surface Mining Control and Reclamation Act of 1977 requires the coal mine operator to file a bond payable to the regulatory authority, in this case Utah's Division of Oil, Gas and Mining, in the amount equal to the estimated cost of completing the work described in the reclamation plan. The applicant believes that a bond should not be required for the surface area over the underground workings. Due to the strata characteristics above the coal seams, the overburden depth ranging from 1400 to 2300 feet and that the slow and uniform rate of subsidence will not affect the surface terrain to such an extent that reclamation work will be necessary.

The proposed mining plan has been designed with entries aligned in a north-south or east-west direction, paralleling the joint pattern in the area. This alignment will result in a uniform rate or subsidence over the property rather than forming an irregular settling pattern. The mining plans will prevent subsidence from causing material damage to the surface, maintain the land's present use and value and maintain reasonable foreseeable use of that surface.

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No effect upon the growth of trees or other vegetation will occur as the maximum slope of the subsidence trough is 1.7 feet in 100 feet. This conclusion will be evaluated by the subsidence monitoring plan.

The quality or the quantity of flow from the 11 springs will not be affected as described in the hydrology Section 7.1.4. As presented in Table 12-3, elastic deflection is anticipated to occur within the first 340 feet of the stratigraphic column above the Blind Canyon Seam, well within the Blackhawk Formation. The presence of bentonite shale layers within this formation will swell when wet forming an impervious clay layer sealing any possible subsidence cracks, thus preventing any downward migration of water and subsequent loss of springs.

Any roads which are materially damaged by subsidence will be repaired and regraded to restore them to their pre-subsidence usefulness.

Any fences which are materially damaged by subsidence will be repaired to restore them to their pre-subsidence usefulness.

The 345 KV UP&L transmission line is the only existing structure present, the right-of-way being granted by the State of Utah on September 14, 1970, #1242.

As no restrictions or conditions were placed on the right of way, even though State Coal Lease ML 22509 was granted on 12-28-64, it is believed that the applicant is responsible for the lines relocation or repair if damaged by subsidence.

Liability would be limited to structural replacement or correction and not continue to repercussion of loss of service to UP&L customers or loss of business due to any possible temporary loss of transmission capacity. According to the attached letter from Utah Power and Light, (Exhibit 12-1). UP&L is willing to accept responsibility for monitoring of the pylons (from aerial photography and actual ground surveys as described in the monitoring section) and insulators to assess possible damage during the longwall retreat. Longwall panel number one was aligned so that pylon UP&L T1 would be located at the end of the retreat panel. The concrete footing could then be monitored as the longwall retreats and if potential damage becomes more probable the panel may be stopped prematurely and moved while remedial action is negotiated for the following nine pylons. Maximum subsidence of 2.5 feet is not anticipated until pylon UP&L T5 is reached under longwall panel number 4 according to Table 12-3. Negotiations between the applicant and UP&L will be initiated before the longwall retreats in the first panel to outline a plan of action for remedial activities which is anticipated to include a combination of the following:

1) monitoring of subsidence and its effects, with findings of no significant effect based upon the results of the

first panels retreat and subsequent evaluation of the later panel results, no corrective measures will be necessary

2) reinforcement of the present pylons by the applicant to withstand the settling due to subsidence

3) redesign the pylon footings by the applicant to act as a rigid unit (slab) capable of withstanding the subsidence and not place additional stress on the pylon structure

4) reroute the 345 KV line to unaffected areas or previously subsided areas not expected to further settle.

12.4.4 Subsidence Monitoring Plan

The subsidence monitoring plan will include ground survey control work and aerial photography interpretation. The ground survey will be used in conjunction with the aerial photography in monitoring the effects of subsidence on the UP&L 345 KV transmission line. The aerial photography will be used to measure the amount of subsidence across the remainder of the property to determine the effects of subsidence on hydrology, changes in vegetation resources and subsequent wildlife resource changes.

The applicant has contracted with the Manti-LaSal National Forest to conduct the aerial photography portion of the subsidence monitoring plan so that the applicant will receive the photographs and reduced data on an annual basis (the complete plan with details is attached). The target monuments were constructed over the designated areas as shown on Plate 12-2 with the precise coordinates and elevations determined using the Utah Coordinate system as shown in the following table (Table 12-4):

The baseline aerial photography will be completed during the summer of 1983 at a time determined by the Forest Service. The Forest Service will perform the aerial triangulation, make one set of color and one set of color infared prints and assist in range analysis, timber surveys and wildlife habitat studies. Color aerial photography will be required initially for baseline data collection. Subsequent flights will be annual and will cover the area mined and the area to be mined in the next 18 months or the entire lease area as may be appropriate. The subsidence values will be reported to the Division of Oil, Gas and Mining annually. The aerial program will continue until it is deemed no longer necessary but not to exceed five years following the closure of the mine. An annual field inspection will be made each year to determine the conditions of the ground surface above all undergound mine workings. The survey will attempt to locate the presence of tension cracks, fissures,

TABLE 12-4

WEST APPA COAL COMPANY
Flight Control

Station	Pin. Elev.	Ground Elev.	Northing	Easting
WAC-TP-1	9794.63	9794.43	382 740.34	2 082 884.63
WAC-TP-2	9736.02	9735.88	383 174.14	2 083 738.23
WAC-TP-3	10264.70	10264.53	383 078.51	2 087 901.97
WAC-TP-4	10280.74	10280.37	388 007.02	2 086 758.89
WAC-TP-5	9864.64	9864.09	383 052.07	2 093 415.80
WAC-TP-6	9359.65	9359.37	385 142.39	2 099 816.08
WAC-TP-7	9368.25	9368.00	384 914.47	2 099 800.51
WAC-TP-8	9372.60	9372.35	385 120.87	2 099 958.15
WAC-TP-9	7698.85	7698.85	390 119.26	2 097 683.95
WAC-TO-10	6925.60	6925.35	394 362.79	2 108 074.72
WAC-TO-11	7219.82	7219.54	392 887.84	2 107 519.00
WAC-TP-12	7029.78	7029.57	397 052.30	2 105 856.87
WAC-TP-13	7017.16	7017.00	394 730.46	2 106 200.88
WAC-1	9952.84	9952.58	386 414.89	2 084 571.69
WAC-2	9712.66	9712.31	384 813.22	2 084 821.20
WAC-3	9772.22	9772.02	383 687.44	2 084 526.25
WAC-4	9547.36	9547.15	382 759.51	2 084 176.39
WAC-5	9174.35	9174.07	380 968.81	2 084 527.85
WAC-6	9739.78	9739.63	383 901.24	2 091 661.41
WAC-7	9473.48	9473.01	385 381.31	2 091 903.26
WAC-8	9239.11	9238.36	386 055.67	2 092 151.79
WAC-9	9682.79	9682.47	382 013.45	2 091 309.00
WAC-10	9334.56	9334.26	385 424.92	2 096 999.18
WAC-11	8857.78	8857.42	386 132.47	2 097 780.10
WAC-12	9228.44	9228.11	385 487.34	2 099 652.06
WAC-13	9315.19	9314.93	384 161.74	2 100 284.71
WAC-14	9093.68	9093.31	382 659.99	2 100 461.40
WAC-15	8222.70	8222.37	388 743.69	2 097 753.41
WAC-16	8105.34	8105.14	388 514.90	2 099 213.26
WAC-17	8187.42	8187.10	390 796.65	2 097 495.72
WAC-18	8160.25	8159.38	391 034.62	2 099 358.66
WAC-19	7459.87	7459.54	390 646.51	2 103 941.19

Station	Pin. Elev.	Ground Elev.	Northing	Easting
WAC-20	7447.59	7446.77	391 357.55	2 103 081.75
WAC-21	6861.42	6861.24	393 191.10	2 109 083.32
WAC-22	7491.20	7490.90	396 028.63	2 104 933.93
WAC-23	7002.52	7002.27	397 189.79	2 106 229.64
HL-100	7059.85	7059.65	392 775.72	2 107 970.09
C 1/4 22	6945.94	6944.59	394 904.61	2 106 400.41
1/4 29&28	7570.12	7568.82	389 515.29	2 098 413.67
35/36 3	9162.96	9162.26	381 335.84	2 084 557.10
M-1	7672.27	7672.21	389 818.90	2 098 605.49
M-2	7656.08	7656.09	389 421.19	2 099 206.83
R-3	7484.13	7483.73	390 053.05	2 101 054.10
36/ 1/ 6	--	--	--	--

structural offsets, subsidence damage to roads and powerlines, changes in spring flow and determination if any areas can be considered unstable.

The subsidence monitoring of the area near the transmission line will include ground surveys in addition to the aerial work described above. The vertical angle of the insulators on the support towers will be monitored to determine any changes in the line position. A brass survey plug will be cemented on each concrete footing of the pylons (T1 through T10 as on Plate 12-1). The coordinate and evaluation of each will be determined from ground surveys and reported to DOGM after mining commences but before any possible subsidence effects would occur. Each brass station over the mining area will be resurveyed twice a year to determine precise movements and will be annually reported to DOGM. Electronic distance measuring equipment will be used by the applicant to determine the coordinates and elevations.

12.5 ANALYSIS OF EARTHEN STRUCTURES

12.5.1 Sediment Pond Embankment

The mine site sedimentation control pond will be partially an in-situ pond with an embankment constructed around approximately one-half of its perimeter. The embankment height is 12 feet and the side slopes are 2.5 h to 1 v. See Plates 3-6 and 3-9.

12.5.1.1 Hazard Considerations

The sedimentation pond will impound a maximum of 1.6 acre-feet. The pond is located downstream and therefore poses no hazard to the site. There are no structures along the Rilda Canyon stream between the sedimentation pond and Huntington Creek. This distance is slightly more than 2 miles. There are no dwellings along Huntington Creek between where the Rilda Canyon stream enters it and the diversion structure at UP&L's Huntington Power Plant.

12.5.2 Construction Material Characteristics

The sedimentation pond will be lined with a one-foot-thick layer of clay material to prevent seepage. The clay liner will be protected with compacted gravel. Considering the embankment height and side slopes, the embankment should be stable if (the normal anticipated) soil with rock fragments is used to construct it. Exact embankment material characteristics will be determined during the geotechnical investigation for the site. The results of this investigation will be submitted to DOGM when completed before construction commences.

12.5.3 Foundation Material Characteristics

Characteristics of the foundation materials below the pond embankment will be determined during the geotechnical investigation for the site.

12.5.4 Hydrologic Characteristics

Hydrologic characteristics of the embankment and foundation materials will be determined during the geotechnical investigation for the site.

12.5.5 Design and Construction Plans

The design and construction plans for the sedimentation pond are shown on Plates 3-6 and 3-9. The foundation material will be scarified to a depth of 1 foot and recompacted to 95 percent of maximum density as determined by ASTM D698 (Standard Practice). The embankment will be constructed in lifts not exceeding 1 foot and compacted to 95 percent of ASTM D698. The clay liner and gravel surface will also be compacted to 95 percent maximum density.

12.5.6 Stability Analysis

A stability analysis for the pond embankment is not required due to its low height. However, embankment stability will be addressed during the site geotechnical investigation.

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12.7 PLATES

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CHAPTER XIII

DESIGNS

Prepared for

West Appa Coal Company

Price, Utah

by

Ford, Bacon & Davis, Incorporated

Salt Lake City, Utah

April 1983

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CHAPTER XIII

DESIGNS

13.0 DESIGNS

Design drawings occur in the appropriate chapters, but most are found in Chapter III and appear as Plates 3-1 through 3-15. See Section 13.0 (Table of Contents) for a list of design drawings.

CHAPTER XIV

CONSULTATION AND COORDINATION

Prepared for
West Appa Coal Company
Price, Utah

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CHAPTER XIV

CONSULTATION AND COORDINATION

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George Cook - U.S. Soil Conservation Service (SCS), Price

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