Canadian life zone; where as the river otter and mink utilize the Canadian and Hudsonian life zones. The river otter is not known to inhabit the environs of the project area, but mink are present.

The substantial valued use area for marten and wolverine is the montane ecological association. The marten does not utilize the Alpine life zone but the wolverine can be found in the environs of the project site, but it is unlikely that the marten is present.

The black-footed ferret is a species primarily dependent upon prairie dogs as a prey source. Currently, the ferret's relative abundance is so low that the animal is endangered with extinction. Utah lies on the western edge of the black-footed ferrets historic range. The substantial value use area for this species is restricted to prairie dog colonies. Prairie dog colonies are found within a multitude of wildlife habitats within the cold desert, submontane and montane (Canadian life zone) ecological associations. It should be noted that the project site does not provide habitat for prairie dogs; thus ferrets would also be absent.

The substantial valued use area for badger and skunks span all wildlife habitats other than dense forests in the cold desert, submontane and montane (Canadian life zone) ecological associations. Skunks and badgers are dependent upon a suitable prey source.

A crucial period for maintenance of all furbearers, raccoons and muskrat populations is when they have young in a nest, den or lodge. Such sites are critical for reproductive success.

Bobcat, Canada lynx and cougar are known to inhabit the biogeographic area that surrounds the project site. For all of these species a crucial period for maintenance of their population is when the female has her young secreted at a den site. Such sites are of critical value when being utilized. It is also crucial to their survival that a female accompanied by young not be killed or harassed.

The substantial valued use area for bobcats extends from the cold desert through the submontane and into the montane (Canadian life zone) ecological association. The bobcat is normally associated with precipitous terrain, but has been observed in every wildlife habitat within the aforementioned ecological associations. Their primary prey source is represented by small mammals and birds or any other small animal they can catch. It is important to note that bobcats occasionally kill the young of big game animals.

The substantial valued use area for the Canada lynx is restricted to the Canadian and Hudsonian life zones of the montane ecological association. Normally, this cat would be expected to utilize riparian and forested wildlife habitats. The lynx is similar in predation habits to the bobcat.

The substantial valued use area for the cougar (locally known as mountain lion) extends from the submontane into the montane (canadian and Hudsonian life zone) ecological association. Due to the dependency of the cougar upon mule deer as a prey source, a ranking of the lion's seasonal distribution parallels that of the deer.

Mule deer are inhabitants of the biogeographic area that surrounds the project site. Their substantial valued use area spans all wildlife habitats extending from the cold desert through the submontane and montane ecological associations. In some situations deer show altitudinal migrations in response to winter conditions. There are, however, habitats where deer reside on a yearlong basis.

Migration of mule deer from summer range to winter range is initiated during late October; probably, the annual disturbance of the fall hunting season coupled with changing weather conditions is the initial stimulus. The onset of winter weather reinforces the deer's urge to migrate and continued adverse weather keeps the deer on the winter range.

A portion of the project site represents winter range for mule deer herd unit 27b. Winter ranges for mule deer are all ranked as being of high-priority value to the animal; these areas are usually inhabited between November 1 and May 15 each year. During winters with severe conditions the higher elevation portion of the winter range becomes unavailable to deer due to snow depth. Traditionally, some restricted portions of the winter range have shown concentrated use by the deer; these sites are ranked as being of critical value. Critical valued sites must be protected from man's disturbance when the deer are physically present on the range.

Deer began their migration back to summer range during mid-May and remain there throughout October. Summer ranges on the project area represent deer herd unit 27b. They are ranked as being of high-priority value to mule deer. In instances where extent of summer range is the major limiting factor for a deer herd, those summer ranges are ranked as being of critical value.

There are ranges lying southwest of the project area that support mule deer on a yearlong basis. Most of these ranges are of limited value to deer. However, there are some areas supporting yearlong use that are ranked as being of high-priority value to deer. Within the yearlong range all riparian habitats are ranked as being critical value to mule deer.

Mule deer fawn during the month of June. The continuum of wildlife habitats extending from the pinion-juniper through the shrubland and into the aspen type probably represents the fawning area. All riparian areas are of critical value for fawning and maintenance of the deer population. To date no specific areas showing annual use for fawning are known. It is probable that such areas exist; they would be ranked as being of critical value to deer. It is important to note that June represents a crucial period of maintenance of deer populations.

Agriculture areas nearby to the project area are utilized yearlong by mule deer. Their use is sometimes intensified during the winter and spring periods.

Rocky mountain elk are inhabitants of the biogeographic area that surrounds the project site. Their substantial valued use area spans all wildlife habitats extending from the submontane through the montane ecological association. Elk do not show as strong of altitudinal migration as mule deer do in response to the winter conditions, but they do migrate to wintering areas.

Migration of elk from summer range to winter range is initiated during late October; probably, the annual disturbance of the fall hunting seasons coupled with changing weather conditions is the initial stimulus. The onset of winter weather reinforces the elk's urge to migrate and continued adverse weather keeps elk on the winter range.

A portion of the project site represents winter range for the Range Creek elk herd. Winter ranges for elk are all ranked as being of high-priority value to the animal; these areas are usually inhabitated between November 1 and May 15 each year. During winters with severe conditions some portions of the winter range become unavailable to elk due to snow depth. Traditionally, some restricted portions of the winter range have shown concentrated use by the elk; these sites are ranked as being of critical value. Note, that critical valued wintering sites have not yet been identified for the Range Creek herd. Critical valued wintering sites have not yet been identified for the Range Creek herd. Critical valued sites must be protected from man's disturbance when the elk are physically present on the range.

Elk begin their migration back to summer range during mid-May and remain their throughout October. Summer ranges on the project area support the Range Creek elk herd; they are ranked as being of high-priority value.

Elk calf during the month of June. Their preferred calving areas are best described as aspen forests with lush understory vegetation. All riparian areas on summer range are of critical value for calving and maintenance of the elk population. To date no specific areas showing annual use for calving are known. It is probable that such areas exist; they would be ranked as being of critical value to elk. It is important to note that June represents a crucial period for maintenance of elk populations.

Pronghorn antelope representing the Icelander herd are inhabitants of the biogeographic area immediately west of the project site. Their substantial valued use area spans all wildlife habitats except urban and park areas in the cold desert and extends up into the pinion-juniper forest of the submontane ecological association. It is unlikely that antelope would extend their use on the project area. In some situations antelope show longitudinal migrations in response to winter conditions. There are, however, habitats where antelope reside on a yearlong basis.

During winter and at times of severe snow conditions the portion of the range inhabited by antelope is ranked as being of critical value. During such a crucial period antelope must be protected from man's disturbance.

Within the yearlong range all riparian habitats are ranked as being of critical value to antelope.

Antelope kid during the month of June. This activity takes place in the area they happen to be when the time for birth occurs. The doe secrets herself from disturbance and predators and drops her kid. The young animal is capable of following the female in a few hours. Protection of the kid antelope from disturbance during the first day following birth is critical for maintenance of antelope populations.

Rocky mountain and desert bighorn sheep are inhabitants of the biogeographic area that surrounds the project site. The substantial valued use area for the rocky mountain subspecies spans all wildlife habitats (except the urban and parks habitat) extending from the submontane to the montane ecological association. The substantial valued use area for the desert subspecies spans all wildlife habitats (except the urban and parks habitat) in the cold desert and submontane ecological associations. In some situations bighorns show altitudinal migrations in response to winter conditions. There are, however, habitats where they reside on a yearlong basis.

Migration of bighorn sheep from summer range to winter range, in locals where this phenomenon exists, is initiated during the rut. Probably the change of weather conditions is the initial stimulus. The onset of winter weather reinforces the sheep's urge to migrate and continued adverse weather keeps them on the winter range; at which time that weather conditions allow, the bighorns then begin to migrate back to the summer range.

The environs associated with the project area support low numbers of the Range Creek rocky mountain bighorn herd on a yearlong basis. Desert bighorns have not and will likely never extend their range onto the project area. Generally speaking, about 70 percent of the yearlong range is of limited value to sheep; such areas represent the less precipitous terrain within their substantial valued use area. The remaining 30 percent of the bighorn's yearlong use area is ranked as being of high-priority value; such areas are represented by precipitous terrain and adjacent habitats. Note, all riparian habitats within the bighorn's substantial valued use area are ranked as being of critical value.

Bighorn's annually rut between November 1 and December 31. This is a crucial period for maintenance of their population.

Bighorn sheep lamb during the months of May and June. The cliff and tallus wildlife habitats represents a critical valued lambing area during the crucial period of mid-May through mid-June. To date no specific areas showing annual use for lambing are known. It is probable that such areas exist. It is important to note that May and June represents a crucial period for maintenance of sheep populations.

Currently, there are no other known high interest wildlife species or their habitat use areas on adjacent to the project area. It is not unreasonable to suspect that in the future, some additional species of wildlife may become of high interest to the local area, Utah or the Nation. If such is the case, the required periodic updates of project permits and reclamation plans can be adjusted and appropriate recommendations made.

3.30 Operating Plan

The Sunnyside Mines have been in operation since the end of the nineteenth century. The majority of the impacted vegetation was disturbed before the mine was permitted. Past and future disturbance will account for approximately 2 percent of the permit area vegetation.

Disturbed ground within the permit area that surrounds the facilities will be revegetated during the life of the mine. Areas adjacent to construction sites which have been disturbed during the life of the mine will be seeded during the first appropriate season.

Contemporaneous reclamation of disturbed sites will be conducted as needed on an annual basis, this will stabilize the disturbed areas.

Late fall seedings is best in the mountain and valleys of the intermountain region, where 45 to 65 percent of the precipitation comes in the winter months (Valentine 1971, Cook et al. 1974). Seeding at the Sunnyside Mines will generally be performed in the late fall, as also recommended by the SCS. However, because of the precipitation regime, grasses and forbs may also be successfully seeded in the spring. See Table 3-49 for the temporary reclamation seed mix used in contemporaneous reclamation.

Mining activity has occurred in Whitmore Canyon since the end of the nineteenth century. Fish and wildlife populations have reached an equilibrium with their environment. The ongoing operations have altered the environment of the local aquatic and terrestrial faunal communities, e.g. mine water discharge and noise pollution. Unless problems arise, the environment will continue in its altered state until mining operations cease.

Efforts to justify the use of coarse refuse for road base material resulted in the Winget study in 1980. Results of the aquatic resource analysis study (Winget 1980) showed that water quality in Grassy Trail Creek above the mine discharge is adequate for most aquatic species, except for questionable levels of nickel, zinc and oil and grease. Water quality below the mine discharge show considerable degradation: increases in conductivity, TDS, alkalinity, chloride, nitrate, phosphate, sulfate, sodium and oil and grease. There was an increase in sediment fines proceeding downstream; however, there was no evidence of toxicity type impacts chemical analyses nor biological community investigations provided any data that indicated a heavy metal problem in Grassy Trail Creek (Appendix 3-1).

The Winget study also noted:

"If impacts from mine discharge waters were eliminated, the impacts from the road bed materials would probably be negligible compared with natural environmental community limiting factors. Grass Trail Creek is not a Trout fishery type stream -- even without the Sunnyside mine the biotic community would be of marginal quality."

"There is no natural fish population in Grassy Trail Creek due to natural low flows, lack of unembedded spawning gravels and marginal water quality. Utah Division of Wildlife Resources plants catchable-size rainbow trout in the stream each year. The plants are more politically motivated than ecologically sound since the stream is only marginal fish habitat at best."

In 1989 a second study by Dr. Richard Baumann was conducted. The results of the second study by Dr. Baumann showed overall an improvement since the original study by Winget (Appendix 3-2).

Many of the species that potentially occur on the permit area have some or all of the habitat requirements in the riparian zones associated with drainage bottoms, seeps, springs, wetlands and flood plains. In the permit area, the canyon bottomlands provide most of the riparian habitats and are most productive in terms of herbage produced and wildlife use. Historically, the botttomlands have also been the areas preferred for human land use activity.

In addition to mining, the major land use activities have been grazing, recreation and water development (Grassy Trail Reservoir). Forage available for grazing on the permit area is limited because of the steep canyon slopes. Therefore, grazing occurs primarily in the canyon bottoms. A plan was designed to protect bottomlands from overgrazing and to stimulate production by a rest-rotation grazing system.

Land use during operation will continue to be mining, fish and wildlife habitat, recreation, limited livestock grazing, and minor cropland. Livestock which has been historically drifted along Grassy Trail Creek, while being moved to summer range, is required to be trailed from the mine site to a point above Grassy Trail Reservoir within one day.

This policy will be effective in the fall of 1990 and continue for the life of the mine. The purpose of this policy is to protect the riparian zones and vegetation along Grassy Trail Creek.

The effect of this underground coal mining operation on such land use is minimal and is not expected to change during the permit period.

3.31 Minimal Disturbance Measures

During any new construction activities, surface disturbance will be confined to as small an area as feasible. Equipment operators will be instructed to disturb as little vegetation as possible.

Federally listed threatened or endangered plant species are not located on or near the permit area, therefor none will be jeopardized by any coal mine developments. No unique or critical germ plasm will be lost.

3.32 Impacts of Subsidence on Renewable Resource Land

Minimal, if any, subsidence is expected to occur over much of the permit area as a result of controlled caving during the mining process. This may be accounted for by the geologically massive 150-foot thick Castlegate Sandstone that is about 200 feet above the Upper Sunnyside seam.

Subsidence impacts in renewable resource lands will be minimal to non existent and will not require mitigation.

3.33 Minimize Impacts to Fish and Wildlife

Impacts from operation of the ventilation fans are unavoidable. Where possible, mitigations will be achieved by minimizing these impacts and after the impacts, restoration to pre-impact conditions.

Dozing will be restricted to the minimum amount necessary for the shafts sites, power transmission lines and road upgrading. Upgrading the roads will be carried out according to current road building standards.

All revegetated areas will create induced and/or inherent edges. Induced edges are a result of various adjacent successional stages of the same community. Inherent edges occur where two different communities meet, e.g., where mountain brush on a slope abuts sage/ grass vegetation on a valley floor. On the largest areas of disturbance, a mosaic of induced edges will develop where revegetated areas adjoin non-mined and older reclaimed areas planted with crested wheatgrass.

The potential for optimizing the edge effect through vegetation groupings at Sunnyside is limited. The amount of edge is determined by length, width and configuration. Although boundaries of many disturbed areas are long, they are also very regular and narrow, thus restricting the potential to create more edge. Additionally, because most areas are small in size, habitat richness and variation of configuration is restricted (Thomas et al, 1979).

The ongoing operations have altered the environments of local aquatic and terrestrial faunal communities. Unless problems arise, the environments will continue in their altered state until mining operations cease.

The riparian habitat along Grassy Trail Creek is a primary concern for wildlife protection. During the course of mine development, facilities were constructed within 100 feet of the stream. Most of the construction occurred at the mine site in Section 32 (Plate 3-2). The riparian habitat that remains is marked with buffer zone signs (4) posted between the upper mine entrance to a point below the lower mine workings (SW1/4 Section 32).

Water discharged into Grassy Trail Creek must meet NPDES effluent criteria, Different water quality parameters are monitored on a monthly and quarterly basis.

The water quality of Grassy Trail Creek will be monitored during the life of the mine. Corrective measures will be undertaken if parameters exceed limits set in the National standards if the cause is due to mining activity.

The operator will avoid the use of persistent pesticides in the permit area during underground coal mining and reclamation activities unless approved by the Division.

3.40 Reclamation Plan

3.41 Revegetation

Areas disturbed by mining operations will be prepared for revegetation as particular sites are withdrawn from active service. Experience and site conditions may occasionally modify these methods.

Methods for revegetation at the Sunnyside mines follow established and proven techniques for critical area stabilization (Currier 1973). The basic considerations are:

Use adapted species considering the post-mine land use

Reduce plant competition and prepare a good seedbed

Cover seed to proper depth

Provide sufficient plant nutrients

Modify moisture regimen

(a) Use of Adapted Species

Lack of availability, economics and practicality makes replacement of all plants species virtually impossible. It is not realistic to expect to be able to plant climax plant communities on soils which are not in an equivalent state of development (Curry 1975).

The seed mixtures have been designed to provide a diverse, permanent and effective cover of vegetation for stabilization, range and wildlife use. Seed mixtures are included in Tables 3-49 Through 3-50. The wildlife value of each species is contained in Table 3-45 and cultural characteristics in Table 3-51.

The amount of seed mixture to be applied will range from 15 to 30 pounds pure live seed (PLS) per acre, depending upon the aspect and method of application (Cook et al. 1974). When possible seed will be drilled otherwise it will be broadcasted at double the drill rate.

(b) Reduce Plant Competition and Prepare a Good Seedbed

Areas to be seeded will be cultivated on the contour when possible by disc plowing or other means, to turn under competitive species present before seeding (Cook et al. 1974). The cultivation will present the seed with loose, friable surface, optimal for successful seeding (Valentine 1971).

(c) Cover Seed to Proper Depth

Seed has little chance of survival in an arid climate unless covered by mineral soil (Currier 1973). Following seeding areas otherwise covered will be dragged with a section of chainlink or chain to cover the seed.

(d) Seed at Proper Time

Late fall seeding is best in the mountains and valleys of the intermountain region, where 45 to 65 percent of the precipitation comes in the winter months (Valentine 1971, Cook et al. 1974). Seeding at the Sunnyside Mines will generally be performed in late fall, as also recommended by the SCS. However, because of the precipitation regime, grasses and forbs may also be successfully seeded in the spring.

(e) Provide Sufficient Plant Available Nutrients

Most soils are enhanced for plant production by application of chemical fertilizer (EPA 1975, Valentine 1971, Cook et al. 1974, Bauer et al. 1978). Although soil tests performed at the Utah State Soil Testing Laboratory indicated the need for an application of nitrogen and phosphorus, these recommendations are based on agronomic crops. Phosphorus is important for seed establishment (Berg 1979). The phosphorus and ammonium nitrate will be applied and disked into the soil. Any necessary nitrogen fertilization will be based on interpretation of the analyses in site specific teems considering species and soil materials to be seeded and the results of revegetation testing.

(f) Modify Soil Moisture Regimen to Supply Adequate Water

The Sunnyside area is characterized by hot summers, cool winters and an average annual precipitation of sixteen inches. At this site, available moisture is often deficient due to excessively high evapotranspiration rates, well-drained soils, and erratic precipitation. The lack of plentiful, dependable moisture is the principal impediment to plant establishment in this region(Cook et al. 1974).

All revegetated areas will be mulched with at a rate of 1 tons/acre. Tackifier will be applied with the mulch at a rate of 105 pounds/acre. Mulch will decrease moisture loss, increase site stabilization, moderate soil surface temperature and reduce wind velocity at the soil surface.

Reclaimed areas not subject to future disturbance will be monitored at intervals recommended by DOGM during the bond period, Ground cover, i.e. vegetation, litter, rock and bare ground will be estimated. The sampling will be consistent and comparable across the years.

During the last two years of the responsibility period the reclaimed sites and the referenced areas will be sampled to help determine revegetation success. The sampling will be comparable and statistically adequate. Parameters to be sampled include vegetation cover, productivity, and shrub density.

3.42 Fish and Wildlife

All disturbed sites no longer needed for mining operations will be reclaimed according to current reclamation standards. The reclamation techniques and seed mixtures are designed to have the capability to support the post-mining land uses of wildlife habitat and grazing land. Post-mining land use will continue to be wildlife, grazing, recreation and culinary water use in Grassy Trail Reservoir. The sites disturbed by mining activities will be reclaimed to wildlife and grazing uses

Bibliography

Bauer, A., W.A. Berg and W.L. Gould. 1978. Correction of nutrient deficiencies and toxicities in strip-mined lands in semi-arid and arid regions, pp. 451-466. In F.W. Schaller and P. Sutton (eds.) Reclamation of Drastically Disturbed Lands. American Society of Agronomy. Madison, Wisconsin.

Berg, W.A. Unpublished notes. 1979. Colorado State University. Fort Collins, Colorado.

Christensen, E.M. and H.B. Johnson. 1964 Presettlement vegetation and vegetational change in three valleys in central Utah. Brigham Young Univ. Sci. Bull., Biol. Ser. 4:1-16.

Cook, C.W. and C.D. Bonham. 1977. Techniques for revegetation measurements and analysis for pre- and post-mining inventory. Range Science Series No. 28 Colorado State University. Fort Collins, Colorado.

Cook, C.W., R.M. Hyde and P.L. Sims. 1974. Revegetation Guidelines for surface Mining. Range Science Series No. 16. Colorado State University. Fort Collins, Colorado.

Currier, W.F. 1974. Basic Principles of Seed Planting. Pp 225-232. In Proc. 1st Research and Applied Technology Symposium on Mined-Land Reclamation. NCA/BCR Coal Conference, Pittsburgh, Pennsylvania. BCR. Monreoville, Pennsylvania.

Driscoll, R.S. 1964. A relict area in the central Oregon juniper zone. Ecology 4J:345-353.

Environmental Protection Agency. 1975. "Methods of Quickly Vegetated Soils of Low Productivity, Construction Activities." EPA 440/9-75-006. EPA. Washington, D.C.

Harrington, H.D. and L.W. Durrell. 1957. How to Identify Plants. The Swallow Press Inc. Chicago, Illinois.

Joyce, Linda A. 1981. Climatic/vegetation relationships in the Northern Great Plains and the Wyoming North Central Basins. Phd thesis. Colorado State University, Fort Collins, Colorado.

Mueller-Dombois, Dieter and Heinz Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons. New York.

Packer, P.E. and E.F. Aldon. 1978. "Revegetation Techniques for Dry Regions." Pp. 425-450, In F.W. Schaller and P. Sutton (eds.) Reclamation of Drastically Disturbed Lands. American Society of Agronomy. Madison, Wisconsin.

Pearson, L.C. 1965. Primary production in grazed and ungrazed desert communities of eastern Idaho. Ecology 46:278-285.

Thomas, J.W., C. Maser and J.E. Rodiek, 1979. Wildlife habitat in managed forests of Blue Mountains of Oregon and Washington USDA Forest Service, Ag. Handbook No. 553.

USFWS. 1980. Federal list of threatened and endangered species.

Vallentine, J.F. 1971. Range Developments and Improvements. Brigham Young University Press. Provo, Utah.

Welsh, S.L. and G. Moore. 1973. Utah Plants - Tracheophyta. Brigham Young University Press. Provo, Utah.

List of Exhibits

United States Department of Agriculture
Soil Conservation Service
350 N. 400 E.
Price, UT 84501

November 4, 1981

John Abbott
Kaiser Steel Corporation
Sunnyside, UT 84539

Dear John;

This letter confirms the findings of George Cook when he visited your Sunnyside operation on September 30, 1981. The rangeland productivity estimates by site are listed below:

Site #1 (upper portal) - Mountain brush community
800 lbs/acre air dry

Site #2 (Bear Canyon bottom) - Sagebrush/grass community
1000 lbs/acre air dry

Site #3 (cottonwood area) - Riparian community
understory production 2500 lbs/acre air dry
(willow area) - 3000 lbs/acre air dry

Site #4 - Pinyon-juniper grass community
understory - 300 lbs/acre air dry
Pinyon/juniper - 400 lbs/acre

Site #5 - (Fan Canyon) - Pinyon-juniper /Rock community
understory - 200 lbs/acre

If we can be of further assistance, please contact us in Price.

Sincerely,

Gary D. Moreau
District Conservationist
Price/Castle Dale Field Office

GDM/lhb

Figure 3-1, Rangeland Productivity Estimations

United States Department of Agriculture | Soil Conservation Service | 350 North 4th East
Price, Utah 84501

August 8, 1983

Marcia H. Wolfe
Reclamation Engineer
Kaiser Coal Properties
P. O. Box 1107
Raton, New Mexico 87740

Dear Marcia:

I went to East Carbon and checked the condition of the sites that were listed in the letter dated November 4, 1981, from Gary.

Sites #1, 2, and 3 are in fair condition. Sites #4 and 5 are in good condition.

The potential soil productivities are still not available. We will get the draft copy of the information sometime this fall. When it comes, I will send it to you.

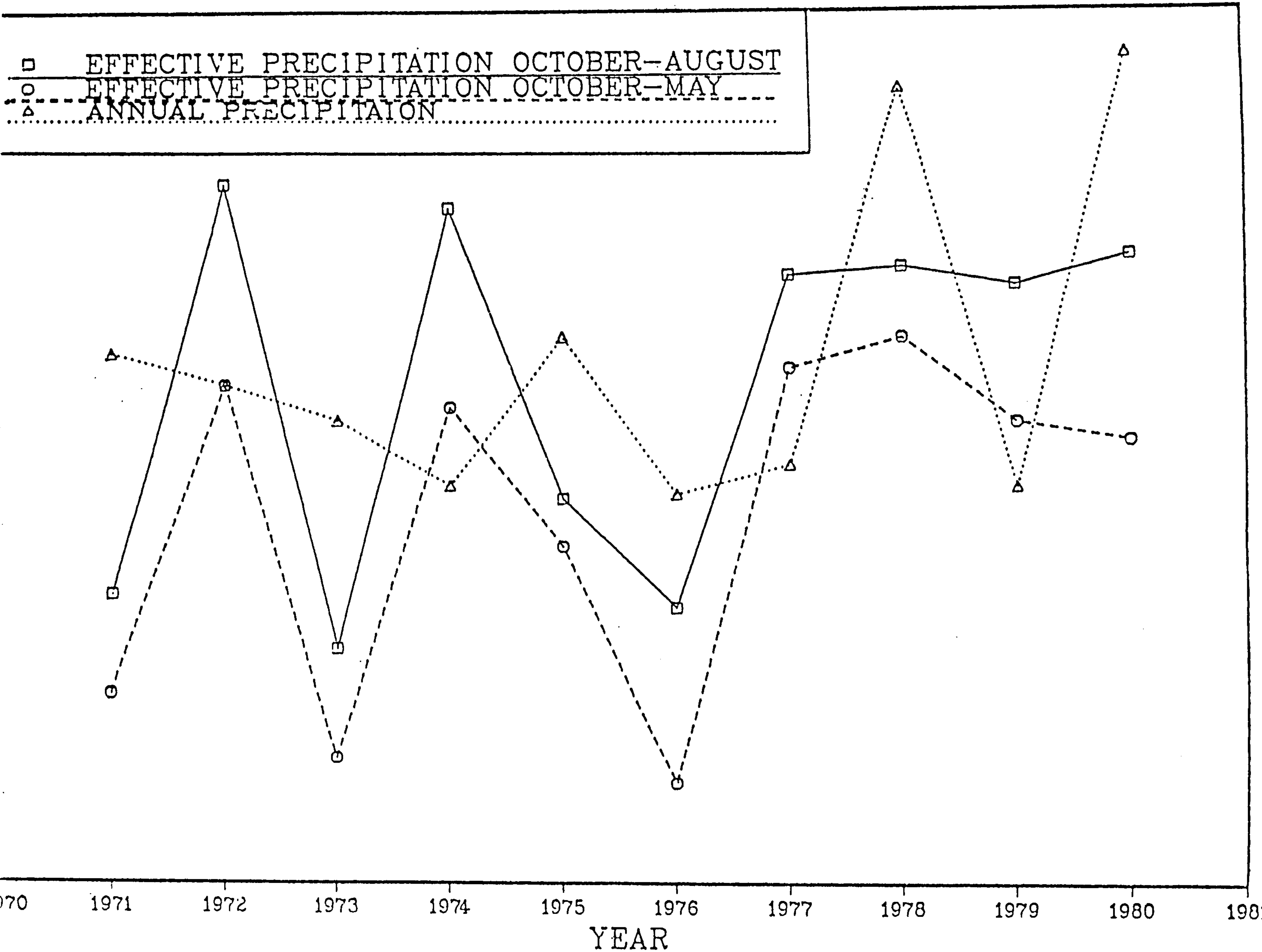
George S. Cook

George S. Cook
Range Conservationist

Figure 3-2
Range conditions at time of SCS productivity estimations.

EFFECTIVE 10 YEAR SUNNYSIDE PRECIPITATION

Figu[illegible]3-3



KAISER STEEL
KAISER STEEL CORPORATION
WESTERN COAL OPERATIONS
SUNNYSIDE, UTAH 84539
TELEPHONE 801-888-4421

13 July 1981

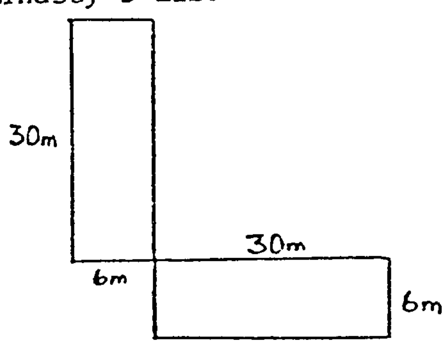
Ms. Mary Ann Wright
Dept. of Natural Resources
Division of Oil, Gas and Mining
1588 West North Temple
Salt Lake City, UT 84116

Dear Mary Ann:

I am writing to confirm our conversation in your office on Wednesday, June 10, 1981. The vegetation sampling plan we agreed upon for Kaiser's Sunnyside and South Lease permits is described in the following:

Type: Pinyon-Juniper

Modified Lindsey's Elbow



Parameters Collected:

1. Herbaceous cover in 1% increments from 40 randomly located 20 x 50 cm quadrats.
2. Shrub cover from two (2) 30 meter line intercepts.
3. Tree cover from two (2) 30 meter line Intercepts.
4. Tree basal diameter for each tree in the elbow.
5. Tree density from no. 4.
6. Frequency (generated from cover data).
7. Species list

Figure 3-4
Confirmation of DOGM approval of vegetation survey methods.

Figure 3-4

(Cont)

Type: Shrub and Grass Communities

Line transects with randomly located quadrats.

Parameters collected:

1. Herbaceous cover in 1% increments from 20 randomly located quadrats along a 50 meter line.
2. Frequency generated from cover data.
3. Species list.

Type: Grass dominated communities (cover less than 30% shrubs or trees).

Line transects with randomly located quadrats.

Parameters collected:

1. Herbaceous cover in 1% increments from 20 randomly located quadrats along a 50 meter line.
2. Frequency generated from cover data.
3. Species list.
4. Production will be double sampled (1 quadrat clipped to 5 quadrats estimated).

Type: Riparian areas

Line transects with randomly located quadrats.

Parameters collected:

1. Herbaceous cover in 1% increments from 20 randomly located quadrats along a 10 meter line.
2. Frequency generated from cover data
3. Shrub cover from 10m line intercept.
4. Species list.

Sample Adequacy as per cook and Bonham (1977) formulat

$$\frac{(\text{t-value})^2 (2)(s^2)}{\left[(\%\text{change})(\bar{x})\right]^2} = n_{min}$$

with the t-value being two tailed and the % change in accord with the Regulations Pertaining to Surface Effects of Underground Coal Mining Activities.

These methods cover the types of vegetation present in the disturbed areas of the Sunnyside Mine and the potential disturbed area of the South Lease.

Thanks for your help and clarification.

Yours truly,

John P. Abbott

John Abbott
Range Scientist

JA:sp

Figure 3-4 Cont.

Table 3-1. Sampling intensities for measured vegetation parameters. Sunnyside Mines, Utah. August through September 1981.

Vegetation Type	Parameter	$n_{sampled}$	$n_{minimum}$
Mountain Brush	Cover quadrats	220	202
	Point-lines	12	9
	Shrub density	20	13
	Line intercept	13	12
Pinyon-Juniper	Cover quadrats	240	914
	Point-lines	26	26
	Shrub density	30	28
	Line intercept	20	19
	Tree density	22	19
Pinyon-Juniper/Grass	Cover quadrats	360	168
	Point-lines	28	19
	Shrub density	19	222
	Line intercept	19	19
	Tree density	17	11
Pinyon-Juniper/Sagebrush	Cover quadrats	13	13
	Point-lines	11	10
	Shrub density	10	9
	Tree density	10	8
	Line intercept	21	16
Riparian	Point-lines	10	1
	Shrub density	7	5
Sagebrush-Grass	Cover quadrats	120	100
	Point-lines	6	1
	Shrub density	15	10
	Line intercept	14	8

Table 3-2. Shrub stem density by species. Mountain Brush vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Stem Density per acre	Stem Density per hectare
Amelanchier alnifolia	Serviceberry	265	654
Artemisia tridentata	Big sagebrush	35	86
Cercocarpus montanus	True mountain mahogany	520	1284
Chrysothamnus nauseosus	Rubber rabbitbrush	20	49
Pachistima myrsinites	Box leaf	40	99
Philadelphus microphyllus	Mock orange	50	123
Rosa woodsii	Woods rose	20	49
Symphoricarpus spp.	Snowberry	50	123
Symphoricarpus vaccinoides	Snowberry	40	99
Tetradymia canescens	Gray horsebrush	5	12
Xanthocephlum sarothrae	Broom snakeweed	35	86
Total		1080	2664

Table 3-3. Shrub cover by species from a 50 m line-intercept. Mountain Brush vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Cover (%)
Amelanchier alnifolia	Serviceberry	13.90
Artemisia tridentata	Big sagebrush	.10
Cercocarpus montanus	True mountain mahogany	11.20
Chysothamnus depressus	Dwarf rabbitbrush	.001
Chysothamnus nauseosus	Rubber rabbitbrush	.11
Philadelphus microphyllus	Mock orange	.23
Rhus trilobata	Skunkbush sumac	.02
Rosa woodsii	Woods rose	.02
Xanthocephalum sarothrae	Broom snakeweed	.20
Total Shrub Cover		25.60

Table 3-4. Vegetation cover from 0.10 m^2 quadrats. Mountain Brush vegetation type. Sunnyside Mines, Utah. August 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Forb	1.9	19
Grass	6.7	68
Shrub	1.3	13
Vegetation Cover	9.90	
Bare ground	38.6	
Litter	19.6	
Rock	31.9	
Total	100.0	100

TABLE 3-5. PERCENT COVER AND CONSTANCY BY SPECIES FOR MOUNTAIN BRUSH VEGETATION TYPE. SUNNYSIDE MINES, UTAH. JULY-AUGUST, 1981.

STAND NUMBER	1	2	3	4	5	6	7	8	9	10	11	CONSTANC
GRID NUMBER	13	13	13	13	13	13	13	13	13	13	13	
ELEVATION IN FEET	7350	7300	7325	7300	7350	7300	7375	7400	7400	7325	7425	
ASPECT	E	E	E	E	NE	NE	NE	E	E	E	E	
SLOPE IN PERCENT	44	62	62	44	64	55	64	48	49	60	58	
SOIL MAPPING UNIT	PSH	PSH	PSH	PSH	PSH	PSH	PSH	PSH	PSH	PSH	PSH	
GRASSES:												
Elymus salina	4.3	10.0	5.2	2.1	1.6	1.5	2.0	7.4	9.3	7.9	18.4	100
Koeleria cristata	•	•	•	0.3	0.3	0.1	0.5	•	•	•	•	36
Poa pratensis	•	•	•	0.7	•	0.4	•	•	•	•	•	18
Unknown grass	•	•	•	•	0.2	2.1	•	•	•	•	•	18
FORBS:												
Artemisia ludoviciana	•	•	•	.75	.2	•	1.2	•	•	•	•	27
Aster spp.	•	•	•	•	•	1.5	.1	•	•	•	0.4	27
Astragalus tenellus	•	•	1.4	1.1	0.2	1.0	•	•	•	•	•	36
Balsamorhiza sagittata	•	•	•	•	•	•	0.8	•	•	•	•	9
Castilleja flava	•	•	•	.1	•	•	•	•	•	•	•	9
Cirsium sp.	•	•	•	•	•	0.1	•	•	•	•	•	9
Gaillardia spathulata	•	•	•	•	+	•	•	•	•	•	•	9
Gilia aggregata	•	•	•	•	•	+	•	•	•	•	•	9
Hedysarum boreale	•	•	0.1	1.0	•	0.3	•	0.1	0.1	•	1.5	55
Hymenoxys richardsonii	•	•	0.8	+	0.5	0.2	0.2	•	0.4	0.2	•	64
Machaeranthera grindelioides	+	0.3	0.6	.9	+	•	0.1	+	0.3	0.6	•	82
Thytaria acutifolia	•	0.1	0.5	0.3	•	0.4	•	+	0.2	0.4	+	73
Senecio sp.	•	•	•	•	0.2	•	•	•	•	•	•	9
[illegible]doo sparsifolia	•	•	0.4	•	0.4	0.2	•	•	•	•	•	27
[illegible]on dubius	•	•	+	•	0.1	•	•	•	•	•	•	18
Vicia americana	•	•	•	•	•	0.1	•	•	•	•	•	9
Unknown forb	•	•	•	0.3	0.3	•	0.3	0.1	•	0.2	•	45
SHRUBS:												
Amelanchier alnifolia	•	•	0.3	•	•	•	•	•	•	0.1	•	18
Artemisia tridentata	•	•	•	•	•	•	0.1	•	•	•	•	9
Cercocarpus montanus	•	0.1	0.2	•	•	•	•	•	0.4	+	•	36
Chrysothamnus depressus	•	0.9	•	•	•	0.5	•	•	0.6	•	•	27
C. nauseosus	•	•	•	•	•	•	+	•	•	•	•	9
Mahonia repens	•	•	•	•	•	1.1	•	•	0.1	•	•	18
Pachystima myrsinites	•	•	•	•	•	1.8	•	•	•	•	•	9
Tetradymia canescens	•	0.3	•	•	•	1.6	•	•	0.1	•	•	27
Xanthocephalum sarothrae	•	•	•	0.3	•	•	•	•	•	•	•	9

Table 3-6. Vegetation cover from 30 m point-line transect. Mountain Brush vegetation type. Sunnyside Mines, Utah. August 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Forb	1.2	3
Grass	11.7	25
Shrub	33.3	72
Vegetation Cover	46.2	
Bare ground	19.6	
Litter	19.0	
Rock	15.2	
Total	100.0	100

Table 3 -7. Comprehensive species list for the Mountain Brush vegetation type. Sunnyside Mines, Utah. June through September 1981.

Scientific Name	Abbreviation	Common Name
Forbs		
Achillea millefolium	ACMI	Western yarrow
Artemisia ludoviciana	ARLU	Louisiana sagebrush
Aster spp.	ASTER	Aster
Astragalus spp.	ASTRA	Milkvetch
Astragalus tenellus	ASTE	Looseflower milkvetch
Balsamorhiza sagittata	BASA	Arrowleaf balsamroot
Castilleja chromosa	CACH	Desert Indian paintbrush
Castilleja flava	CAFL	Yellow Indian paintbrush
Caulanthus crassicalis	CACR	Thickstem wildcabbage
Cirsium spp.	CIRSI	Thistle
Eriogonum spp.	ERIOG	Wild buckwheat
Gaillardia spathulata	GASP	Blanket flower
Gilia aggregata	GIAG	Skyrocket gilia
Hedysarum boreale	HEBO	Northern sweetvetch
Hedysarum occidentale canone	HEOCC	Western sweetvetch
Hymenoxys richardsonii	HYRI	Pinque hymenoxys
Leucelene ericoides	LEER	Heath aster
Lupinus concinnus	LUCO	Bajada lupine
Machaeranthera grindelioides	MAGR	Aster (var.)
Opuntia spp.	OPUNT	Pricklypear
Penstemon comarrhenus	PECO	Dusty penstemon
Penstemon watsonii	PEWA	Watson penstemon
Physaria acutifolia	PHAC	Common twinpod
Senecio multilobatus	SEMU	Lobeleaf groundsel
Senecio spp.	SENEC	Groundsel
Solidago sparsiflora	SOSP	Goldenrod
Tragopogon dubius	TRDU	Yellow salsify

Table 3-7 Cont.

Scientific Name	Abbreviation	Common Name
Grasses		
Agropyron spicatum	AGSP	Bluebunch wheatgrass
Bouteloua gracilis	BOGR	Blue grama
Elymus salina	ELSA	Salina wildrye
Koeleria cristata	KOCR	Prairie junegrass
Oryzopsis hymenoides	ORHY	Indian ricegrass
Phleum pratense	PHPR	Timothy
Poa pratensis	POPR	Kentucky bluegrass
Grasslike		
Carex spp.	CAREX	Sedge
Shrubs		
Amelanchier alnifolia	AMAL	Serviceberry (var.)
Amelanchier utahensis	AMUT	Utah serviceberry
Artemisia tridentata	ARTR	Big sagebrush
Cercocarpus ledifolius	CELE	Curlleaf mountain mahogany
Cercocarpus montanus	CEMO	Mountain mahogany
Chrysothamnus depressus	CHDE	Dwarf rabbitbrush
Chrysothamnus nauseosus	CHNA	Rubber rabbitbrush
Chrysothamnus vaseyi	CHVA	Vasey rabbitbrush
Chrysothamnus viscidiflorus	CHVI	Low rabbitbrush
Holodiscus microphyllus	HOMI	Ocean-spray
Mahonia repens	MARE	Creeping barberry
Pachistima myrsinites	PAMY	Myrtle pachistima
Philadelphus microphyllus	PHMI	Littleleaf mockorange
Potentilla fruticosa	POFR	Shrubby cinquefoil
Rhus trilobata	RHTR	Skunkbush sumac
Rosa woodsii	ROWO	Woods rose
Symphoricarpos vaccinioides	SYVA	Snowberry

Table 3-7 Cont.

Scientific Name	Abbreviation	Common Name
Shrubs		
Tetradymia canescens	TECA	Grey horsebrush
Xanthocerphalum sarothrae	XASA	Broom snakeweed
Trees		
Juniperus communis	JUCO	Common juniper
Populus tremuloides	POTR	Quaking aspen
Pseudotsuga menziesii	PSME	Douglas fir

Table 3-8. Tree and shrub cover from 30 m line-intercept transects. Pinyon-Juniper vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Cover (%)
Cercocarpus ledifolius	Curlleaf mountain mahogany	0.90
Cercocarpus montanus	True mountain mahogany	3.40
Chrysothamnus nauseosus	Rubber rabbitbrush	.03
Cowania mexicana	Stansbury cliffrose	1.00
Ephedra viridis	Green Mormon tea	.50
Juniper osteosperma	Utah juniper	13.00
Pinus edulis	Pinyon Pine	15.00
Total		33.83

Table 3-9. Tree density by species. Pinyon-Juniper vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Stem Density per acre	Stem Density per hectare
Juniperus osteosperma	Utah juniper	125	309
Pinus edulis	Pinyon pine	132	325
Total		257	634

Table 3-10. Tree basal areas by species. Pinyon-Juniper vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Basal Area ft^2/A	Basal Area m^2/ha
Juniperus osteosperma	Utah juniper	61	14
Pinus edulis	Pinyon pine	29	7
Total		90	21

TABLE 3-11. PERCENT COVER AND CONSTANCY BY SPECIES

FOR PINYON-JUNIPER VEGETATION TYPE.

SUNNYSIDE MINES, UTAH. JULY-AUGUST, 1981.

STAND NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	CONSTANCY
GRID NUMBER	14	14	14	14	14	14	14	14	14	14	14	14	
ELEVATION IN FEET	7225	7250	7380	7400	7380	7225	7200	7240	7280	7360	7360	7400	
ASPECT	E	E	E	E	E	E	E	E	E	E	E	E	
SLOPE IN PERCENT	61	61	61	61	41	41	41	41	41	52	71	71	
SOIL MAPPING UNIT	RWG	RWG	RWG	RWG	RWG	RWG	RWG	RWG	RWG	RWG	RWG	RWG	
GRASSES:													
Agropyron sp.	•	•	•	•	•	•	0.1	•	•	•	•	•	8
Bromus tectorum	•	•	•	•	•	•	+	•	•	•	•	•	8
Elymus salina	•	+	•	0.2	•	•	•	•	•	•	•	•	17
Oryzopsis hymenoides	0.7	0.4	1.4	9.5	0.8	•	0.2	•	0.2	0.2	0.2	0.4	83
Poa sp.	•	0.2	0.3	•	•	•	0.4	+	•	•	•	•	33
Unknown grass	0.1	•	0.2	0.1	•	•	•	•	•	•	•	•	25
FORBS:													
Aster sp.	•	•	•	•	•	•	•	•	0.2	•	•	•	8
Brassicaceae spp.	0.2	+	0.2	+	•	0.1	•	•	•	•	+	•	50
Corringa orientalis	•	•	•	•	•	0.1	•	0.1	•	•	•	•	17
Cryptantha spp.	+	0.2	0.3	0.1	•	0.1	•	•	•	•	+	•	50
Hedysarum boreale	2.9	0.3	0.8	0.1	•	•	•	•	•	•	•	•	33
Leucelene ericoides	•	•	•	•	•	•	•	•	•	0.2	•	•	8
Malva neglecta	•	•	•	0.1	•	•	•	•	•	•	•	•	8
Opuntia sp.	•	•	•	•	•	•	1.6	•	•	0.6	•	0.2	25
Penstemon subglaber	•	0.8	•	•	•	•	•	•	•	•	•	•	8
Physaria acutifolia	•	•	0.1	0.1	0.1	+	+	•	0.1	0.4	0.1	•	67
Senecio multilobatus	•	•	0.1	•	•	•	•	•	•	•	•	+	17
Vicia americana	•	+	•	•	•	•	•	•	•	•	•	•	8
Unknown forb	+	•	•	•	•	•	0.1	0.1	•	•	•	•	25
SHRUBS:													
Cercocarpus ledifolius	•	•	•	+	•	•	•	•	•	•	0.5	•	17
C. montanus	•	•	•	•	+	•	•	•	•	+	•	+	25
Chrysothamnus nauseosus	•	•	•	•	•	0.1	•	•	•	•	•	•	8
Cowania mexicana	•	•	•	•	+	•	•	•	+	•	•	•	17
Ephedra viridis	•	•	•	•	0.1	•	•	•	•	•	•	•	8
TREES:													
Juniperus osteosperma	•	+	•	•	•	•	•	•	•	•	•	•	8
Pinus edulis	0.2	•	•	•	•	•	•	•	•	•	•	0.3	17

Table 3-12. Comprehensive species list for Pinyon-Juniper vegetation type. Sunnyside Mines, Utah. June through September 1981.

Scientific Name	Abbreviation	Common Name
Forbs		
Aster spp.	ASTER	Aster
Brassica spp.	BRASS	Mustard
Conringia orientalis	COOR	Treacle haresear
Cryptantha mensana	CRME	Cryptantha (var.)
Cryptantha spp.	CRYPT	Cryptantha
Hedysarum boreale	HEBO	Northern sweetvetch
Leucelene ericoides	LEER	Heath aster
Malva spp.	MALVA	Mallow
Opuntia spp.	OPUNT	Pricklypear
Penstemon spp.	PENST	Beardstongue
Physaria acutifolia	PHAC	Common twinpod
Senecio multilobatus	SEMU	Lobeleaf groundsel
Vicia americana	VIAM	American vetch
Grasses		
Agropyron spp.	AGROP	Wheatgrass
Bromus tectorum	BRTE	Cheatgrass brome
Elymus salina	ELSA	Salina wildrye
Oryzopsis hymenoides	ORHY	Indian ricegrass
Poa spp.	POA	Bluegrass
Sitanion hystrix	SIHY	Bottlebrush squirreltail
Shrubs		
Amelanchier spp.	AMELA	Serviceberry
Artemisia nova	ARNO	Black sagebrush
Cercocarpus ledifolius	CELE	Curlleaf mountain mahogany
Chrysothamnus nauseosus	CHNA	Rubber rabbitbrush
Cowania mexicana	COMES	Stansbury cliffrose

Table 3-12 Cont.

Scientific Name	Abbreviation	Common Name
Shrubs		
Ephedra torreyana	EPTO	Torrey ephedra
Xanthocephalum sarothrae	XASA	Broom snakeweed
Trees		
Juniperus osteosperma	JUOS	Utah juniper
Juniperus scopulorum	JUSC	Rocky Mountain juniper
Pinus edulis	PIED	Pinyon pine

Table 3-13. Shrub stem density by species. Pinyon-Juniper vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Stem Density per acre	Stem Density per hectare
Amelanchier alnifolia	Saskatoon serviceberry	2	5
Artemisia nova	Black sage	2	5
Cercocarpus ledifolius	Curlleaf mountain mahogany	59	145
Cercocarpus montanus	True mountain mahogany	78	193
Chrysothamnus nauseosus	Rubber rabbitbrush	32	78
Cowania mexicana	Stansbury cliffrose	84	207
Ephedra viridis	Green ephedra	57	142
Xanthocephalum sarothrae	Broom snakeweed	19	47
Total		333	822

Table 3 -14. Vegetation cover by life form from 0.25 m^2 quadrats. Pinyon-Juniper vegetation type. Sunnyside Mines, Utah. August 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Cryptogam	0.12	7.5
Forb	0.79	49
Grass	0.54	34
Shrub	0.04	2
Tree	0.12	7.5
Vegetation Total	1.61	
Bare ground	48.55	
Litter	14.05	
Rock	31.96	
Total	100.17 -	100.0

Table 3 -15. Vegetation cover by life form from 30 m point-line transects. Pinyon-Juniper vegetation type. Sunnyside Mines, Utah. August 1981.

Parameter	Absolute Cover (%)	Relative Vegetation Cover (%)
Forb	0.6	2
Grass	0.4	1
Shrub	5.5	19
Tree	22.2	78
Vegetation Total	28.7	
Bare ground	12.3	
Litter	19.6	
Rock	39.4	
Total	100.0	100

Table 3-16. Vegetation cover by species from 30 m line-intercept transects. Pinyon-Juniper/Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Total Cover (%)
Shrubs:		
Cercocarpus montanus	True mountain mahogany	.59
Trees:		
Juniperus osteosperma	Utah juniper	17.93
Pinus edulis	Pinyon pine	13.47
Total		31.99

Table 3-17. Shrub stem and tree density by species. Pinyon-Juniper/Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Stem Density per acre	Stem Density per hectare
Shrub:			
Artemisia nova	Black sagebrush	20	50
Cercocarpus montanus	True mountain mahogany	520	1300
Chrysothamnus nauseosus	Rubber rabbitbrush	61	150
Xanthocephalum sarothrae	Broom snakeweed	951	2350
Shrub Total		1558	3850
Tree:			
Juniperus osteosperma	Utah juniper	149	368
Pinus edulis	Pinyon pine	102	253
Tree Total		241	621

Table 3-18. Tree basal area by species. Pinyon-Juniper/Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Basal Area ft^2/A	Basal Area m^2/ha
Juniperus osteosperma	Utah juniper	6325	1451
Pinus edulis	Pinyon pine	2423	556
Total		8748	2007

Table 3-19. Tree seedling density by species. Pinyon-Juniper/Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Seedling Density per acre	Seedling Density per hectare
Juniperus osteosperma	Utah juniper	107	265
Pinus edulis	Pinyon pine	210	519
Total		317	784

Table 3-20. Vegetation cover from 0.25 m^2 quadrats. Pinyon-Juniper/ Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Forb	4.77	53.72
Grass	3.73	42.00
Shrub	0.0*	0.0
Tree	.39*	4.28
Vegetation Cover	8.89	
Bare ground	24.60	
Litter	55.04	
Rock	20.54	
Total	100.00	100.00

* Only individuals <12 inches in height (33 cm) are included in herbaceous data.

TABLE 3-21. PERCENT COVER AND CONSTANCY BY SPECIES FOR PINYON-JUNIPER/GRASS VEGETATION TYPE. SUNNYSIDE MINES, UTAH. JULY-AUGUST, 1981.

AND NUMBER	1	2	3	4	5	6	7	8	9	10
ID NUMBER	19	19	19	19	19	19	19	19	19	19
VATION IN FEET	6380	6390	6400	6380	6390	6380	6360	6390	6400	6400
ECT	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
OPE IN PERCENT	1	1	1	1	1	1	1	1	1	1
IL MAPPING UNIT	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE
ASSES:										
Agropyron smithii	•	•	•	•	•	•	•	+	•	•
Aristida spp.	0.4	+	•	0.2	•	•	•	+	4.2	•
A. wrightii	•	•	•	•	•	•	•	•	•	0.1
Bromus tectorum	•	•	0.1	•	•	•	•	•	+	•
Oryzopsis hymenoides	9.6	2.4	5.9	4.7	6.4	2.1	2.4	4.6	1.1	2.0
Sitanion hystrix	0.2	•	0.3	+	0.2	•	+	•	•	0.1
Stipa comata	•	•	•	0.2	•	•	•	•	•	•
Unknown grass	•	•	•	•	•	•	•	•	•	•
RBS:										
Brassicaceae spp.	0.1	0.2	0.5	•	0.1	•	+	•	•	•
Caulanthus crassicaulis	0.3	•	•	•	0.1	0.2	0.2	0.2	0.2	0.1
Chenopodium album	•	•	0.1	+	•	•	•	+	•	+
Cryptantha spp.	0.7	0.1	1.4	0.2	0.2	0.2	0.3	0.1	0.9	0.6
Eriogonum spp.	0.3	0.2	0.1	+	•	+	0.1	0.1	0.4	0.1
Euphorbia fendleri	0.4	0.1	0.1	•	•	•	0.1	+	0.3	+
Hedysarum boreale	•	•	•	•	•	0.3	•	•	•	•
Hymenoxys richardsonii	0.5	•	0.8	0.3	0.1	0.3	0.2	0.1	0.2	0.1
Opuntia sp.	•	0.5	1.5	•	•	-	0.3	•	0.4	•
Fr[illegible] subglaber	2.6	1.0	2.4	1.0	2.4	2.1	3.3	1.7	4.0	2.7
Fr[illegible] americana	•	•	•	+	•	•	•	•	•	•
Phys[illegible] acutifolia	•	•	•	•	•	•	•	•	0.6	•
Senecio multilobatus	0.7	1.0	1.0	0.4	0.7	0.7	1.8	0.7	1.0	0.8
Townsendia incana	0.3	0.1	0.3	0.1	0.1	0.3	0.1	1.1	0.1	0.2
Xanthocephalum sarothrae	•	•	•	•	•	•	•	•	0.1	•
Unknown forb	•	+	•	•	+	+	•	•	•	•
REES:										
Pinus edulis	•	•	•	•	•	0.1	0.4	•	0.3	•
Juniper osteosperma	•	•	•	0.4	0.3	+	1.4	•	•	•
Cryptogam	0.5	0.1	•	•	•	0.2	•	•	•	0.3

TABLE 3-21 (CONT.)

TAND NUMBER	11	12	13	14	15	16	17	18	CONSTANCY
RID NUMBER	19	19	19	19	19	19	19	19	
.L[illegible] IN FEET	6380	6380	6380	6380	6360	6360	6400	6490	
SPE[illegible]	SW	SW	SW	SW	SW	SW	SW	SW	
LOPE [illegible] PERCENT	1	1	1	1	1	1	1	1	
OIL MAPPING UNIT	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	
RASSES:									
Agropyron smithii	•	0.1	•	•	•	+	•	•	17
Aristida spp.	•	+	•	•	0.3	+	•	•	44
A. wrightii	•	•	•	+	•	0.2	•	•	17
Bromus tectorum	•	•	•	•	•	•	•	•	11
Oryzopsis hymenoides	2.2	2.0	4.7	3.6	0.8	0.7	2.3	2.2	100
Sitanion hystrix	0.1	•	0.1	•	0.1	+	0.4	•	61
Stipa comata	•	•	•	•	•	•	•	•	6
Unknown grass	+	•	•	•	•	•	+	•	11
ORBS:									
Brassicaceae spp.	•	•	0.1	•	0.1	•	•	•	39
Caulanthus crassicaulis	0.2	+	0.1	0.1	0.1	0.2	•	0.1	78
Chenopodium album	•	+	•	•	•	•	0.1	•	33
Cryptantha spp.	1.2	0.6	0.6	0.3	0.9	0.6	0.7	0.8	100
Eriogonum spp.	•	0.3	0.1	0.1	0.1	0.1	0.1	•	83
Euphorbia fendleri	0.1	+	+	0.2	0.1	•	+	+	78
Hedysarum boreale	•	•	•	•	•	•	•	•	6
Hymenoxys richardsonii	•	0.5	+	•	•	•	•	•	61
Opuntia sp.	0.6	0.1	0.2	+	•	•	•	0.5	50
Penstemon subglaber	4.1	1.9	2.5	0.8	3.4	1.2	2.6	2.9	100
Phacelia neomexicana	•	0.1	•	•	0.1	0.1	•	0.6	28
Physaria acutifolia	•	•	•	•	•	•	•	•	6
Senecio multilobatus	0.9	0.3	0.9	0.3	1.1	0.3	1.3	0.9	100
S[illegible]dia incana	0.2	•	0.5	0.1	+	+	•	•	83
X[illegible]phalum sarothrae	•	•	•	•	•	•	•	•	6
[illegible]nknown forb	•	•	0.1	•	+	+	+	•	39
REES:									
Pinus edulis	0.5	+	1.0	0.3	0.1	•	1.0	•	50
Juniper osteosperma	0.3	0.1	•	0.1	•	•	+	•	44
Cryptogam	•	+	•	+	•	+	•	•	39

Table 3-22. Comprehensive species list for the Pinyon-Juniper/Grass vegetation type. Sunnyside Mines, Utah. June through September 1981.

Scientific Name	Abbreviation	Common Name
Forbs		
Astragalus mollissimus	ASMO	Woolly milkvetch
Astragalus spp.	ASTRA	Milkvetch
Caulanthus crassicalis	CACR	Thickstem wildcabbage
Chorispora tenella	CHTE	Blue mustard
Cryptantha fulvocanescens	CRFU	Beggarlice hiddenflower
Cryptantha spp.	CRYPT	Cryptantha
Erigeron pumilus	ERPU	Low fleabane
Erysimum asperum	ERAS	Plains erysimum
Euphorbia fendleri	EUFE	Fendler euphorbia
Gilia aggregata	GIAG	Skyrocket gilia
Haplopappus armerioides	HAAR	Thrifty goldenweed
Hedysarum boreale	HEBO	Northern sweetvetch
Hymenoxys acaulis	HYAC	Stemless hymenoxys
Hymenoxys richardsonii	HYRI	Pinque hymenoxys
Lappula echinata	LAEC	European stickseed
Lathyrus lanzwertii	LALA	Thickleaf peavine
Lepidium montanum	LEMO	Mountain pepperweed
Leptodactylon pungens	LEPU	Prickly phlox
Lesquerella intermedia	LEIN	Bladderpod (var.)
Lesquerella ludoviciana	LELU	Silver bladderpod
Lygodesmia spp.	LYGOD	Skeletonweed
Machaeranthera grindelioides	MAGR	Aster (var.)
Opuntia spp.	OPUNT	Pricklypear
Penstemon spp.	PENST	Beardtongue
Penstemon subglaber	PESU	Penstemon (var.)
Physaria australis	PHAU	Twinpod (var.)
Physaria spp.	PHYSA	Twinpod

Table 3-22 Cont.

Scientific Name	Abbreviation	Common Name
Forbs		
Senecio multilobatus	SEMU	Lobeleaf groundsel
Sisymbrium altissimum	SIAL	Tumblemustard
Stanleya viridiflora	STVI	Princesplume
Tragopogon dubius	TRDU	Yellow salsify
Grasses		
Aristida spp.	ARIST	Three-awn
Aristida wrightii	ARWR	Wright three-awn
Bromus tectorum	BRTE	Cheatgrass brome
Elymus salina	ELSA	Salina wildrye
Oryzopsis hymenoides	ORHY	Indian ricegrass
Sitanion hystrix	SIHY	Bottlebrush squirreltail
Stipa comata	STCO	Needle-and-thread
Shrubs		
Cercocarpus montanus	CEMO	Mountain mahogany
Chrysothamnus nauseosus	CHNA	Rubber rabbitbrush
Chrysothamnus spp.	CHRYS	Rabbitbrush
Eurotia lanata	EULA	Winterfat
Xanthocephalum sarothrae	XASA	Broom snakeweed
Trees		
Juniperus osteosperma	JUOS	Utah juniper
Juniperus scopulorum	JUSC	Rocky Mountain juniper
Pinus edulis	PIED	Pinyon pine

Table 3-23. Vegetation cover from 30 m point-line transect. Pinyon-Juniper/Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Forb	3.58	10.22
Grass	4.00	11.42
Shrub	.50	1.43
Tree	26.95	76.93
Vegetation Cover	35.03	
Bare ground	25.09	
Litter	20.16	
Rock	19.72	
Total	100.00	100.00

Table 3-24. Comprehensive species list for Riparian vegetation type. Sunnyside Mines, Utah. June through September 1981.

Scientific Name	Abbreviation	Common Name
Forbs		
Abronia fragrans	ABFR	Snowball sandverbena
Artemisia ludoviciana	ARLU	Louisiana sagebrush
Aster fendlerii	ASFE	Aster (var.)
Clematis columbiana	CLCO	Virginsbower
Dalea flavescens	DAFL	Yellow prairie clover
Eriogonum shockleyi	ERSH	Shockley wild buckwheat
Gilia aggregata	GIAC	Skyrocket gilia
Lappula occidentalis	LOAC	Annual stickseed
Lupinus masculatus	LUMA	Lupine
Mentha arvensis	MEAR	Field mint
Myosotis verne	MYVE	Forget-me-not
Vicia americana	VIAM	American vetch
Grasses		
Agropyron spp.	AGROP	Wheatgrass
Agrostis alba	AGAL	Redtop
Aristida fendleriana	ARFE	Fendler three-awn
Oryzopsis hymenoides	ORHY	Indian ricegrass
Poa pratensis	POPR	Kentucky bluegrass
Poa secunda	POSE	Sandburg bluegrass
Stipa lettermani	STLE	Letterman needlegrass
Grasslike		
Juncus balticus	JUBA	Baltic rush
Juncus ensifolius	JUEN	Swordleaf rush
Shrubs		
Alnus tenuifolia	ALTE	Thinleaf alder

Table 3 -24 Cont.

Scientific Name	Abbreviation	Common Name
Shrubs		
Amelanchier spp.	AMELA	Serviceberry
Artemisia tridentata	ARTR	Big sagebrush
Cercocarpus montanus	CEMO	Mountain mahogany
Chrysothamnus nauseosus	CHNA	Rubber rabbitbrush
Chrysothamnus viscidiflorus	CHVI	Low rabbitbrush
Philadelphus microphyllus	PHMI	Littleleaf mockorange
Rhus trilobata	RHTR	Skunkbush sumac
Ribes aureum	RIAU	Golden current
Salix spp.	SALIX	Willow
Symphoricarpos vaccinoides	SYVA	Snowberry
Trees		
Acer glabrum	ACGL	Rocky Mountain maple
Acer negundo	ACNE	Box Elder
Juniperus communis	JUCO	Common juniper
Juniperus scopulorum	JUSC	Rocky Mountain juniper
Populus angustifolia	POAN	Narrowleaf cottonwood
Ulmus parvifolia	ULPA	Chinese elm

TABLE 3-25. PERCENT COVER AND CONSTANCY BY SPECIES

FOR RIPARIAN VEGETATION TYPE.

SUNNYSIDE MINES, UTAH. JULY-AUGUST, 1981.

											CONSTANCY
AND NUMBER	1	2	3	4	5	6	7	8	9	10	
ID NUMBER	15	15	15	15	15	15	15	15	15	15	
EVATION IN FEET	6900	6900	6900	6900	6900	6900	6900	6900	6900	6900	
SPECT	S	S	S	S	S	S	S	S	S	S	
OPE IN PERCENT	2	3	2	2	2	3	3	3	3	3	
IL MAPPING UNIT	CIC	CIC	CIC	CIC	CIC	CIC	CIC	CIC	CIC	CIC	
ASSES:											
Agropyron spp.	16	20	•	16	•	•	•	•	•	4	40
Bromus tectorum	4	•	•	12	4	•	•	•	•	•	30
Elymus salina	•	8	•	•	•	•	•	•	•	•	10
Oryzopsis hymenoides	•	•	•	•	•	•	4	•	4	•	20
Poa pratensis	•	16	16	4	40	8	8	4	4	12	80
RASSLIKE:											
Juncus balticus	•	•	•	•	+	•	•	•	•	•	10
J. ensifolius	+	•	•	•	•	•	•	•	•	•	10
DRBS:											
Artemisia ludoviciana	•	•	4	4	•	•	16	•	4	4	50
A. tridentata	•	20	•	•	•	•	•	•	•	•	10
Asclepias sp.	+	•	•	4	•	•	•	•	•	•	20
Aster fendleri	•	•	•	•	12	•	•	•	+	•	20
A. sp.	•	4	•	•	•	•	4	•	12	•	30
Clematis columbiana	+	•	•	•	12	•	•	•	•	•	20
Melilotus officinalis	4	•	•	•	•	•	•	•	•	•	10
Salsola kali	4	•	•	•	•	•	•	•	•	•	10
Solidago sparsiflora	•	•	•	•	•	•	•	•	4	•	10
SH											
ysothamnus nauseosus	•	•	•	•	•	12	•	•	•	•	10
alix exigua	84	68	48	84	80	92	52	48	56	32	100
TREES:											
Acer negundo	•	•	16	•	•	•	36	36	•	•	30
Populus angustifolia	•	•	•	•	•	•	•	•	20	48	20
Ulmus americana	•	•	12	•	•	•	•	•	•	•	10

Table 3 -26. Vegetation cover from 10 m point-line transects. Riparian vegetation type. Sunnyside Mines, Utah. August 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Forb	2.4	3
Grass	2.0	2
Shrub	68.4	78
Tree	14.4	17
Vegetation Total	87.2	
Bare ground	2.8	
Litter	7.2	
Rock	2.8	
Total	100.0	100

TABLE 3-27. PERCENT COVER AND CONSTANCY BY SPECIES

FOR SAGEBRUSH-GRASS VEGETATION TYPE.

SUNNYSIDE MINES, UTAH. JULY-AUGUST, 1981.

							CONSTANCY
AND NUMBER	1	2	3	4	5	6	
ID NUMBER	12	12	12	12	12	12	
EVATION IN FEET	7100	7100	7100	7100	7100	7100	
SPECT	357	357	357	357	357	357	
OPE IN PERCENT	7	7	7	7	7	7	
IL MAPPING UNIT	CIC	CIC	CIC	CIC	CIC	CIC	
ASSES:							
Agropyron cristatum	.8	.8	.5	1.0	.2	1.0	100
A. smithii	2.2.	•	•	12.5	8.5	5.1	50
A. spicatum	•	•	•	.3	•	.3	33
Bouteloua gracilis	.2	•	•	•	•	•	17
Bromus tectorum	.9	22.00	24.00	11.2	15.8	16.3	100
Calamagrostis sp.	•	.3	•	•	•	•	17
Elymus salina	4.0	.2	16.6	•	.1	4.3	83
Oryzopsis hymenoides	2.9	6.2	5.8	4.3	12.0	11.5	100
Sitanion hystrix	.6	1.5	.9	.3	•	3.5	83
Sporobolus cryptandrus	•	•	•	•	•	.4	17
Stipa comata	1.1	.3	.9	•	•	•	50
S. sp.	1.2	•	•	•	•	•	17
ORBS:							
Artemesia ludoviciana	.1	•	•	•	•	•	17
Brassicaceae spp.	•	.1	•	•	•	•	17
Cirsium sp.	1.3	•	2.0	•	•	•	33
Crytantha spp.	.5	•	.1	•	•	1.8	50
Grindelia squarrosa	•	.1	•	•	•	•	17
Hedysarum sp.	2.0	•	•	•	•	•	17
Hy... richardsonii	.7	•	•	•	•	•	17
L... spp.	•	.1	.3	•	.1	.8	67
... spp.	•	.1	.1	•	•	•	33
Machaeranthera grindelioides	.2	•	•	•	•	•	17
Opuntia sp.	•	•	•	1.3	•	•	17
Sphaeralcea coccinea	•	.6	•	•	•	1.0	33
S. sp.	•	•	•	.1	.3	1.0	50
Unknown forbs	.4	.1	.4	.6	.1	.2	100

Table 3 -28. Shrub stem density by species for Sagebrush-Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Stem Density per acre	Stem Density per hectare
Artemisic tridentata	Big sagebrush	3477	8576
Amelanchier alnifolia	Serviceberry	13	34
Chrysothamnus nauseosus	Rubber rabbitbrush	220	543
Xanthocephalum sarothrae	Broom snakeweed	20	49
Unknown shrub		7	16
Total		3733	9218

Table 3 -29. Comprehensive species for Sagebrush-Grass. Sunnyside, Utah. June through September 1981.

Scientific Name	Abbreviation	Common Name
Forbs		
Achillea lanulosa	ACMIL	Western yarrow
Artemisia ludoviciana	ARLU	Louisiana sagebrush
Asclepias spp.	ASCLE	Milkweed
Cirsium spp.	CIRSI	Thistle
Cryptantha spp.	CRYPT	Cryptantha
Grindelia squarrosa	GRSQ	Curlycup gumweed
Hedysarum boreale	HEBO	Northern sweetvetch
Hymenoxys richardsonii	HYRI	Pinque hymenoxys
Lappula spp.	LAPPU	Stickseed
Lepidium spp.	LEPID	Pepperweed
Machaeranthera grindelioides	MAGR	Aster (var.)
Opuntia spp.	OPUNT	Pricklypear
Solidago spp.	SOLID	Goldenrod
Sphaeralcea coccinea	SPCO	Scarlet globemallow
Sphaeralcea spp.	SPHAE	Globemallow
Grasses		
Agropyron cristatum	AGCR	Fairway wheatgrass
Agropyron smithii	AGSM	Western wheatgrass
Agropyron spicatum	AGSP	bluebunch wheatgrass
Bouteloua gracilis	BOGR	Blue grama
Bouteloua hirsuta	BOHI	Hairy grama
Bromus tectorum	BRTE	Cheatgrass brome
Calamagrostis spp.	CALAM	Reedgrass
Elymus cinereus	ELCI	Great Basin wildrye
Elymus salina	ELSA	Salina wildrye
Oryzopsis hymenoides	ORHY	Indian ricegrass
Sitanion hystrix	SIHY	Bottlebrush squirreltail

Table 3-29 Cont.

Scientific Name	Abbreviation	Common Name
Grasses		
Sporobolus spp.	SPORO	Dropseed
Stipa comata	STCO	Needle-and-thread
Stipa spp.	STIPA	Needlegrass
Shrubs		
Amelanchier alnifolia	AMAL	Serviceberry
Artemisia tridentata	ARTR	Big sagebrush
Chrysothamnus nauseosus	CHNA	Rubber rabbitbrush
Eurotia lanata	EULA	Winterfat
Symphoricarpos spp.	SYMPH	Snowberry
Xanthocephalum sarothrae	XASA	Broom snakeweed

Table 3-30. Vegetation cover for the Sagebrush-Grass vegetation type from 0.25 m^2 quadrats. Sunnyside Mines, Utah. July 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Forb	2.61	7.00
Grass	33.40	93.00
Shrub	+	
Tree	*	
Vegetation Cover	35.01	
Bare ground	25.43	
Litter	34.11	
Rock	4.39	
Total	100.00	100.00

* No trees present

+ Only shrubs <12 inches (33 cm) were measured in quadrats. Line-intercept data for shrubs is included in Table IX-26.

Table 3-31. Shrub cover from 30 m line-intercept. Sagebrush-Grass vegetation type. Sunnyside Mines, Utah. August 1981.

Species	Common Name	Cover (%)
Artemisia frigida	Fringed sage	.24
Artemisia tridentata	Big sagebrush	19.34
Chrysothamnus nauseosus	Rubber rabbitbrush	.79
Symphoricarpus spp.	Snowberry	.13
Total		20.60

Table 3-32. Vegetation cover for the Sagebrush-Grass vegetation type from 50 m point-line transect. Sunnyside Mines, Utah. July 1981.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Forb	3.33	4.22
Grass	49.34	33.33
Shrub	26.33	62.45
Tree	*	
Vegetation Cover	79.00	
Bare ground	4.33	
Litter	15.00	
Rock	1.67	
Total	100.00	100.00

* No trees present

Percent cover, frequency and constancy by species for pinyon-juniper sagebrush habitat type. [illegible]

Table 3-33

Stand number	1	2	3	4	5	6	7	8	9	10	11	12	13			
State and county						Carbon County, Utah										
Grid number	41	41	41	41	41	41	41	41	41	41	41	41	41			
Elevation in feet	7120	7120	7120	7120	7120	7120	7120	7120	7120	7120	7120	7120	7120			
Aspect	117°	117°	126°	125°	128°	126°	117°	119°	117°	123°	123°	125°	140°			
Slope percent	76%	66%	58%	58%	70%	65%	67%	65%	53%	76%	76%	50%	63			
Soil mapping unit	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2	RSH_2			
	Average Cover and Frequency													Cover (%)		
Species	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	AC-F	x̄	s	Constancy (%)
Grasses																
Agropyron spicatum	+	0.40-15	0.20-5	1.70-65	1.70-35	0.45-15	2.95-40	2.20-55	1.10-30	1.90-35	3.85-50	2.35-55	3.25-60	1.70	1.22	92
Bouteloua gracilis	•	•	•	+	+	•	•	•	+	•	•	•	•	+	•	0
Bromus tectorum	•	+	•	0.35-20	0.35-10	•	0.75-25	0.05-5	0.05-5	0.30-5	0.20-10	0.60-10	0.35-10	0.23	0.25	69
Elymus salina	3.05-55	4.70-85	5.50-70	0.95-25	0.30-20	1.10-25	0.55-20	1.20-30	1.40-35	1.15-45	1.50-15	0.15-5	0.95-10	1.73	1.66	100
Oryzopsis hymenoides	+	0.05-5	+	+	+	+	•	•	0.15-10	0.65-10	0.10-5	•	•	0.07	0.18	31
Oryzopsis micrantha	•	•	•	•	0.25-10	•	•	•	•	•	•	•	+	0.02	0.07	8
Poa spp.	•	•	•	•	•	0.05-5	0.05-5	+	0.45-15	•	•	•	0.10-5	0.05	0.12	31
Sporobolus cryptandrus	•	•	•	+	•	•	•	•	•	•	•	0.65-15	•	0.05	0.18	8
Total	3.05	5.15	5.70	3.00	2.60	1.60	4.30	3.45	3.15	4.00	5.65	3.75	4.65	3.85	1.22	
Grass-like																
Carex spp.	•	•	•	•	0.05-5	0.05-5	•	•	•	•	•	•	•	0.01	0.02	15
Forbs																
Artemisia ludoviciana	•	•	•	•	•	•	•	•	•	•	•	0.10-5	•	0.01	0.03	8
Chryptantha spp.	+	•	•	•	•	•	•	•	+	•	•	•	•	+	•	0
Descurainia spp.	•	•	•	•	•	0.05-5	•	•	•	•	•	•	•	T	•	8
Erigeron spp.	•	•	•	•	•	•	•	•	+	•	•	•	•	+	•	0
Erigeron divergens	•	•	•	•	•	•	•	•	•	•	•	0.05-5	•	T	•	8
Erigeron flagellaris	•	•	•	•	•	•	•	•	+	•	•	•	•	+	•	0
Machaeranthera spp.	+	•	•	+	+	•	•	0.05-5	•	•	0.05-5	•	+	0.01	0.02	15
Oxybaphus linearis	•	•	•	•	•	•	•	•	•	•	0.15-10	•	•	0.01	0.04	8
Senecio multilobatus	•	+	•	•	+	+	•	•	0.05-5	•	•	•	•	T	•	8
Sisymbrium altissimum	•	•	•	•	•	•	•	•	•	•	•	0.05-5	•	T	•	8
Tragopogon dubius	+	•	•	•	•	•	•	•	•	•	•	•	•	+	•	0
Unknown forbs	•	•	•	0.05-5	•	•	•	•	+	•	•	•	•	T	•	8
Total	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.05	0.00	0.05	0.35	0.00	0.04	0.10	
Shrubs																
Amelanchier alnifolia	+	+	•	•	•	•	•	•	+	+	•	•	+	+	•	0
Amelanchier tridentata	+	+	+	0.25-5	0.05-5	+	+	0.70-10	+	+	+	0.10-10	+	0.08	0.10	31
Atriplex canescens	+	+	+	+	•	•	+	+	+	+	•	•	•	+	•	0
Atriplex confertifolia	•	+	+	•	•	•	•	•	•	•	•	•	•	+	•	0
Brickellia microphylla	•	•	•	•	•	+	•	•	•	•	•	•	•	+	•	0
Cercocarpus montanus	•	•	•	•	•	+	•	•	•	•	•	•	•	+	•	0
Chrysothamnus nauseosus	+	+	•	•	•	•	•	•	+	•	•	•	•	+	•	0
Cowania mexicana	+	•	•	•	+	•	•	•	•	•	•	•	•	+	•	0
Echinocereus spp.	•	+	•	•	+	0.25-5	•	•	+	•	•	•	+	0.02	0.07	8
Ephedra viridis	+	+	+	+	+	+	+	+	+	0.10-5	+	+	+	0.01	0.03	8
Gutierrezia sarothrae	•	0.10-5	0.15-5	+	+	0.25-10	0.25-5	0.05-5	+	•	•	•	•	0.14	0.34	38
Opuntia polyacantha	•	0.10-5	+	+	+	+	•	•	•	•	•	•	+	0.01	0.03	8
Philadelphus microphyllus	•	•	+	•	•	+	•	•	+	•	•	•	•	+	•	0
Symphoricarpos oreophilus	+	•	+	•	+	+	•	+	•	•	•	•	+	+	•	0
Total	0.00	0.20	0.15	0.25	0.05	0.50	1.25	0.75	0.00	0.10	0.00	0.10	0.00	0.26	0.37	
Trees																
Juniperus osteosperma	+	+	+	+	+	+	+	+	+	+	+	+	+	+	•	0
Juniperus scopulorum	+	•	+	+	•	•	•	•	•	•	•	+	•	+	•	0
Pinus edulis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	•	0
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Others																
Moss	•	•	•	•	•	0.75-15	•	0.15-5	•	•	•	•	•	0.07	0.21	15
Total vegetation	3.05	5.35	5.85	3.25	2.70	2.95	5.55	4.40	3.20	4.10	5.70	4.20	4.65	4.23	1.18	
Rock	56.35	45.25	58.55	33.65	62.40	62.70	48.70	50.85	55.30	45.45	65.85	51.10	54.40	53.12	8.73	
Litter	9.20	12.65	10.25	3.00	1.70	16.15	1.95	2.45	1.50	6.90	10.05	6.80	1.50	6.47	4.90	
Bareground	31.40	36.75	25.35	60.10	33.20	18.20	43.80	42.30	40.00	43.55	18.40	37.90	39.45	36.18	11.32	

The + indicates that the species was observed but not in the plot.

The T represents mean cover values which are less than 0.005 percent.

Table 3 -34. Tree population analyses for pinyon-juniper/sagebrush habitat type. Sunnyside Mines, B-Canyon, Utah. Summer 1983.

Plant Community	Species	Cover %	Basal Area m^2ha	Basal Area ft^2/ac	Density Trees/ha	Density Trees/ac	Timber Volume (Board ft/ac)	Site Index
Pinyon-juniper/sagebrush	*Juniperus osteosperma*	8.7	7.09	30.87	153	62	N/A	N/A
	Juniperus scopulorum	0.5			11	4	N/A	N/A
	Pinus edulis	7.4	1.75	7.62	144	58	N/A	N/A
Total		16.6	8.84	38.49	308	124		

Table 3 -35. Shrub population characteristics in 1983 of the pinyon-juniper/sagebrush habitat type. Sunnyside Mines, B-Canyon, Utah.

Species	Canopy Cover (%)	Density	
		Stems/ha	Stems/acre
Amelanchier alnifolia	0.2	36	15
Atriplex canescens	0.5	150	61
Atriplex confertifolia	0.1	11	4
Artemisia nova	0.1		
Artemisia tridentata	11.2	3478	1409
Cercocarpus montanus		6	2
Chrysothamnus nauseosus		17	7
Cowania mexicana		3	1
Ephedra viridus	1.9	896	363
Philadelphus microphyllus		72	29
Symphoricarpos oreophilus		8	3
Total	14.0	4677	1894

Table 3 -36. Vegetation cover from 30 meter point line transects. Pinyon-juniper/sagebrush habitat type. Sunnyside Mines, B-Canyon, Utah. Summer 1983.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Grass	11.27	26.83
Shrub	14.73	35.07
Trees	16.00	38.10
Total Vegetation Cover	42.00	
Bareground	6.18	
Rock	32.91	
Litter	18.91	

Table 3-37. Vegetation cover estimated from 0.10 m^2 quadrats. Pinyon-juniper/sagebrush habitat type. Sunnyside Mines, B-Canyon, Utah. Summer 1983.

Parameter	Cover (%)	Relative Vegetation Cover (%)
Grass	3.85	91.00
Grasslike	0.01	0.24
Forb	0.04	0.95
Shrub	0.26	6.15
Moss	0.07	1.66
Total Vegetation Cover	4.23	
Bareground	6.47	
Rock	53.12	
Litter	36.18	

Table 3 -38. Comprehensive species list for pinyon-juniper/sagebrush habitat type. Sunnyside Mines, B-Canyon, Utah. Summer 1983.

Trees	
Juniperus osteosperma	Utah juniper
Juniperus scopulorum	Rocky Mountain juniper
Pinus edulis	pinyon pine
Shrubs	
Amelanchier alnifolia	Saskatoon serviceberry
Artemisia nova	black sagebrush
Artemisia tridentata	big sagebrush
Atriplex canescens	four-wing saltbush
Atriplex confertifolia	shadscale saltbush
Brickellia microphylla	brickellia
Cercocarpus montanus	true mountain mahogany
Chrysothamnus nauseosus	rubber rabbitbrush
Cowania mexicana	cliffrose
Echinocereus spp.	echinocereus
Ephedra viridis	green ephedra
Gutierrezia sarothrae	broom snakeweed
Opuntia polyacantha	plains prickly pear
Philadelphus microphyllus	littleleaf mockorange
Symphoricarpus oreophilos	mountain serviceberry
Forbs	
Artemisia ludoviciana	Louisiana sagebrush
Cryptantha spp.	cryptantha
Descurainia spp.	tansy mustard
Erigeron spp.	fleabane
Erigeron divergens	spreading fleabane
Erigeron flagellaris	trailing fleabane
Machaeranthera spp.	aster
Oxybaphus linearis	

Table 3-38. Continued.

Forbs	
Senecio multilobatus	groundsel
Sisymbrium altissimum	garlic mustard
Tragopogon dubius	salsify
Grasses	
Agropyron spicatum	bluebunch wheatgrass
Bouteloua gracilis	blue grama
Bromus tectorum	cheatgrass brome
Elymus salina	salina wildrye
Oryzopsis hymenoides	indian ricegrass
Oryzopsis micrantha	littleseed ricegrass
Sporobolus cryptandrus	sand dropseed
Poa spp.	bluegrass
Others	
Moss	moss

Table 3-39. Comparison of Actively Disturbed Site to Proposed Reference Site

Parameter	Disturbed Site	Proposed Reference Site (1)
Vegetation Type	Mountain Brush	Mountain Brush
Location	Whitmore Canyon	Whitmore Canyon
Section	SW¼SW¼, Section 17, T14S, R14E	SW¼NW¼, Section 20 T14S, R14E
Elevation, Ft./M	7280/2219	7290/2222
Geologic formation	North Horn Flagstaff Formation	North Horn Flagstaff Formation
Soils mapping unit	Zillion Complex	Zillion Complex
Slope (percent)	40	42.5
Aspect (degrees)	102	96
Species composition	Assumed to be similar*	Amelanchier/Elymus dominants
Plant Cover		
Quadrat data (Herbaceous only)	**	10.0%
Point Line Data	**	45.8%
Productivity	**	800lb/acre

*This disturbed site is adjacent to the mountain brush community. The probable potential of the disturbed site is determined to be mountain brush. Species composition, plant cover and productivity undoubtedly would fall within the normal variation expected in this type.

**No vegetation data is presented because the sites are already disturbed, therefore no statistical comparisons can be made.

Table 3-40. Comparison of Actively Disturbed Site to Proposed Reference Site

Parameter	Disturbed Site	Proposed Reference Site (2)
Vegetation type	Pinyon/Juniper	Pinyon/Juniper
Location	Slaughter Canyon	Fan Canyon
Section	SW¼SW¼, Section 30 T14S, R14E	NE¼SW¼, Section 30, T14S, R14E
Elevation, Ft./M	7020/2139	7280/2210
Geologic Formation	Mesa Verde and Mancos Shale	Mesa Verde and Mancos Shale
Soils Mapping Unit	Ildefonso - Rock uptcrop complex. Menefee Rock outcrop complex. Rock-Rubble-Sunup complex.	Rock-Rubble-Sunup Complex
Slope (percent)	Streambed - 14 Canyon walls -59	62
Aspect (degrees	275° and 95°	112
Species composition	Assumed to be similar	Pinus/Ephedra
Plant cover		
Quadrat data (Herbaceous only)	**	1.44%
Point Line data	**	28.5%
Productivity	**	200lb/acre

*This previously disturbed site is in the pinyon/juniper habitat type. Species composition, cover and productivity are assumed to fall within the normal variation expected in this vegetation type.

**No vegetation data is presented because sites are already disturbed therefore no statistical comparisons can be made.

Table 3-41. Comparison of Actively Disturbed Site to Proposed Reference Site

Parameter	Disturbed Site	Proposed Reference Site (2)
Vegetation type	Pinyon/Juniper	Pinyon/Juniper
Location	Fan Canyon	Fan Canyon
Section	NW¼SW¼, Section 30, T14S, R14E	NW¼SW¼, Section 30, T14S, R14E
Elevation, Ft./M	7120/2172	7280/2210
Geologic Formation	Mesa Verde and Mancos Shale	Mesa Verde and Mancos Shale
Soils Mapping Unit	Ildefonso Rock outcrop complex. Minfre Rock outcrop complex.	Rock-Rubble-Sunup Complex
Slope (percent)	68	62
Aspect (degrees)	92	112
Species composition	Assumed to be similar	<u>Pinus/Ephedra</u>
<u>Plant cover</u>		
Quadrat date (Herbaceous only)	**	1.44%
Point Line data	**	28.5%
Productivity	**	200lb/acre

*This previously distrubed site is in the pinyon/juniper habitat type. Species composition, cover and productivity are assumed to fall within the normal variation expected in this vegetation type.

**No vegetation is presented because the sites are already disturbed, therefore no statistical comparisons can be made.

Table 3-42. Comparison of Actively Disturbed Site to Proposed Reference Site

Parameter	Disturbed Site	Proposed Reference Site (3)
Vegetation type	Pinyon/Juniper/Grass	Pinyon/Juniper/grass
Location	Mouth of Whitmore Canyon	Mouth of Whitmore Canyon
Secetion	NE¼SE¼, Section 6, T15S, R14E	NE¼NW¼, Section 7, T15S, R14E
Elevation, Ft./M	6525/1989	6480/1975
Geologic Formation	Mesa Verde and Mancos Shale	Mesa Verda and Mancos Shale
Soils Mapping Unit	Ildefonso Very Stony Loam Shingle-Ildelfonso-Badland complex	Ildefonso Very Stony Loam
Slope (percent)	0-5	0-5
Aspect (degrees)	260	247
Species composition	Assumed to be similar*	Juniperus/Oryzopsis
Plant cover		
Quadrat data		
(Herbaceous only)	**	3.49
Point Line data	**	8.89
Productivity	**	300lb/acre

*This actively disturbed site appears to be in the pinyon/juniper/grass habitat type as deduced from old aerial photographs.

**No vegetation data is presented because the sites are already disturbed, therefore no statistical comparisons can be made.

Table 3-43. Comparison of Actively Disturbed Site to Proposed Reference Site

Parameter	Sagebrush/Grass Disturbed Site	Proposed Reference Site (5)
Vegetation type	Sagebrush/Grass	Sagebrush/Grass
Location	Whitmore Canyon	Whitmore Canyon
Section	S½. Section 32, T14S, R14E	NW¼NW¼, Section 29, T14S, R14E
Elevation, Ft./M	7080/2158	7000/2106
Geologic Formation	Price River	Price River
Soils Mapping Unit	Haverson Loam, Rivra Loam	Rivra Loam
Slope (percent)	0-5	0-3
Aspect (degrees)	227	187
Species Composition	Assumed to be similar*	Artemisia/Elymus
Plant Cover		
Quadrat data (herbaceous only)	**	36%
Point Line data	**	79%
Productivity	**	1,000lb/acre

*This previously disturbed site is in the sagebrush/grass habitat type. Species, composition, cover and productivity are assumed to fall within the normal variation expected in this vegetation type.

**No vegetation data is presented because the sites are already disturbed, therefore no statistical comparisons can be made.

Table 3-44. Comparison of Actively Disturbed Site to Proposed Reference Site
Pinyon-Juniper/Sagebrush

Parameter	Disturbed Area	Proposed Reference Site (5)
Vegetation Type	Pinyon-Juniper/Sagebrush	Pinyon-Juniper/Sagebrush
Location	B Canyon	B Canyon
Section	14	14
Elevation, Ft./M		
Geologic Formation	Mesa Verde/Mancos Shale Groups	Mesa Verde/Mancos Shale Groups
Soils Mapping Unit	RSH_2/RO	RO
Slope (percent)	66%	70%
Aspect (degrees)	120	117
Species Composition	*	PJ/Elymus and Agropyron
Plant Cover		
Quadrat data (herbaceous only)	**	4.23
Point Line Data	*	42.00
Productivity	*	800 lb/acre

* This site is previously disturbed and falls within the same vegetation mapping unit as the reference area. Therefore, species composition, cover, and productivity undoubtedly would fall within the normal variation for this site.

** No vegetation data is presented because the site is already disturbed; therefore, no statistical comparisons can be made.

Table 3-45 Value of revegetation species to deer and elk for the Sunnyside mine, Utah.

Plant Species	Animal Species	Usage[1,2]	Comments[2,3]
TREES			
Juniperus spp.	Deer	****Su	
	Elk	**W,Sp,Su	
Pseudotsuga menziesii	Deer	****W	
	Elk	****W	
Populus augustifolia	Deer	*F	
	Elk	*W,Sp	
SHRUBS			
Acer glabrum	Deer	**	Leaves, twigs, sprouts
	Elk	*W	are fair in palatability
Amelanchier spp.	Deer	***Su,F	1) Good cover
	Elk	##W,Sp,Su,F	2) L-M elk forage value
Artemisia spp.		---	Fair to good winter browse
Cercocarpus spp.	Deer	***F,W,Sp	1) Good cover
	Elk	##F,W,Sp	2) M-H elk forage value
Chrysothamnus nauseosus	Deer	*F,W	
	ELK	##W	L-M elk forage value
		#Sp	
Cowania mexicana		---	Good winter browse
Ephedra viridis		---	1) Exc. Su & W browse
			2) Good Sp browse
Eurotia lanata	Deer	---	1) Good Sp, Su, W browse
	Elk	##W	2) Low elk forage value
Potentilla fruticosa	Deer	---	L-M deer & elk forage
	Elk	#W	
Rhus trilobata	Deer	+	Poor to fair deer
	Elk	---	and elk forage

(Continued on Next Page)

Table 3-45 (Continued).

Plant Species	Animal Species	Usage[1,2]	Comments[2,3]
Rosa woodsii	Deer	---	1) Sp, Su & F browse
	Elk	##Su,F #Sp	2) Med. elk forage value
Salix spp.	Deer	+	L-M elk forage value
	Elk	**W,Sp ###W,Su,F	
Symphoricarpos spp.	Deer	---	1) Important deer Su forage
	Elk	#S,F,W	2) L-M elk forage value
GRASSES			
Agropyron spp.	Deer	**Sp,Su	Fair winter forage
	Elk	*W,Sp	
Agropyron spicatum	Deer	---	
	Elk	##W,Sp,Su,F	L-M elk forage value
Agrostis alba		---	1) Poor deer forage 2) Good elk forage
Bouteloua gracilis	Deer	---	1) Poor to fair deer forage
	Elk	##Su,F #W	2) Low elk forage value
Elymus spp.	Deer	---	1) Fair Sp,F,W forage
	Elk	+	2) Good Su forage
Hilaria jamesii	---	---	---
Koeleria cristata	Deer	**Sp,Su	Fair deer and elk forage
	Elk	+	
Oryzopsis hymensides	Deer	**Sp,Su	
	Elk	###F ##W	L-M elk forage value
Poa pratensis	Deer	---	1) Good Sp,F,W forage
	Elk	---	2) Poor Su forage

(Continued on Next Page)

Table 3-45 (Continued).

Plant Species	Animal Species	Usage[1,2]	Comments[2,3]
Sitanion hystrix	Deer Elk	--- #Su	1) Good Sp forage 2) Poor Su,F,W forage 3) Low elk forage value
Sporobolus cryptandrus		---	1) Exc. Su forage 2) Poor F,W,Sp forage
Stipa comata	Deer Elk	--- ###F ##S #W	1) Fair deer forage 2) L-H elk forage value
FORBS			
Achillea lanulosa		---	poor for deer and elk
Artemisia ludoviciana		---	1) Fair F,W forage 2) Good Sp,Su forage
Balsamorhiza sagittata		---	Exc. Sp forage
Castilleja spp.		---	Fair deer and elk forage
Gaillardia aristata	Deer Elk	--- #Su	1) Low deer Su usage 2) Low elk forage value
Gilia aggregata		---	Low deer usage all year
Hedysarum boreale		---	1) Good Sp, Su forage 2) Fair F,W forage
Medicago sativa	Deer Elk	+ ---	1) Good Sp,Su forage 2) Poor F,W forage
Melilotus officinalis		---	1) F-G forage 2) winter hardy
Oenothera pallida		---	Poor forage value
Penstemon spp.		---	1) Fair summer forage 2) Occassional winter use
Petalostemon purpureum		---	---

(Continued on Next Page)

Table 3-45 (Continued).

Plant Species	Animal Species	Usage[1,2]	Comments[2,3]
Solidago canadensis		---	1) Poor F,W forage 2) Good Sp,Su forage
Sphaeralcea coccinea		---	Moderate deer fall usage

1 From Martin et al (1951).
- - = Use to an undertermined extent
- + = 1/2 to 2% of diet
- * = 2 to 5% of diet
- ** = 5 to 10% of diet
- *** = 10 to 25% of diet
- **** = 25 to 50% of diet
- W = Winter; Sp = Spring; Su = Summer; F = Fall

2 From Thomas and Toweill (1982).
- # = light use; ## = moderate use; ### = heavy use
- L = low forage value; M = moderate; H = high

3 Other information obtained from: Dittberner (1978), Johnson and Nichols (1970), Kufeld (1973), Plant Information Network, Plummer et al (1968), Taylor (1956) and Martin (1951).

Table 3-46

High Interest Species that Potentially Occur on the Permit Area and Species that were Potentially Impacted by Mine Development and Operation

	Status	Population Trend
Fishes		
Family Salmonidae		
Cutthroat Trout (*Salmo clarki*)	C-P-GF	Stable
Rainbow Trout (*Salmo gairdneri*)	C-P-GF	Stable
Brown Trout (*Salmo trutta*)	C-P-GF	Stable
Family Cyprinidae		
Utah Chub (*Gila atraria*)	L-P-I	Abundant
Roundtail Chub (*Gila robusta*)	C-P-I	Stable
Red Shiner (*Notropis lutrensis*)	C-P-I	Increasing
Fathead Minnow (*Pimephales promelas*)	C-P-I	Stable
Colorado Squawfish (*Ptychocheilus lucius*)	E-P-I	Decreasing
Speckled Dace (*Rhinichthys osculus*)	C-P-I	Stable
Redside Shiner (*Richardsonius balteatus*)	C-P-I	Stable
Family Catostomidae		
Bluehead Sucker (*Catostomus discobolus*)	C-P-I	Stable
Flannelmouth Sucker (*Catostomus latipinnis*)	C-P-I	Stable
Amphibians		
Family Ambystomatidae		
Tiger Salamander (*Ambystoma tigrinum*)	C-P-I	Unknown
Family Pelobatidae		
Great Basin Spadefoot Toad (*Scaphiopus intermontanus*)	C-N-I	Unknown
Family Bufonidae		
Woodhouse's Toad (*Bufo woodhousei*)	C-N-I	Unknown
Family Ranidae		
Leopard Frog (*Rana pipiens*)	C-N-I	Unknown
Reptiles		
Family Iguanidae		
Collared Lizard (*Crotaphytus collaris*)	C-N-I	Unknown
Leopard Lizard (*Crotaphytus wislizenii*)	C-N-I	Unknown
Eastern Fence Lizard (*Sceloporus undulatus*)	C-N-I	Unknown
Sagebrush Lizard (*Sceloporus graciosus*)	C-N-I	Unknown

Table 3-46 (Cont)

	Status	Population Trend
Order Galliformes		
Family Phasiandiae		
California Quail (*Lophortyx californicus*)	C-P-SG-I resident	Stable
Chukar (*Alectoris chukar*)	C-P-SG-I resident	Stable
Order Gruiformes		
Family Rallidae		
American Coot (*Fulica americana*)	C-P-MG resident and transient	Stable
Order Charadriiformes		
Family Charadriidae		
Mountain Plover (*Charadrius montanus*)	R-P-I transient	Stable
Family Scolopacidae		
Long-billed Curlew (*Numenius americanus*)	U-P-X summer resident and transient	Declining
Order Columbiformes		
Family Columbidae		
Mourning Dove (*Zenaida macroura*)	C-P-MG-I summer resident and transient	Stable
Order Strigiformes		
Family Strigidae		
Great Horned Owl (*Bubo virginianus*)	C-P-I resident	Stable
Pygmy Owl (*Glaucidium gnoma*)	K-P-I resident	Unknown
Burrowing Owl (*Speotyto cunicularia*)	L-P-X resident	Declining
Long-eared Owl (*Asio otus*)	C-P-I resident	Stable
Order Caprimulgiformes		
Family Caprimulgidae		
Poor-will (*Phalaenoptilus nuttallii*)	C-P-I summer resident	Stable

Table 3-46
(Cont)

	Status	Population Trend
Order Apodiformes		
Family Apodidae		
Black Swift (*Cypseloides niger*)	U-P-I-X summer resident	Unknown
White-throated Swift (*Aeronautes saxatalis*)	C-P-I summer resident	Unknown
Family Trochilidae		
Black-chinned Hummingbird (*Archilochus alexandri*)	C-P-I summer resident	Unknown
Broad-tailed Hummingbird (*Selasphorus platycercus*)	C-P-I summer resident	Unknown
Order Piciformes		
Family Picidae		
Common Flicker (*Colaptes auratus*)	C-P-I resident	Stable
Order Passeriformes		
Family Tyrannidae		
Cassin's Kingbird (*Tyrannus vociferans*)	U-P-I summer resident	Unknown
Ash-throated Flycatcher (*Myiarchus cinerascens*)	C-P-I summer resident	Stable
Says Phoebe (*Savornis sava*)	C-P-I resident	Unknown
Dusky Flycatcher (*Empidonax oberholseri*)	C-P-I summer resident	Unknown
Gray Flycatcher (*Empidonax wrightii*)	K-P-I summer resident	Unknown
Family Alaudidae		
Horned Lark (*Eremophila alpestris*)	C-P-I resident	Unknown
Family Corvidae		
Scrub Jay (*Aphelocoma coerulescens*)	C-P-I resident	Unknown
Black-billed Magpie (*Pica pica*)	C-P-I resident	Unknown
Pinion Jay (*Gymnorphinus cyanocephala*)	C-P-I resident	Unknown
Family Paridae		
Plain Titmouse (*Parus inornatus*)	C-P-I resident	Unknown
Bushtit (*Psaltriparus minimus*)	C-P-I resident	Unknown

Table 3-46 (Cont.)

	Status	Population Trend
Family Sittidae		
White-breasted Nuthatch (*Sitta carolinensis*)	C-P-I resident	Unknown
Family Troglodytidae		
Bewick's Wren (*Thryomanes bewickii*)	C-P-I resident	Unknown
Family Mimidae		
Gray Catbird (Dumetella carolinensis)	U-P-I summer resident	Unknown
Sage Thrasher (*Oreoscoptes montanus*)	C-P-I resident	Unknown
Family Muscicapidae		
Western Bluebird (*Sialia mexicana*)	U-P-I-X summer resident	Unknown
Townsend's Solitaire (*Myadestes townsendi*)	C-P-I resident	Unknown
Family Sylviidae		
Blue-gray Gnatcatcher (*Polioptila caerulea*)	C-P-I summer resident	Unknown
Golden-crowned Kinglet (*Regulus satrapa*)	U-P-I resident	Unknown
Family Laniidae		
Northern Shrike (*Lanius excubitor*)	U-P-I winter resident	Unknown
Family Vireonidae		
Solitary Vireo (*Vireo solitarius*)	U-P-I summer resident	Unknown
Family Parulidae		
Orange-crowned Warbler (*Vermivora celata*)	C-P-I summer resident and transient	Unknown
Virginia's Warbler (*Vermivora virginiae*)	C-P-I summer resident	Unknown
Black-throated Gray Warbler (*Dendroica nigrescens*)	C-P-I summer resident	Unknown
Family Embarizidae		
Black-headed Grosbeak (*Pheucticus melanocephalus*)	C-P-I summer resident	Unknown
Lapland Longspur (*Calcarius lapponicus*)	R-P-I winter resident	Unknown
Lazuli Bunting (*Passerina amoena*)	C-P-I summer resident	Unknown
Green-tailed Towhee (*Chlorura chlorura*)	C-P-I summer resident	Unknown

Table 3-46 (Cont.)

	Status	Population Trend
Family Embarizidae (Continued)		
Rufous-sided Towhee (<u>Pipilo erythrophthalmus</u>)	C-P-I resident	Unknown
Lark Bunting (<u>Calamospiza melanocorys</u>)	O-P-I transient	Unknown
Vesper Sparrow (<u>Pooecetes gramineus</u>)	C-P-I summer resident	Unknown
Lark Sparrow (<u>Chondestes grammacus</u>)	C-P-I summer resident	Unknown
Sage Sparrow (<u>Amphispiza belli</u>)	U-P-I summer resident	Unknown
Gray-headed Junco (<u>Junco caniceps</u>)	C-P-I summer resident	Unknown
Brewer's Sparrow (<u>Spizella breweri</u>)	C-P-I summer resident	Unknown
White-crowned Sparrow (<u>Zonotrichia leucophrys</u>)	C-P-I resident	Unknown
Song Sparrow (<u>Zonotrichia melodia</u>)	C-P-I resident	Unknown
Black-throated Sparrow (<u>Amphispiza bilineata</u>)	U-P-I summer resident	Unknown
Family Fringillidae		
House Finch (<u>Carpodacus mexicanus</u>)	C-P-I resident	Unknown
Lesser Goldfinch (<u>Carduelis psaltria</u>)	C-P-I resident	
Mammals		
Order Insectivora		
Family Soricidae		
Merriam Shrew (<u>Sorex merriami</u>)	U-N-I	Unknown
Order Chiroptera		
Family Vespertilionidae		
Fringed Myotis (<u>Myotis thysanodes</u>)	U-N-I	Unknown
Western Big-eared Bat (<u>Plecotus townsendii</u>)	C-N-I	Unknown
Pallid Bat (<u>Antrozous pallidus</u>)	C-N-I	Unknown
Order Lagomorpha		
Family Leporidae		
White-tailed Jackrabbit (<u>Lepus townsendii</u>)	C-N-I	Stable
Snowshoe Hare (<u>Lepus americanus</u>)	C-P-SG	Cyclic
Black-tailed Jackrabbit (<u>Lepus californicus</u>)	C-N-I	Stable

Table 3-46 (Cont.)

	Status	Population Trend
Family Leporidae (Continued)		
Mountain Cottontail (*Sylvilagus nuttallii*)	C-P-SG-I	Stable
Desert Cottontail (*Sylvilagus audubonii*)	C-P-SG-I	Stable
Order Rodentia		
Family Sciuridae		
White-tailed Prairie Dog (*Cynomys leucurus*)	C-N	Stable
Golden-mantled Ground Squirrel (*Spermophilus lateralis*)	C-N-I	Stable
Least Chipmunk (*Eutamius minimus*)	C-N-I	Stable
Uintah Chipmunk (*Eutamius umbrinus*)	C-N-I	Stable
Cliff Chipmunk (*Eutamius dorsalis*)	U-N-I	Stable
Family Geomyidae		
Valley or Botta Pocket Gopher (*Thomomys bottae*)	C-N-I	Unknown
Ord Kangaroo Rat (*Dipodomys ordii*)	C-N-I	Unknown
Family Castoridae		
Beaver (*Castor canadensis*)	C-P-F	Increasing
Family Cricetidae		
Canyon Mouse (*Peromyscus crinitus*)	C-N-I	Unknown
Deer Mouse (*Peromyscus manicalatus*)	C-N-I	Unknown
Brush Mouse (*Peromyscus boylei*)	C-N-I	Unknown
Pinion Mouse (*Peromyscus truei*)	C-N-I	Unknown
Desert Wood Rat (*enotoma lipida*)	C-N-I	Unknown
Muskrat (*Ondatra zibethicus*)	C-N-I	Stable
Mountain Vole (*Microtus montanus*)	C-N-I	Unknown
Longtail Vole (*Microtus longicaudus*)	C-N-I	Unknown
Order Carnivora		
Family Canidae		
Coyote (*Canis latrans*)	C-N-I	Stable
Red Fox (*Vulpes fulva*)	C-N-I	Stable
Kit Fox (*Vulpes macrotis*)	U-N	Stable
Gray Fox (*Urocyan cinereoargenteus*)	C-N-I	Stable
Family Ursidae		
Black Bear (*Ursus americanus*)	C-P-BG	Increasing
Family Procyonidae		
Ring-tailed Cat (*Bassariscus astutus*)	C-N-I	Stable

	Status	Population Trend
Family Mustelidae		
Short-tailed Weasel (*Mustela erminea*)	R-P-F-I	Stable
Long-tailed Weasel (*Mustela frenata*)	C-P-F-I	Stable
Mink (*Mustela vison*)	L-P-F	Unknown
Black-footed Ferret (*Mustela nigripes*)	E-P	Unknown
Striped Skunk (*Mephitis mephitis*)	C-P-F-I	Increasing
Spotted Skunk (*Spilogale gracilis*)	C-P-F-I	Stable
Family Felidae		
Bobcat (*Lynx rufus*)	C-P-I	Declining
Cougar (*Felis concolor*)	C-P-BG	Stable
Order Artiodactyla		
Family Cervidae		
Mule Deer (*Odocoileus hemionus*)	C-P-BG-I	Increasing
Rocky Mountain Elk (*Cervus canadensis*)	C-P-BG-I	Increasing

STATUS KEY:

- K Status unknown - It is believed that these species are present, but little is known of their population dynamics.
- C Common - These species are widespread and abundant.
- U Uncommon - These species are widespread, but not abundant.
- R Rare - These species are seldom identified during any one year.
- O Occasional - These species are periodically identified during a long term period - 10-50 years.
- E Endangered - These species are endangered with extinction or extirpation from wildland in Utah
- T Threatened - These species are threatened with becoming endangered in Utah.
- L Limited - These species are common but restricted to a particular use area or habitat type in Utah.
- P Protected - These species are protected by state or federal laws in Utah
- N Nonprotected - These species are not protected by any laws in Utah.
- F These species are classified as furbearers.
- I These species were potentially impacted by mine development and operation.
- X A migratory bird of high federal interest
- GF These species are classified as game fish.
- SG These species are classified as small game.
- BG These species are classified as big game.
- MG These species are migratory game birds.

Table 3-46 (Cont.)

The following terminology is used to describe the seasonal status for avian species.

Transient - These species pass through southeastern Utah twice a year during their migratory travels.

Resident - These species occur yearlong in southeastern Utah.

Summer Resident - These species breed in southeastern Utah and migrate elsewhere for the winter.

Winter Resident - These species breed elsewhere but winter in southeastern Utah.

Reference: Utah Division of Wildlife Resources (1978)

Table 3-47 Optimum Deer Population on Winter Range in Unit 27B.*

Vegetation Type	Acres Available: Normal Winter	Acres Available: Severe Winter	Optimum Deer Population
Total winter range	573,824	364,864	29,885
Pinyon-juniper-mountain brush-grass	195,584	157,760	10,893
Grassland	14,208	14,208	1,133

*Utah State Department of Fish and Game 1967, and written communication, L.J. Wilson 1977, both cited in USDI 1979.

Table 3-48

Selected Data from Deer Management Units - 1979.[1]

	Fawns per 100 Does[2]	Bucks Harvested	Hunter Success-%(A)	Range-Acres[3](B)	Density Index A/Log B
All Units-$\bar{x}$[4]	81	743	30	401,432	5.4
27B	76	468	26	793,700	4.4
27A	37	78	13	267,500	2.4
19	93	3,673	49	331,100	8.9
30B	-	29	25	94,100	2.4
29	52	87	29	1,737,000	4.6

[1] UDWR 1980a, 1980b.

[2] Preseason.

[3] Includes total of winter and summer range available to deer.

[4] Desired data was not available for some units.

Ranking of value per ecological association for wildlife habitats of vertebrate species having high interest to the State of Utah. Crucial-critical (C) habitats are the highest valued followed in respective order by high priority (H), substantial value (S) and limited value (L) habitats.

Table 3-49

Ecological Association	Wildlife Habitats											
	Riparian and Wetland	Desert Scrub	Pasture and Fields	Urban or Parks	Cliffs and Tallus	Sagebrush	P-J Forest	Shrubland	Aspen Forest	Ponderosa Forest	Parkland	Spruce-fir Forest
	LOWER SONORAN LIFE ZONE											
Warm Desert	This ecological association does not exist in the Southeastern Region											
	UPPER SONORAN LIFE ZONE											
Cold Desert	C(H[1],S[2])	S	S	S	H							
	TRANSITION LIFE ZONE											
Submontane	C(H[1],S[2])		S	S	H	S	S	S				
	CANADIAN LIFE ZONE											
Montane	C(H[1]L[2])		S	L	S				S	S	S	S
	HUDSONIAN LIFE ZONE											
Montane	H(S[1],L[2])				S							S
	ALPINE LIFE ZONE											
Montane	This ecological association does not exist in the Southeastern Region											

This Table represents a summation of effort where by numerical values were assigned as a ranking per high interest specie to each wildlife habitat. The numerical values were as follows: critical, 1; high-priority, 2; substantial, 3; and limited, 4. Once the individual values were assigned they were then summed and a mean calculated, for each wildlife habitat. A mean value lying between 1.0 and 1.8 was ranked as critical; a value between 1.9 and 2.3 was ranked as high-priority; a value between 2.4 and 3.4 was ranked as substantial; and a value between 3.5 and 4.0 was ranked as limited.

1. Habitat ranking value for species associated with the riparian-wetland type that represents just the wet meadow situation.
2. Habitat ranking value for species associated with the riparian-wetland type that represents just the dirt bank situation.

Table 3-50

PERMANENT REVEGETATION SEED MIXTURE - Part 1

Species	Seeds/Pound	Drill Rate #PLS/acre	Broadcast Rate #PLS/acre
GRASSES			
Agropyron smithii western wheatgrass	110,000	5.4	8.0
Bouteloua gracilis blue gramma	712,000	0.3	0.5
Elymus cinereus greatbasin wildrye	130,000	0.8	1.25
Oryzopsis hymenoides Indian ricegrass	235,000	2.3	3.5
Sitanion hystrix bottlebrush squirreltail	192,000	0.6	0.9
Agropyron spicatum bluebunch wheatgrass	117,000	0.9	1.4
Koeleria macranthera Prairie junegrass	400,000	0.3	0.4
FORBS			
Hedysarum boreale sweetvetch	33,600	1.9	2.9
Artemisia ludoviciana Louisiana sagebrush	2,770,000	0.1	0.1
Penstemon palmeri Palmer penstemon	610,000	0.1	0.1
Sphaeralcea grossulariaefolia globemallow		0.1	0.1
Achillea lanulosa western yarrow	4,124,000	0.1	0.1
Gaillarardia aristata blanket flower	132,000	0.2	0.2

Table 3-50
(Cont.)

PERMANENT REVEGETATION SEED MIXTURE - Part 2

Species	Seeds/Pound	Drill Rate #PLS/acre	Broadcast Rate #PLS/acre
FORBS (continued)			
Solidago candensis Canada goldenrod		0.1	0.1
Petalostemon purpureum prairie clover	293,000	0.1	0.1
SHRUBS			
Atriplex canescens fourwing saltbush	52,000	1.3	1.9
Artemisia tridentata big sagebrush	2,576,000	0.1	0.1
Cercocarpus montanus mountain mahogany	59,000	0.7	1.1
Eurotia lanata winterfat	159,500	0.1	0.2
Ephedra viridis green ephedra	24,995	0.1	0.1
Cowania mexicana cliffrose	63,900	0.1	0.1
TOTAL		15.7	23.15

Table 3-51

Characteristics of species used in the seed mixtures for Sunnyside, Utah.[a,b]

	Typical Soils			Salinity Tolerance	Optimum Ppt.Zone (in.)	Establishment Potential		Persistence	Erosion Control Potentl	Drought Resistance	Sources[c]
	S	Si	C			Init.	Final				
RASSES											
Agropyron smithii	P	G	G	G	14-20	3	5	5	5	4	1,4,6,8,12
A. spicatum	F	G	G	F	12-20	3-4	4	4	4	Yes	1,6,7,8,12
Bouteloua gracilis	F	G	G	F	10-20	3	-	-	4	4	8,9,12
Elymus salina	-	-	-	--	---	2-3	4	5	5	-	5,6,8,15
Hilaria jamesii	Varied			F-G	10-18	2-3	-	-	5	4	2,8,9,11,14
Koeleria cristata	-	-	-	--	---	-	-	-	-	-	---
Oryzopsis hymenoides	G	G	F-P	F	8-16	2	4	4	3	4	2,6,7,8,12,13
Poa pratensis	P	F	F	P-F	---	3	4	5	5	2	6,7,12
Sitanion hystrix	-	-	-	--	---	3	3	3	3	-	6,12
Sporobolus cryptandrus	G	G	F	F	10-18	2-3	4	4	4	4	3,6,8,12
Stipa comata	-	-	-	--	10-16	-	-	-	-	4	3,8
ORBS											
Achillea lanulosa	Most soils			--	---	-	-	-	-	4	7,9,15
Artemisia ludoviciana	S or GR Loam			--	---	1	4-5	4	3	-	3,6

(Continued on Next Page)

Table 3-51 (Cont.)

Characteristics of species used in the seed mixtures for Sunnyside, Utah. (Continued).

	Typical Soils S	Typical Soils Si	Typical Soils C	Salinity Tolerance	Optimum Ppt. Zone (in.)	Establishment Potential Init.	Establishment Potential Final	Persistence	Erosion Control Potentl	Drought Resistance	Sources[c]
Balsamorhiza sagittata	-	-	-	--	---	3	5	5	3	-	6
Castilleja chromosa	-	-	-	--	---	-	-	-	-	-	-
Gaillardia aristata	-	-	-	--	---	-	-	-	-	-	-
Gilia aggregata	-	-	-	--	---	-	-	-	-	-	-
Hedysarum boreale	Varied			P	---	4	3-5	5	4	3-4	2,6,15
Oenothera pallida	-	-	-	--	---	-	-	-	-	-	-
Penstemon bridgesii	-	-	-	--	---	-	-	-	-	-	-
P. palmeri	-	-	-	--	---	4	3	3	3	-	6
P. strictus	sandy loam			--	14-20	-	-	-	4	-	8,11,12
Petalostemon purpureum	-	-	-	--	15-20	-	-	-	-	-	12
Solidago canadensis	-	-	-	--	---	-	-	-	-	-	-
Sphaeralcea coccinea	Varied			F	---	-	-	-	3	4	2,3
SHRUBS											
Amelanchier alnifolia	P	G	G	P	14-20	3	3	4	4	3	6,8,12

(Continued on Next Page)

Table 3-51
(Cont.)
Characteristics of species used in the seed mixtures for Sunnyside, Utah. (Continued).

	Typical Soils[a]			Salinity Tolerance	Optimum Ppt. Zone (in.)	Establishment Potential[b]		Persistence	Erosion Control Potentl	Drought Resistance	Sources[c]
	S	Si	C			Init.	Final				
Artemisia nova	Rocky, shallow			P	10-18	3	5	5	4	-	2,6,8
A. tridentata	P	G	G	F	9-17	3	5	5	4	4	2,6,8,12
Cercocarpus ledifolius	F	G	G	F	10-18	2-3	3	4	3	4	6,8,9,10,12
C. montanus	F	G	G	P-F	12-20	3	2	4	4	3	2,6,8,10,12
Chrysothamnus nauseosus	Varied			F-G	10-18	3	2-4	4	5	3	2,3,5,6,8,11,15
Cowania mexicana	F	P	P	F	12-20	2-3	3	4	4	4	6,8,12
Ephedra viridis	G	-	-	G	8-14	4	4	5	4	5	2,6,8
Eurotia lanata	G	G	G	G	8-14	3-4	4	4	3	4	6,8,9,10,12
Potentilla fruticosa	P	G	G	-	16-20	-	-	-	-	-	8,11
Rhus trilobata	F	G	F	P	10-19	2	4	5	4	3-4	2,6,8,11
Rosa woodsii	F	G	F	-	15-20	3	4	5	4	-	6,11
Symphoricarpos oreophilos	-	-	-	-	---	3	5	5	5	-	6

a P = poor, F = fair, G = good.

b 1 = very poor, 2 = poor, 3 = fair, 4 = good, 5 = very good.

c 1 = Dewey, 1960; 2 = Institute for Land Rehabilitation Staff, 1979; 3 = Johnson and Nichols, 1970; 4 = Martin et al, 1976; 5 = McArthur et al, 1979; 6 = Plummer et al, 1968; 7 = Schiechtl, 1980; 8 = Thornburg, 1982; 9 = USDA Forest Service, 1937; 10 = USDA Forest Service 1974; 11 = U. S. Environmental Protection Agency, 1975; 12 = Vallentine, 1971; 13 = Verner, 1956; 14 = West, 1972; 15 = Wolfe and Abbott, 1982.

Table 3-49

TEMPORARY REVEGETATION SEED MIXTURE

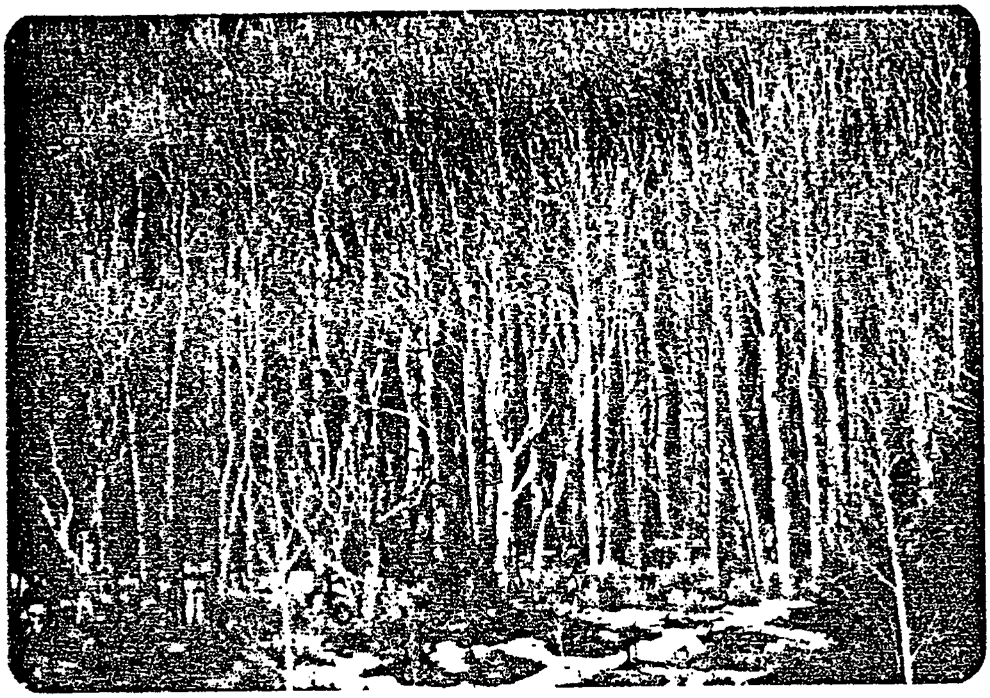
Species	Seeds/Pound	Drill Rate #PLS/acre	Broadcast Rate #PLS/acre
Agropyron intermedium intermediate wheatgrass	93,000	3.5	5.3
Agropyron smithii western wheatgrass	110,000	4.0	5.9
Agropyron trichophorum pubescent wheatgrass	90,000	2.4	3.6
Agropyron trachycalum slender wheatgrass	135,000	3.2	4.8
Agropyron dasystachum thickspike wheatgrass	186,000	1.2	1.8
Elymus cinereus great basin wildrye	130,000	2.5	3.77
Sanguisorba minor small burnett	55,000	2.0	3.0
Achillea lanulosa western yarrow	4,123,635	0.1	0.1
Onobrychis viciaefolia sainfoin	30,000	3.63	5.44
TOTAL #PLS		22.5	33.7

Photographs and Plates

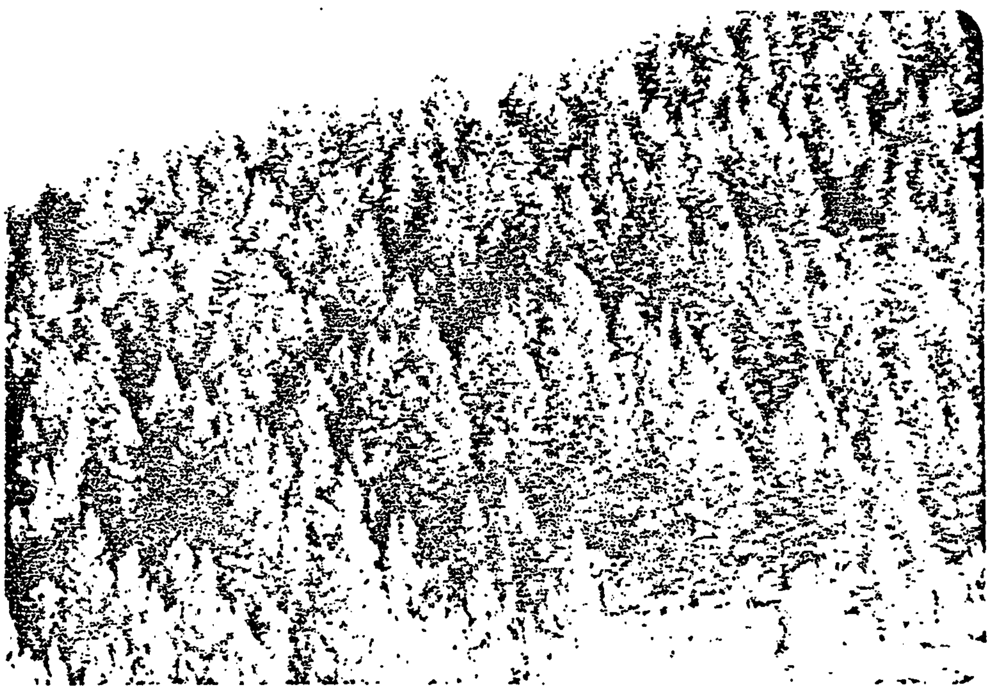
Photographs

Photo No.	Vegetation Type
1	Aspen
2	Douglas fir
3	Douglas fir/aspen
4	Douglas fir/mountain brush
5	Douglas fir/pinyon juniper
6	Mountain brush (serviceberry)
7	Pinyon/juniper
8	Pinyon/juniper-grass
9	Pinyon/juniper-mountain brush
10	Pinyon/juniper-sagebrush
11	Riparian-bullrush-sedge
12	Riparian-cottonwood grove
13	Riparian-willow
14	Sagebrush-grass
15	Sagebrush/mountain brush*
16	Douglas fir/aspen/mountain brush*
17	Douglas fir/sage*

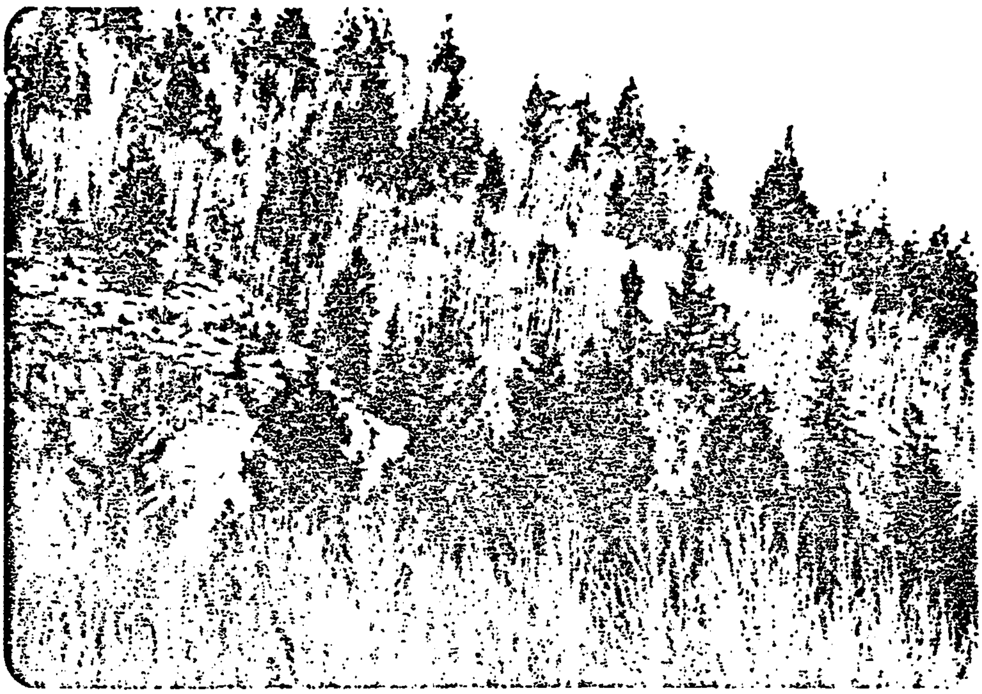
* Photograph unavailable at this time.



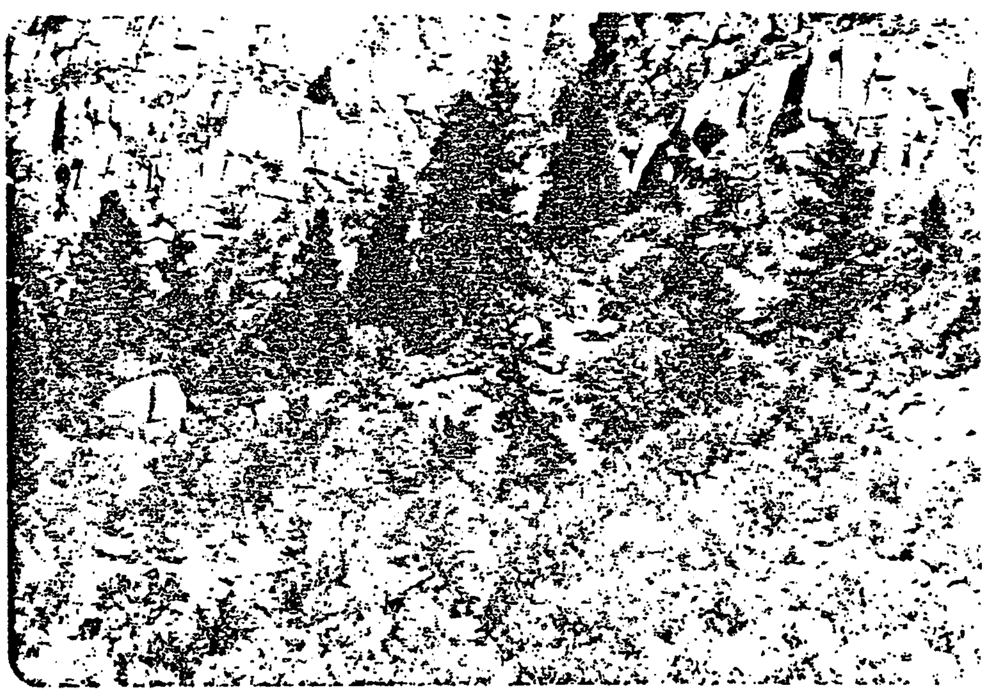
1 Aspen



2 Douglas Fir



3 Douglas Fir/Aspen

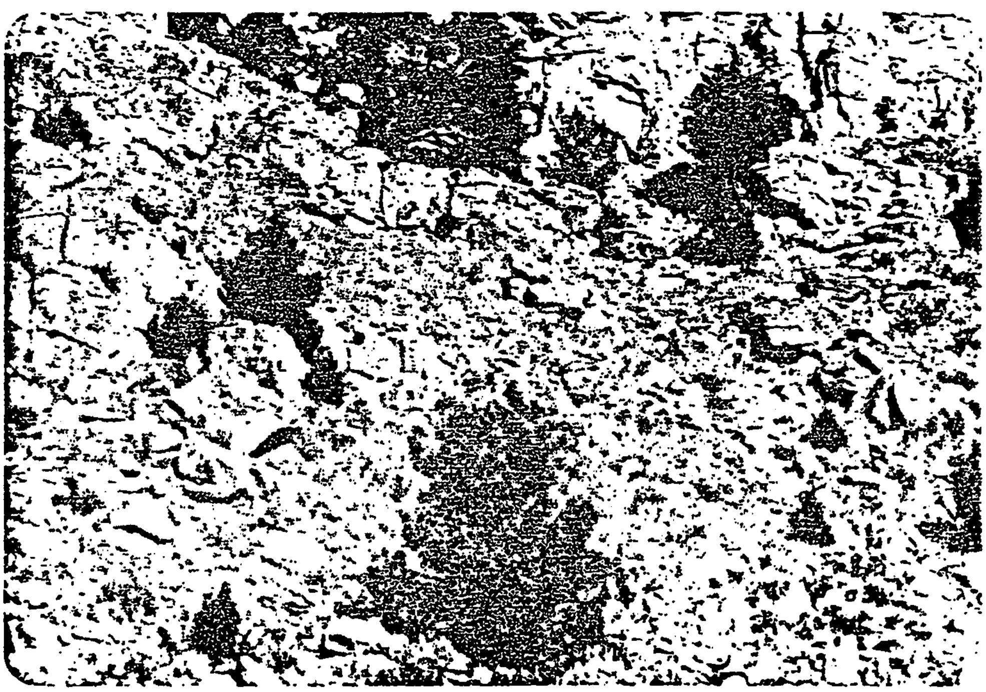


4 Douglas Fir/Mountain Brush

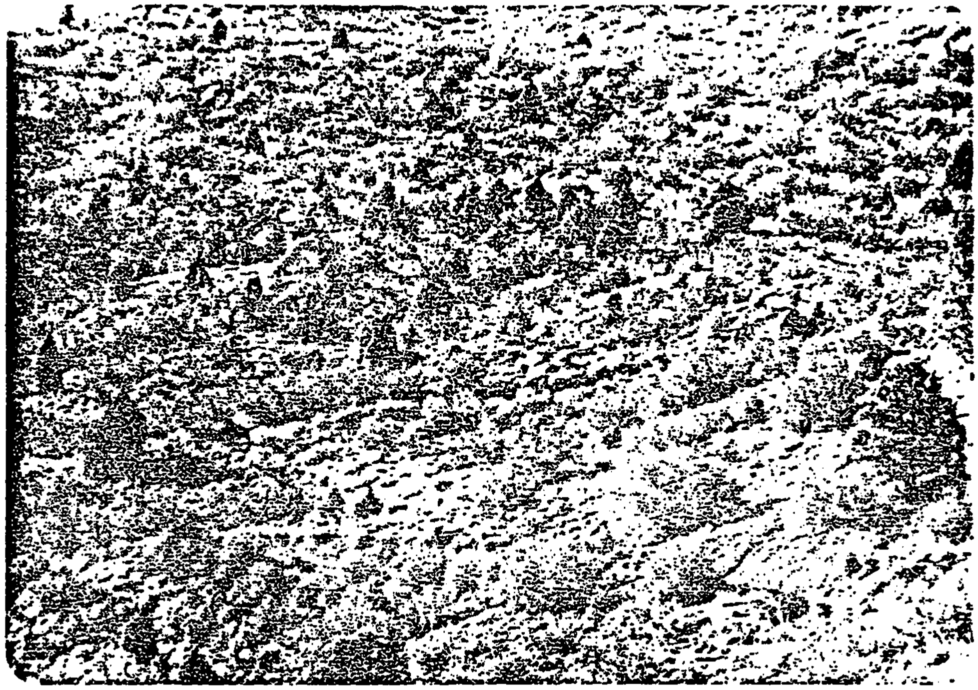
5 Douglas Fir/Pinyon-Juniper

6 Mountain Brush

7 Pinyon/Juniper

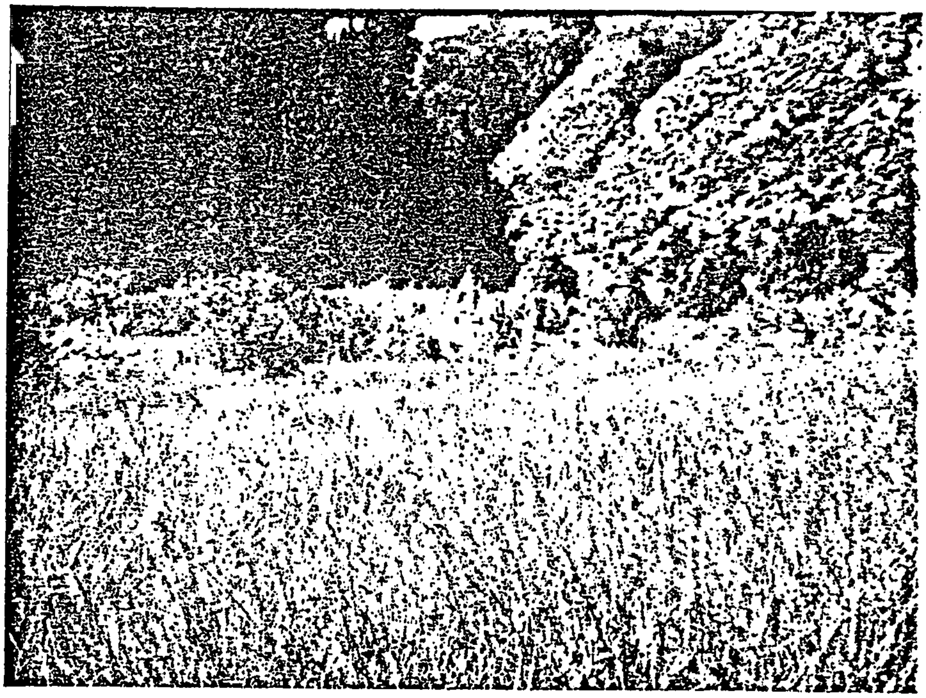


8 Pinyon/Juniper-Grass



9 Pinyon/Juniper-Mountain Brush

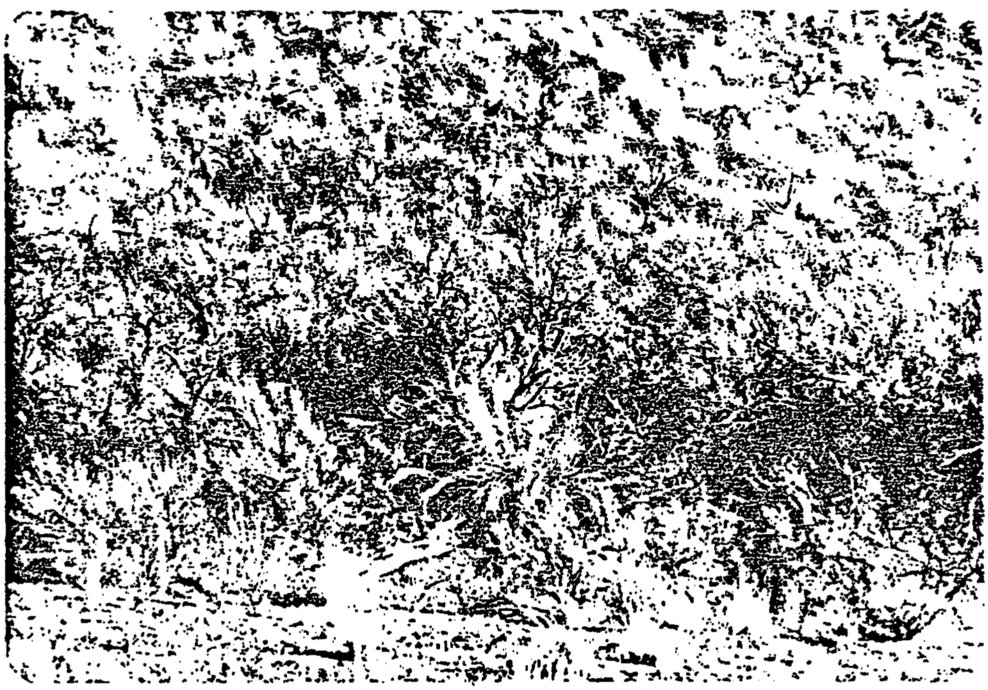
10 Pinyon/Juniper-Sagebrush



11 Riparian-Bulrush-Sedge

12 Riparian-Cottonwood Grove

13 Riparian-Willow



14 Sagebrush-Grass

Appendix 3-1

Winget Study (1980)

-FINAL-

AQUATIC RESOURCE ANALYSIS OF GRASSY TRAIL CREEK, CARBON COUNTY, UTAH

Prepared for:

Kaiser Steel Corporation
Sunnyside Mine Project

5 NOVEMBER 1980

Prepared by:

Robert N. Winget, Ph. D.
Director, Aquatic Ecology Laboratory
Department of Zoology
Brigham Young University
Provo, Utah 84602

TABLE OF CONTENTS

Attachment A (Under separate cover): "Biotic Condition Index: Integrated Biological, Physical, and Chemical Stream Parameters for Management in U. S. Forest Service, Intermountain Regions's Aquatic Ecosystem Inventory Series, dated October 1979, by: Robert N. Winget and Fred A. Mangum.

LIST OF FIGURES

LIST OF TABLES

AQUATIC RESOURCE ANALYSIS OF GRASSY TRAIL CREEK
CARBON COUNTY, UTAH

1 November 1979 to 31 October 1980

for
Kaiser Steel Corporation
Sunnyside Mine Project
P.O. 28062031

5 November 1980

PURPOSE

The purpose of this study was to collect adequate data to: 1) describe the condition of aquatic resources in Grassy Trail Creek; and 2) provide the base line for preparing a management plan for said resources.

AREAS OF CONCERN

Kaiser Steel's Sunnyside Mine project has resulted in several changes in the aquatic environment of Grassy Trail Creek: 1) Grassy Trail Reservoir has altered the stream's natural flow regime; 2) mine discharge waters have resulted in considerable changes in water quality of the lower study stream section; and 3) use of coarse refuse coal mine waste materials as road bed fill appears to contribute to aquatic resource deterioration.

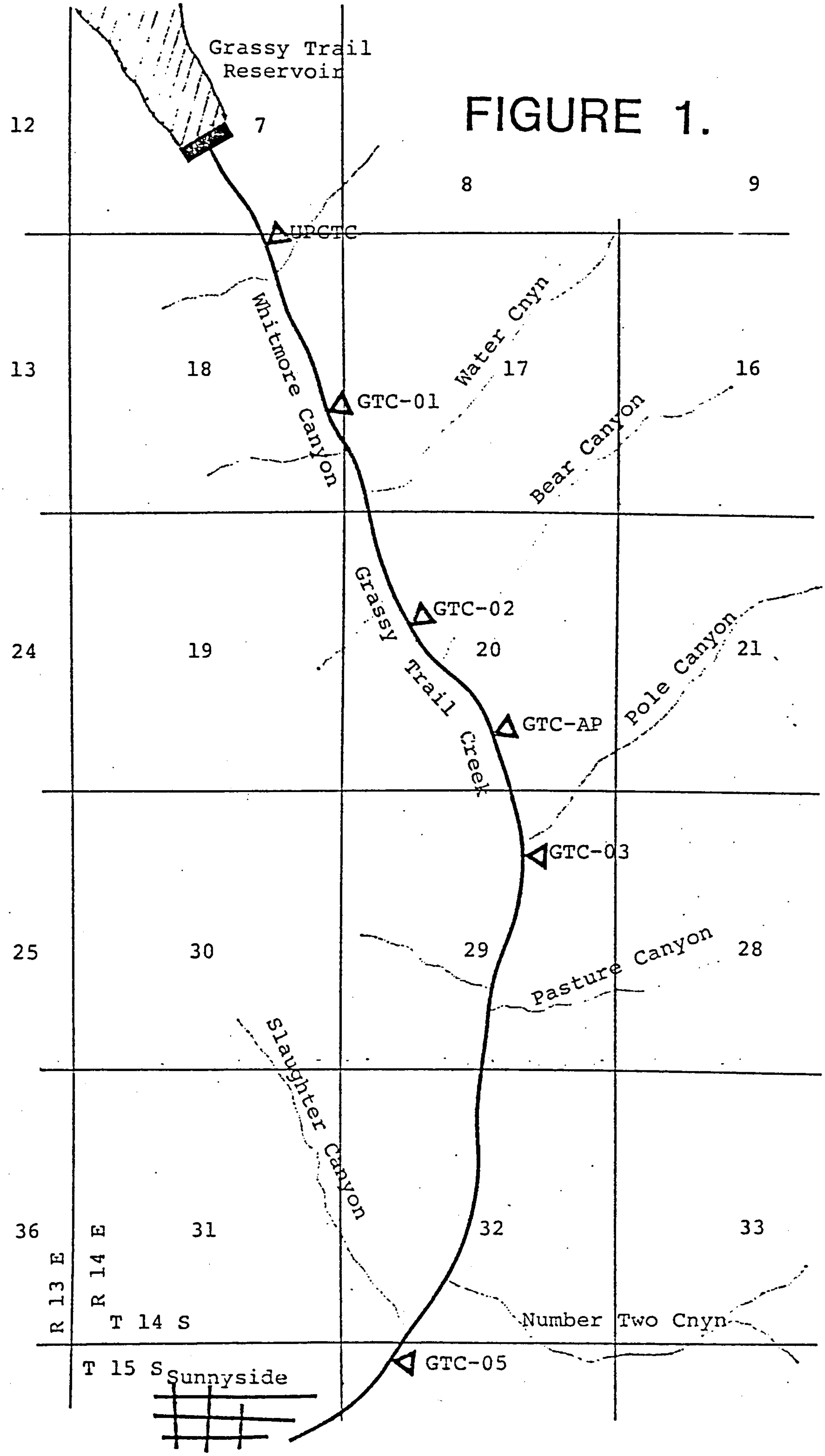
GENERAL STREAM DESCRIPTION

Grassy Trail Creek is a small desert mountain stream. Even though it is in a mountain canyon, low levels of precipitation (6.94 to 16.32 inches total annual precipitation, 1975 to 1979) and a small drainage area result in low fall-winter flows (<1 cfs above mine discharge). Riparian vegetation is sparse with an estimated 25 percent vegetative cover on lands adjoining the stream.

The stream section studied is from Grassy Trail Reservoir downstream to a point below the Sunnyside Mine and above the town of Sunnyside, Utah, approximately 5.5 stream miles (Figure 1).

The stream has an average gradient of 3% and a 1.23 toruosity. The entire stream section has regulated flows resulting from an upstream reservoir and mine discharge waters. Flows above the mine discharge often drop to less than 1 cfs with the average mine water discharge of 1.3 cfs accounting for the majority of stream flow, especially during late fall and winter months. Water quality in 1979 and 1980 above the mine was adequate for most aquatic life forms. Dominant stream substrate was angular gravel-rubble material heavily embedded in sand (on 1 November 1979 gravel beds had from 29 to 64 percent sand by weight; Table 3).

FIGURE 1.


Grassy Trail
Reservoir
12
7
8
9
UPGTC
Water Cnyn
Whitmore Canyon
13
18
17
16
GTC-01
Bear Canyon
GTC-02
Grassy Trail Creek
24
19
20
21
Pole Canyon
GTC-AP
GTC-03
25
30
29
28
Pasture Canyon
Slaughter Canyon
36
31
32
33
R 13 E
R 14 E
T 14 S
Number Two Cnyn
T 15 S
Sunnyside
GTC-05

There is no natural fish population in Grassy Trail Creek due to natural low flows, lack of unembedded spawning gravels and marginal water quality. Utah Division of Wildlife Resources plants catchable-size rainbow trout in the stream each year. The plants are more politically motivated than ecologically sound since the stream is only marginal fish habitat at best.

APPROACH

Aquatic macroinvertebrates, being tied so closely to their aquatic habitat, either have to adapt to changes in their environment or be eliminated by the new environment. Aquatic macroinvertebrates are generally much more susceptible to water-borne toxicants and other environmental stresses than are fish and other higher animals. This habitat dependance and high susceptibility are the reasons aquatic macroinvertebrates are such excellent indicators of water resource condition.

In this study aquatic macroinvertebrates were collected on 3 dates from selected stations above and below suspected impact points. Sediment sizes and chemical composition and water quality were determined for each stream section. Comparisons between physical/chemical measurements and aquatic macroinvertebrate community condition were used to indicate environmental impacts on the aquatic resources of Grassy Trail Creek as a result of coal mining activities of the Sunnyside Mine Project.

METHODS

Sampling Stations Selected

UPGTC : 0.4 miles below Grassy Trail Reservoir, above GTC-01, R14E, T14S, 18,a,b (Photo 1).

GTC-01: at picnic area above upper mine manshaft, R14E, T14S, 18,d,a

GTC-02: below upper manshaft, below Bear Canyon, R14E, T14S, 20,b,d (Photo 2 & 3).

GTC-AP: 50 m above mine discharge pipe, R14E, T14S, 18,a,b (Photo 5).

GTC-03: at Pole Canyon, below mine discharge, R14E, T14S, 29,a,b (Photo 9 & 10).

GTC-05: below Slaughter Canyon, above Sunnyside, Utah, R14E, T15S, 5,b,b.

1 November 1979

Four quantitative benthic samples (stream bottom dwelling macroinvertebrates) were collected from each of 4 stations (GTC-01, GTC-02, GTC-03 and GTC-05) using a modified Surber Sampler (Winget, 1971; Figure 2; Photo 3). Samples were placed in 8 ounce jars, preserved in 10% formalin and transported to the laboratory for processing. Macroinvertebrate samples were each hand processed: organisms separated from debris using a Nikon stereo zoom microscope; organisms were identified, enumerated by taxon, and weighed as dry weight per sample.

Statistical analysis of sample data included: mean number per sample and per taxon for each station; standard deviation of the mean; coefficient of variation; percent standard deviation of the mean; 80% confidence limits; number of taxa per sample set; dominance diversity index (d); and community tolerance quotient (Winget and Mangum, 1979; Exhibit A).

Three sediment samples were taken from each of 4 stations (GTC-01, GTC-02, GTC-03, GTC-05) using a McNeil core sampler with sediments put into cloth flour sacks for transport to the laboratory. Samples were dried, separated into size classes (Table 3) using standard USGS sieves and a soil shaker. Each size class was measured as percent of total dry weight.

9 April, 17 July and 23 September 1980

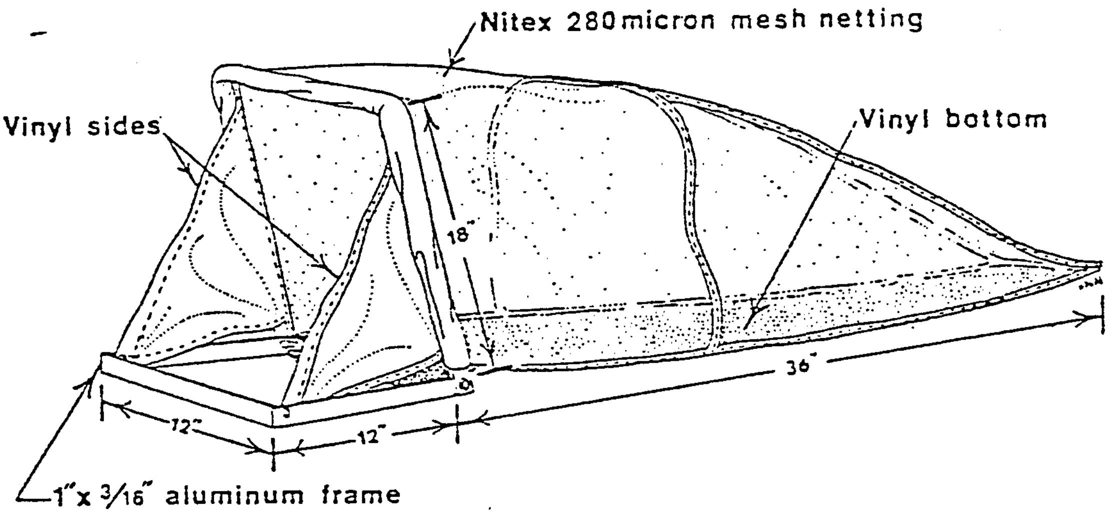
In April, July and September 1980 four quantitative benthic samples were taken from each of the 4 stations sampled in November plus UPGTC and GTC-AP. The methods of sampling, processing and analysis were the same as described for the November sampling.

In April fine sediment samples were collected from 5 stream stations (UPGTC, GTC-02, GTC-AP, GTC-03 and GTC-05) and the coal waste materials used as road bed fill. Stream samples consisted of putting fine stream bottom materials (silt-clay size) in sample bottles. The road bed sample was taken from exposed materials showing signs of erosion and weathering. Samples were shipped to Ford Chemical Laboratory in Salt Lake City for analysis. Acid digestion was used to extract total amounts of 22 selected elements. Results are presented in Table 4.

Supportive Data

All water quality and coal waste descriptive data used in this report were obtained from the records of Mr. John S.Huefner, Civil Engineer for Kaiser Steel Corporation at the Sunnyside Mine (Tables 1 and 5). "Water Quality Criteria for Aquatic Life" contains values gleaned from several sources as cited in Table 2.

Modified Surber Sampler



Benthic samples were taken with a Surber sampler (Surber, 1937), modified by Winget (1971) as shown. The intake opening is 30 cm (12 inches) wide by 45 cm (18 inches) high and the bag is 91 cm (3 feet) long. The standard Surber sampler is only 30 cm (12 inches) high with a 62 cm (2 feet) long bag. The modified sampler was designed with a larger collecting bag to prevent excessive backwash and loss of contents when collecting in deep, swift streams.

FIGURE 2..

RESULTS AND DISCUSSION

Water quality

Table 1 summarizes water quality at GTC-01 (Upper Grassy Trail Creek) and GTC-05 (Lower Grassy Trail Creek) from 1 May 1979 to 30 March 1980.

Water quality in Grassy Trail Creek above the mine discharge is adequate for most aquatic species except for questionable levels of nickel (<.001-0.016 mg/l), zinc (0.012-1.63 mg/l) and oil and grease (<1.0-1.2 mg/l).

Water quality criteria for aquatic life are given in Table 2. Water quality below the mine discharge (station GTC-05) show considerable degradation: increases in conductivity, TDS, alkalinity, chloride, nitrate, phosphate, sulfate, sodium and oil and grease (Table 1). Again, nickel (<.001-0.16 mg/l), zinc (0.005-0.093 mg/l) and oil and grease (<1.0-6.8 mg/l) frequently exceeded the recommended (Table 2) concentration of 0.1-0.01 mg/l, 0.005 mg/l and 0.1 mg/l, respectively. Sulfate levels in excess of 250 mg/l and alkalinity >300 mg/l are restrictive to many species of aquatic life.

Without the mine discharge waters (Photo 6 & 7), Grassy Trail Creek would be near intermittent (mine waters being >90% of total stream flow) part of the year during most years. This would severely limit the aquatic community of the stream, but with present water quality, the community is also severely limited.

It is suspected, but not tested, that mine discharge waters carry a fairly high BOD or COD, as evidenced by the strong sulfide smell and black color of the sediments below the mine discharge at station GTC-03 (Photo 9 & 10). These symptoms indicate anoxic condition in the sediments, fairly uncommon in turbulent mountain streams such as Grassy Trail Creek. The turbulance of the waters generally allows an active gas exchange with the atmosphere resulting in near saturated dissolved oxygen levels in the waters. The presence of increased fine sediments below GTC-02 (Table 3) also contributes to the anoxic condition by not allowing stream surface waters to freely flow through substrate materials providing an oxygen source to sub-surface sediments. Sediments at GTC-AP (immediately above the discharge pipe) were slightly darker than at GTC-02 and a slight sulfide smell was obvious.

At station GTC-05 there were even higher amounts of fine sediments than at GTC-03 but the sediments were more brown in color and less sulfide smell was evident indicating a partial oxidation compared with GTC-03. This helps support the theory of BOD or COD loading in the mine discharge waters as the main cause of anoxic conditions at GTC-03 rather than the road bed coarse refuse problem discussed below.

Stream Sediments

Table 3 presents a summary of sediment size composition at 4 stations on Grassy Trail Creek on 1 November 1979. The most obvious trend was an increase in fines (<0.50mm in diameter) proceeding downstream. Fine sediments at GTC-01 and GTC-02 were brown in color with no sulfide smell detected. Sediments at GTC-03 were black and emitted a strong sulfide smell when disturbed indicating strong anoxic conditions. Station GTC-05 sediments were dark brown with only a slight sulfide smell indicating at least partial oxidation or recovery from upstream conditions.

Table 4 gives the size breakdown of the silt/clay fraction of coarse refuse materials used as road bed materials. This fraction accounts for anly 2-5 percent of the total coarse refuse material used. The presence of fines was obvious at stations GTC-AP, GTC-03 and GTC-05 during November 1979 and April, July and September 1980. There was no obvious build-up of fines (<0.074 mm diameter) at stations GTC-02 or GTC-AP (Photos 2 & 5) even though some road bed above these stations contained coarse refuse materials.

Table 5 contains the results of an acid digestion bared analysis of the chemical composition of stream fine sediments at 5 stations plus composition of coal waste road bed materials. Chemical composition was fairly similar for all 6 samples with some possible trends apparent. Six elements (Ba, B, Ca, F, Mg and Mn) higher in the road bed materials than at upstream UPGTC showed downstream increases in concentrations. Five elements (As, Cr, K, Na and Zn) increased downstream independant of road bed sediment influence. Cadmium and iron increased below the mine discharge point (between GTC-AP and GTC-03) while 4 elements (B, Cr, Mn and Na) decreased in concentration. These increases and decreases were probably influenced by a combination of higher levels of fine sediments and BOD and/or COD from the mine effluents (resultant anoxic reducing conditions at GTC-03 is discussed above under water quality). Some elements appear to increase in concentration while others decrease under reducing conditions and the reverse is true for oxidizing conditions. Comparing sediment composition between GTC-03 with strong reducing conditions and GTC-05 with sediments largely oxidized, As, Ba, F, Mn, K and Zn concentrations were lower in the oxidized sediments.

The fine materials created from deterioration of coarse refuse used in the road bed (Photo 4) if allowed to enter the stream could seal off the hyphoreic substrates (below surface substrates) from oxygen carrying stream waters resulting in anoxic, reducing, acid conditions. These reducing conditions can free from sediments or organic debris several elements toxic to aquatic organisms, thus increasing the potential of toxic reactions from mine discharge waters and/or sediments themselves.

The moderation of seasonal flows from the upstream reservoir has reduced the seasonal removal of fine sediments from the river via spring runoff and summer storm freshets. This has allowed a buildup of natural fine sediments (fine sands) plus road bed erosion products.

Biota

Tables 6, 7, 8 and 9 contain summaries of aquatic macroinvertebrate sampling efforts on 1 November 1979 and 9 April, 17 July and 23 September1980.

1 November 1979 (Table 6). Four stations were sampled on 1 November 1979, above the mine road bed materials (GTC-01), one above the mine discharge but within limited influence of the road bed materials (GTC-02), one below the mine discharge and subject to the full impacts of road bed erosion (GTC-03), and one station below the major mining activities (GTC-05).

There appeared to be no direct correlation with total numbers, dry weight, number of taxa, or dominance diversity (d) and the mine related impacts on 1 November 1979. But, when community composition was analyzed, there were definitely some community stresses.

As indicated by the community tolerance quotient CTQa (Winget and Mangum, 1979, exhibit A), when 45 to 70 is considered acceptable for a stream such as Grassy Trail Creek, a value of 83 at the control station (GTC-01) indicates a community under stress. The low number of taxa (14) substantiates this evaluation. As fragile species are eliminated or replaced by more tolerant species, the CTQa increases. The lower CTQa (75) at GTC-02 was the result of more desirable taxa at this station than at GTC-01. GTC-01 was in a more narrow canyon site than GTC-02 and there was less green algae on the rocks at GTC-01. This habitat difference could account for the poorer community at GTC-01.

The increased CTQa value (88) at station GTC-03, even though the number of taxa (15) was higher than GTC-01 (14) indicates a severe stress at this station. This is even more evident considering oligochacte worms and chironomid midges accounted for 85% of the total community numbers compared with 18% and 14% at GTC-02 and GTC-01, respectively. The stoneflies (Isoperla and Capniidae) at GTC-01 and GTC-02 were not sampled at GTC-03. Baetis mayflies accounted for 58% and 66% of the total community at GTC-01 and GTC-02 respectively, compared with only 7 percent at GTC-03.

The only reason Baetis mayflies were present at GTC-03 was because of the active downstream drifting behavior of these organisms--they are probably transient with little chance of surviving to adult stage.

Station GTC-05 showed some improvement over GTC-03 with CTQa values of 84 and 88, respectively, even though the number of taxa was 15 for both stations. The presence of Argia at GTC-05 seems to indicate an improved sediment condition, assumption supported by observance of brown sediments (black at GTC-03) and near absence of sulfide smell during sampling.

The apparent successful habitation of oligochaetes at station GTC-03 and GTC-05 indicates a general lack of heavy metal toxicity since these worms are quite susceptible to these types of toxicants. Oligochaetes are, however, highly tolerant of oil and grease pollution plus organic and TDS loading of a stream.

9 April 1980 (Table 7). Six stations were sampled on 9 April 1980, the same 4 on 1 November 1979, plus 2 additional stations. The stations added were: UPGTC, above GTC-01 in a more open stream section more closely

resembling GTC-02 in habitat; and GTC-AP, immediately above the mine discharge pipe, but far enough below GTC-02 to better illustrate the impacts of road bed materials without mine discharge water than at GTC-02.

Unlike the November samples, community density (no./m^2), number of taxa and CTQa values all illustrated the extent of community degradation proceeding downstream. UPGTC was an excellent station with a CTQa (68) in the upper limits of acceptable for a stream such as Grassy Trail Creek. GTC-01, like in November, showed signs of stress (CTQa = 76) and was more like CTQ-02 than UPGTC.

GTC-AP definitely showed signs of increased stress over CTQ-02 upstream--CTQa = 91 compared with 78 at GTC-02, 13 taxa compared with 16 at GTC-02, and only 3,110 organisms/m^2 compared with 22,168 at GTC-02.

To illustrate that the stress at GTC-AP was different than at GTC-03, below the discharge pipe, compare dominance of oligochacte worms and chironomid midges above (UPGTC, GTC-01, GTC-02 and GTC-AP) the discharge and below (GTC-03 and GTC-05): 28% at UPGTC, 35% at GTC-01, 32% at GTC-02, 16% at GTC-AP, 90% at GTC-03 and 94% at GTC-05. Also, compare Baetis dominance at the same stations: 40%, 27%, 45%, 47%, 1% and 1%, respectively. Apparently, the mine discharge waters are having the greatest impact on Grassy Trail Creek biota, with the road sediments adding to the impacts to a much lesser degree.

The highest CTQa can go is 108, the values on 9 April of 97 and 100 at GTC-03 and GTC-05, respectively are near that maximum indicating the severity of community stress below the mine discharge pipe.

GTC-05 again showed signs of recovery indicating a potential of stream improvement under proper management.

17 July 1980(Table 8). Six stations were sampled on 17 July 1980, the same stations as were sampled in April. During July the aquatic macroinvertebrate community was characterized by having large numbers of organisms but with little increase in biomass. This was to be expected since following spring emergence and mating of adult insects, large numbers of eggs are deposited into the stream and by July many of these have hatched - the result being large numbers of small instar larvae with little biomass. Of special interest was the relatively small numbers at Stations GTC-03 and GTC-05, both below the discharge pipe. Note the smaller number of taxa and higher CTQ_a at these stations compared with upstream stations. There was no noticeable difference at Stations GTC-02 and GTC-AP (both above the discharge pipe but below the start of coarse refuse material in the road bed) compared with the 2 stations above the area of coarse refuse road bed.

Station GTC-03, as during November and April, showed the most striking community differences in relation to mine operation features - approximately 40,000 fewer organisms, 4.5 gms biomass less, 8 fewer taxa and a CTQ_a 9 points higher than at the upstream Station GTC-AP.

The mayfly Baetis was the most dominant macroinvertebrate found at any station (35 to 78%) except for GTC-03 (Baetis 5%) where Oligochaetes were dominant accounting for 52 percent of the total numbers. The presence of relatively large numbers of chironomids at GTC-03 and GTC05 indicate if there was a heavy metal toxicity it was not severe. The large dominance of oligochaetes at GTC-03 indicates a high probability of oil and grease toxicity below the mine discharge pipe.

23 September 1980(Table 9). The same six stations sampled in April and July were again sampled in September 1980. As in July, high numbers of macroinvertebrates at most stations reflect a successful summer hatch of eggs. For the first time during this study there were large numbers of larvae sampled at Station GTC-03 and the biomass was comparable to that at other stations. Number of taxa at GTC-03 (17) was equal to Station GTC-AP and CTQ_a was lower at GTC-03 (81) compared with 91 at GTC-AP. As larvae become larger following a major hatch, they generally begin to distribute themselves over available habitat. In streams they do this by actively drifting with the current to new downstream habitats. The mayfly Baetis is one of the most active of stream drifters, a fact that helps explain the high numbers of Baetis at Station GTC-03 (41% of the total numbers) in September compared with the other three collection dates of this study (Tables 6, 7 & 8).

Results of the September sampling confirms evaluations made following the other three samplings: there was very little community difference between Stations UPGTC, GTC-01 and GTC-02; Station GTC-AP showed moderate impact related changes, caused more by physical stress than chemical; Station GTC-03 showed severe stress reactions with indications of both physical and chemical stresses; and Station GTC-05 community exhibited similar responses as at Station GTC-03 but with evidence of limited recovery. It appears that fine sediments and oil and grease pollution are the major Sunnyside Mine related factors affecting Grassy Trail Creek. Both of these impacts can be controlled with minor operational modifications (see CONCLUSIONS & RECOMMENDATIONS).

CONCLUSIONS AND RECOMMENDATIONS

1. Deteriorated road bed material (coarse refuse, Photo 4) is having a definite deliterious impact on the aquatic resources of Grassy Trail Creek.

2. Mine discharge waters are magnifying the impacts from fine sediment build-up in Grassy Trail Creek plus contributing chemical related stresses to the biota of the stream.

3. Preventing further erosion of road bed fines into Grassy Trail Creek would result in a significant improvement in the resource quality. Existing fines will probably be reduced by future runoff occurrences - reservoir releases could be used to supplement natural runoff and thus aid in the clean-up process.

4. Removal of oil and grease, plus aerating and retaining mine waters for an adequate period to remove possible BOD or COD, allowing chelation of heavy metals and settling of suspended solids, should greatly improve the aquatic resources of Grassy Trail Creek.

5. There was no evidence of toxicity type impacts from coarse refuse road bed materials. Chemical analyses nor biological community investigations provided any data that indicated a heavy metal problem in Grassy Trail Creek.

Table 1. Water quality measurements taken between 1 May 1979 and 30 March 1980 from Grassy Trail Creek at 1 site above and 1 site below the Sunnyside Mine, Sunnyside, Utah. Information was provided by Mr. John S. Huefner, Kaiser Steel Corporation, Sunnyside, Utah.

		Upper Grassy Trail Creek		Lower Grassy Trail Creek	
Parameter	n	mean	range	mean	range
Turbidity, JTU	5	2.0	0.4-5.0	4.2	1.8-10.0
Cond., umhos/cm 25°C	9	615	510-650	1610	730-1780
pH	10	7.9	7.5-8.4	8.1	7.0-8.4
TDS	9	385	310-420	1084	483-1230
Tot Alk, mg/l CaCO3	10	274	222-308	414	262-478
Arsenic, mg/l As	10	.001	<.001-.004	.003	<.001-.007
Barium, mg/l Ba	5	.08	.050-.155	.069	.029-.14
Boron, mg/l Bo	5	.117	.07-.205	.195	.090-.260
Cadmium, mg/l Cd	5	<.001	<.001	<.001	<.001
Calcium, mg/l Ca	5	59.0	51-90	62.1	45-102
Chloride, mg/l Cl	10	12.0	2.0-28.0	27.4	8.0-44.0
Chromium, mg/l Cr	4	<.001	<.001	<.001	<.001
Copper, mg/l Cu	5	.031	.003-.101	.014	.001-.041
Fluoride, mg/l Fl	5	.22	.12-.28	.48	.08-.57
Hardness, mg/l CaCo3	5	275	242-322	302	260-326
Iron Total, mg/l Fe	8	.141	.030-4.71	.274	.035-.680
Iron Filt, mg/l Fe	9	.089	.020-.293	.094	.026-.186
Lead, mg/l Pb	9	<.001	<.001	.001	<.001-.006
Magnesium, mg/l Mg	5	30.4	3.8-38.9	35.4	4.8-43.7
Manganese, mg/l Mn	10	.147	<.001-.069	.091	.001-.654
Mercury, mg/l Hg	6	<.0002	<.0002	<.0002	<.0002
Nickel, mg/l Ni	4	.005	<.001-.016	.053	<.001-.16
Nitrate, mg/l N	9	.06	<.01-1.60	.136	<.01-1.65
Phosphate, mg/l PO4	4	.04	.02-.14	.247	.10-.61
Potassium, mg/l K	8	3.62	1.20-12.5	3.88	1.32-6.60
Selenium, mg/l Se	9	<.001	<.001-.002	.002	<.001-.004
Silver, mg/l Ag	9	<.001	<.001	.0014	<.001-.003
Sulfate, mg/l SO4	9	72.0	59-80	445	130-640
Sodium, mg/l Na	4	37.0	30.2-62.8	228	58-300
Zinc, mg/l Zn	5	.344	.012-1.63	.038	.005-.093
Acidity	5	12.0	10.0-22.0	13.0	2.0-16.0
Oil & grease, mg/l	7	0.8	<1.0-1.2	2.14	<1.0-6.8

Most materials were present in concentrations below limits estimated to be acceptable to aquatic life (Table 2). Nickel levels below the mine effluent exceeded the limits set by NAS/NAE most of the time but only occasionally exceeded EPA Red Book limits. Oil and grease were consistently too high, especially below the mine effluent. Silver may be too high below the mine but only if aquatic organisms are exposed over long periods of time. Zinc concentrations were above acceptable limits above and below the mine discharge.

Table 2. Water quality criteria for aquatic life: a) developed by the National Academy of Science and National Academy of Engineering, 1973; and b) Environmental Protection Agency "Red Book", Quality Criteria for Water, 1976; and c) Utah public water supply limits.

Chemical parameter	Aquatic life threshold (a) mg/l	(b) mg/l	Public Supply (c) mg/l
Aluminum......................	0.1	0.05	---
Arsenic.......................	0.1	0.05	0.1
Barium........................	1.0	50	1.0
Cadmium.......................	[1,2]0.3 [1,3]0.004	0.0012	0.01
Chromium......................	0.05	0.1	0.05
Copper........................	[2].015-.033 [3].011-.018	[4]0.1	1.0
Iron, soluble.................	2.0	1.0	0.3
Lead..........................	0.03	[4]---	0.05
Manganese, soluble............	---	1.5->1,000	0.05
Mercury.......................	[1]0.05	0.00005	0.002
Nickel........................	0.01	0.1	---
pH	6.5-9.0	6.5-9.0	5.0-9.0
Oil & grease..................	---	[6]---	---
Selenium......................	10.0	0.02	0.01
Silver........................	0.001	[5]---	---
Zinc..........................	0.005	[4]---	5.0

[1]Recommended maximum level.
[2]Hard water.
[3]Soft water.
[4]To be determined by bioassay.
[5]Undetermined, .01X96-hr TL_{50} is recommended.
[6]Undetermined but any amount consistently >.1 mg/l is unacceptable.

Table 3. Sediment composition as percent by weight of sediments passing through each sieve size. Samples were taken from four stations on Grassy Trail Creek in the vicinity of Kaiser Steel Sunnyside Coal Mine. Samples were taken 1 November 1979.

	Station				Refuse Material	
Sieve Size inch (mm)	GTC-01 mean%	GTC-02 mean%	GTC-03 mean%	GTC-05 Mean%	New mean%	Old mean%
1.0 (25.4)	83.3	77.5	75.4	86.5	40.5	74.3
.25(6.35)	--	--	--	--	16.6	37.6
.02(4.75)	29.5	32.0	34.2	54.1	--	--
.08(2.00)	14.1	17.4	21.8	36.6	--	--
.036(0.91)	--	--	--	--	3.2	11.1
.03(0.85)	8.5	10.9	14.8	31.0	--	--
.02(0.50)	7.0	8.9	12.9	18.3	--	--
.01(0.25)	--	--	--	--	1.6	4.9

Table 4. Size composition of coarse refuse material used as road bed material at the Sunnyside Mine. Analysis done by American Chemical & Research Laboratories, Provo, Utah, 22 January 1980.

Sieve opening diameter in mm	New Refuse Material	Old Weathered Refuse Material
	Hydrometer Test* Percentage passing through seive	
0.0680 mm	80	84
0.0402 mm	68	70
0.0290 mm	60	62
0.0212 mm	45	54
0.0157 mm	35	44
0.0114 mm	19	20
0.0052 mm	9	14
0.0009 mm	8	13
	Texture	
sand	20.4%	8.8%
silt	68.0%	66.4%
clay	11.6%	24.8%
	Character	
pH	7.35	6.55
conductivity	1.679umhos	3.685umhos
sodium absorption ratio	101.21	22.20

*Only the silt/clay fraction of refuse material was used in the hydrometer test - that portion passing through a 100 mesh sieve after the sample was pulverized.

Table 5. Chemical analysis of sediments from 5 sites on Grassy Trail Creek and 1 sample from coarse refuse mine waste used as road bed fill along Grassy Trail Creek. Acid digestion was used to obtain total measurements for the listed constituents. Analysis was done by Ford Chemical Laboratory, Inc., Salt Lake City, Utah, Certificates No. 80-00970-6 and 80-00970-7, dated 23 May 1980.

	STATION*					
Chemical parameter	Road bed	Upper GTC	GTC02	GTCAP	GTC03	GTC05
Arsenic, ppm As	0.002	0.002	0.006	0.010	0.015	0.003
Barium, ppm Ba	20.65	1.520	1.115	2.510	2.985	2.360
Boron, ppm B	10.65	1.520	2.830	4.960	2.980	2.360
Cadmium, ppm Cd	<.001	<.001	<.001	<.001	0.005	0.010
Calcium, % Ca	20.25	12.45	11.78	16.85	15.54	15.55
Chloride, %Cl	1.25	0.250	0.310	0.285	0.225	0.240
Chromium, ppm Cr	.009	0.017	0.040	0.120	0.036	0.075
Copper, ppm Cu	<.001	<.001	<.001	<.001	<.001	<.001
Fluoride, ppm F	.450	0.080	0.100	0.200	0.240	0.180
Iron, ppm Fe	1,850	3.150	2.650	2.260	2.850	3.740
Lead, ppm Pb	<.001	<.001	<.001	<.001	<.001	<.001
Magnesium, ppm Mg	15.68	1.36	1.44	1.65	1.20	1.50
Manganese, ppm Mn	6.850	0.159	0.165	0.220	0.250	0.229
Mercury, ppm Hg	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002
Nickel, ppm Ni	.025	<.001	<.001	<.001	<.001	<.001
Potassium, ppm K	150.5	126.5	180.5	250.5	265.8	214.5
Selenium, ppm Se	<.001	<.001	<.001	<.001	<.001	<.001
Silicon, % SiO2	74.40	79.5	80.45	76.65	75.54	74.95
Silver, ppm Ag	<.001	<.001	<.001	<.001	<.001	<.001
Sodium, % Na	0.945	0.245	0.386	1.620	0.085	0.099
Sulfate, ppm SO4	10,650	452	133	98.7	112	68.2
Zinc, ppm Zn	0.860	1.556	1.681	2.456	2.740	1.985

*Road bed was a sample directly from the coarse refuse used as base for the the mine access roads.

Upper GTC is located approximately 0.5 Km above the turn-off to the upper mine man-hole, upstream from any influence of road bed sediments.

GTC02 is located between the upper mine man-hole turn-off and the mine discharge pipe.

GTCAP is located approximately 100 m above the mine discharge pipe.

GTC03 is located approximately 100 m below the mine discharge pipe

GTC05 is located below the mine surface loading facilities and upstream of the city park.

Table 6. Summary of 1 November 1979 macroinvertebrate samples taken from four stations on Grassy Trail Creek, Carbon County, Utah.

	Stations			
	GTC-01	GTC-02	GTC-03	GTC-05
mean No./m^2	6,736	15,349	19,965	6,474
mean dry wt, gm/m^2	1.34	2.84	2.30	4.08
number of taxa	14	22	15	15
d (Shannon-Weaver)	2.047	1.675	1.368	1.953
CTQ_a	83	75	88	84
Dominant taxa - listed in order of dominance	*Baetis* (58%) *Isoperla* (14%) Chironomidae (13%) *Hydropsyche* (6%) Elmidae (3%) Capniidae (2%) Oligochaeta (1%) Hydracarina (1%) Ostracoda (1%)	*Baetis* (66%) *Hydropsyche* (12%) Oligochaeta (10%) Chironomidae (8%) Capniidae (1%) *Isoperla* (1%)	Oligochaeta (72%) Chironomidae (13%) *Baetis* (7%) Nematoda (3%) *Hydropsyche* (1%)	Chironomidae (44%) Oligochaeta (38%) *Hydropsyche* (8%) Copepoda (5%) *Argia* (1%) *Baetis* (1%)

Table 7. Summary of 9 April 1980 macroinvertebrate samples taken from 6 stations on Grassy Trail Creek, Carbon County, Utah.

	Stations		
	UPGTC	GTC-01	GTC-02
mean No./m^2	9,934	11,909	22,168
mean dry wt, gm/m^2	2.42	2.72	15.89
number of taxa	20	17	16
d (Shannon-Weaver)	2.4	2.6	1.9
CTQ_a	68	76	78
Dominant taxa - listed in order of dominance	*Baetis* (40%) Chironomidae (26%) Simuliidae (16%) *Hydropsyche* (5%) Elmidae (4%) *Isoperla* (3%) Oligochaeta (2%) Hydracarina (2%) Ostracoda (1%)	Chironomidae (35%) *Baetis* (27%) *Holorusia* (14%) Elmidae (6%) *Hydropsyche* (4%) *Isoperla* (4%) *Prostoia* (4%) Empididae (1%)	*Baetis* (45%) Chironomidae (30%) *Hydropsyche* (17%) Oligochaeta (2%) Hydracarina (2%) *Isoperla* (1%)

Table 7 Continued.

	GTC-AP	Stations GTC-03	GTC-05
mean No./m^2	3,110	3,260	4,250
mean dry wt, gm/m^2	2.19	0.69	3.63
number of taxa	13	7	9
d (Shannon-Weaver	2.1	1.5	1.1
CTQ_a	91	97	100
Dominant taxa - listed in order of dominance	Baetis (47%) Hydropsyche (29%) Chironomidae (11%) Oligochaeta (5%) Hydracarina (5%) Dicranota (1%)	Oligochaeta (51%) Chironomidae (39%) Nematoda (6%) Empididae (2%) Baetis (1%) Hydracarina (1%)	Chironomidae (79%) Oligochaeta (15%) Nematoda (2%) Argia (1%) Baetis (1%)

Table 8. Summary of 16 July 1980 macroinvertebrate samples taken from 6 stations on Grassy Trail Creek, Carbon County, Utah.

	Stations		
	UPGTC	GTC-01	GTC-02
mean No./m^2	26,548	12,979	36,963
mean dry wt, gm/m^2	4.59	1.39	4.19
number of taxa	30	21	22
H (Shannon-Weaver)	3.12	2.59	2.07
CTQ_a	70	82	80
Dominant taxa - listed in order of dominance	*Baetis* (35) *Heptagenia* (15) *Arctopsyche* (11) Capniidae (9) Chironomidae (8) Simuliidae (5) *Isoperla* (3) Elmidae (2) *Parapsyche* (2) Oligochaeta (1) *Amphinemura* (1) Hydracarina (1) *Hydroptila* (1) *Hydropsyche* (1)	*Baetis* (52) Chironomidae (12) Simuliidae (7) *Arctopsyche* (6) Capniidae (5) Elmidae (4) *Heptagenia* (4) *Isoperla* (2) Hydracarina (2) Nematoda (2) *Hydroptila* (1)	*Baetis* (65) Simuliidae (9) *Hydropsyche* (6) Chironomidae (5) *Arctopsyche* (2) Capniidae (2) Nematoda (2) Oligochaeta (1) *Isoperla* (1) Hydracarina (1) *Heptagenia* (1) Elmidae (1) *Hydroptila* (1)

Table 8 Continued.

	GTC-AP	Stations GTC-03	GTC-05
mean No./m^2	45,044	3,548	6,050
mean dry wt, gm/m^2	4.71	0.23	1.99
number of taxa	21	13	13
d (Shannon-Weaver	1.49	2.15	1.34
CTQ_a	81	90	99
Dominant taxa - listed in order of dominance	Baetis (71) Simuliidae (19) Chironomidae (2) Capniidae (1) Parapsyche (1) Hydroptila (1)	Oligochaeta (52) Hydropsyche (24) Chironomidae (7) Baetis (5) Hydracarina (4) Dytiscidae (3) Ceratopogonidae (1) Empididae (1)	Baetis (78) Hemerodromia (8) Chironomidae (6) Oligochaeta (2) Hydracarina (2) Simuliidae (1)

Table 9. Summary of 23 September 1980 macroinvertebrate samples taken from 6 stations on Grassy Trail Creek, Carbon County, Utah.

	Stations		
	UPGTC	GTC-01	GTC-02
mean No./m^2	19,971	17,754	68,759
mean dry wt, gm/m^2	2.13	2.95	12.20
number of taxa	29	19	23
H (Shannon-Weaver)	2.5	2.1	1.4
CTQ_a	78	74	81
Dominant taxa - listed in order of dominance (% of total density)	*Baetis* (51%) *Hydropsyche* (16%) Elmidae (8%) Capniidae (6%) Chironomidae (5%) *Isoperla* (3%) *Heptagenia* (3%) Oligochaeta (2%) Simuliidae (1%) Hydracarina (1%) Ostracoda (1%)	*Baetis* (57%) Elmidae (15%) *Hydropsyche* (10%) Capniidae (5%) *Isoperla* (5%) Chironomidae (3%) *Heptagenia* (3%)	*Baetis* (75%) *Hydropsyche* (12%) Capniidae (2%) Simuliidae (2%) Chironomidae (1%) *Isoperla* (1%) Elmidae (1%)

Table 9 Continued.

	Stations GTC-AP	GTC-03	GTC-05
mean No./m^2	23,357	38,957	7,637
mean dry wt, gm/m^2	3.56	7.71	0.86
number of taxa	17	17	11
H (Shannon-Weaver	1.7	1.6	1.2
CTQ_a	91	81	102
Dominant taxa - listed in order of dominance (% of total density)	*Baetis* (72%) *Hydropsyche* (10%) Capniidae (4%) Chironomidae (4%) Simuliidae (3%) Oligochaeta (3%) *Isoperla* (1%) Hydracarina (1%)	Oligochaeta (50%) *Baetis* (41%) Chironomidae (4%) Tipulidae (1%) Capniidae (1%)	Oligochaeta (76%) *Baetis* (15%) Chironomidae (6%) *Hydropsyche* (1%) Nematoda (1%)

Appendix 3-2

Baumann Study (1989)

ANALYSIS OF MACROINVERTEBRATE FAUNA OF GRASSY TRAIL CREEK CARBON COUNTY, UTAH, MAY 5, 1989

by

Richard W. Baumann
Department of Zoology
Monte L. Bean Life Science Museum
Brigham Young University
Provo, Utah 84602

for

Sunnyside Reclamation and Salvage Inc
Sunnyside, Utah

June 26, 1989

Objectives

The purpose of this study is to use the macroinvertebrate fauna of Grassy Trail Creek on May 5, 1989 to help answer two questions:

1. How does the overall biological condition of Grassy Trail Creek in 1989 compare with the results reported by Winget in 1980?
2. What do the macroinvertebrate indicators in Grassy Trail Creek indicate about the condition of the creek now, over one month after the soluable oil spill on March 24 and several weeks after the broken irrigation line on April 9 and the sludge spill on April 15?

Methods

Four quantitative samples were collected of the benthic macroinvertebrates in Grassy Trail Creek from each of seven stations. Aquatic macroinvertebrates were collected using a modified Surber sampler (Winget and Mangum, 1979). Samples were preserved in 75% ethyl alcohol for shipment to the laboratory at Brigham Young University. The organisms were then sorted and identified using the latest faunistic publications: Baumann et al. (1977), Edmunds et al. (1976), Gaufin, et al. (1966), Wiggins (1977) and Merritt and Cummins (1984). The macroinvertebrates were then counted, dried and weighed. The data were then used to calculate biomass, relative abundance, and diversity indices.

Water and silt samples were collected at each station and sent to Chemtech and Commercial Testing & Engineering Co. laboratories respectively for analysis.

Study Area

Seven stations were sampled between Grassy Trail Reservoir and the town of Sunnyside. The location of the stations chosen was based on the stations studied by Winget (1980) and the area most heavily impacted by the Spring, 1989 impact events (Figure 1).

Station 1: (UPGTC)W*

Upper Grassy Trail Creek, 3.5 miles below Grassy Trail Reservoir at road bridge.

Gradient:	2%
Substrate:	boulder-rubble
Temperature:	9.5°C
pH:	8.14
Conductivity:	1,300
$PPMO_2$:	7.5

The creek appears to be in good condition at this station, even though it is very close to the reservoir. A small amount of silt was noted and also the presence of some filamentous, green algae on the rocks.

---

*The "W" following station indications in this report refers to stations established by Winget in his 1980 study.

Station 2: (GTCAP)[W]

Grassy Trail Creek, about 15 miles downstream from Grassy Trail Reservoir, above junction of Pole Canyon.

Gradient:	3%
Substrate:	boulder-rubble
Temperature:	18°C
pH:	8.14
Conductivity:	1,200
$PPMO_2$:	5.6

The creek improves slightly from Station 1 to Station 2. Beaver dams appear to have the most obvious influence on this stream reach. Filamentous, green algae and some silt are present, especially where the flow is decreased by logs, boulders or beaver dams. This station is located just above an old outflow pipe.

Station 3: (GTC03)[W]

Grassy Trail Creek, just below the junction of Pole Canyon, below settling pond and outflow pipe.

Gradient:	2%
Substrate:	silt-gravel
Temperature:	18°C
pH:	8.01
Conductivity:	1,700
$PPMO_2$:	5.7

This station is located about 50 feet below the outflow pipe that drains from the mine pond. The creek water, which is clear, is joined by the pipe water, which is dark grey, almost cloudy. Light brown silt is present in the stream channel along with green algae. Black silt overlain with brown silt is deposited below the outflow pipe and supports a heavy growth of blue-green algae.

Station 4: (GTCRG)

Grassy Trail Creek above the Rodeo Ground, about 2 miles downstream from Station 3.

Gradient:	2%
Substrate:	silt-gravel
Temperature:	17°C
pH:	8.46
Conductivity:	2,300
PPMO_2:	6.2

This station is located immediately below the silt fences and straw filters that have been constructed in an effort to improve the creek. Here the stream is greatly stressed biologically. The water is cloudy and there is a combination of both green and blue-green algae.

Station 5: (GTCPC)

Grassy Trail Creek, just above the confluence of Pasture Canyon, about 2 miles downstream from Station 4.

Gradient: 2%

Substrate: silt-gravel

Temperature: 21°C

pH: 8.48

Conductivity: 2,400

$PPMO_2$: 5.6

The water in the creek is relatively clear here but there is still a thick layer of silt present. Only green algae were observed.

Station 6: (GTCPP)

Grassy Trail Creek at the Coal Preparation Plant.

Gradient: 2%

Substrate: silt-rubble

Temperature: 17°C

pH: 8.83

Conductivity: 2,300

$PPMO_2$: 5.6

This station is located in an area where the creek has very steep banks. These banks are partially composed of coal fines and the riparian area looks desolate. However, the water is relatively clear and the algae present are green algae.

Station 7: (GTC05)[W]

Grassy Trail Creek below confluence of Slaughter Canyon and just above Sunnyside.

Gradient:	2%
Substrate:	silt-rubble
Temperature:	17°C
pH:	8.76
Conductivity:	2,500
PPMO_2:	5.6

This station is located just below a large culvert. The water is clear and some green algae are present.

Results

The complete data on the macroinvertebrates collected from Grassy Trail Creek on May 5, 1989 are given in Tables 1-6. The following comments are given to summarize these data so that conclusions can be made.

Stations 1 and 2 are very similar now in 1989 to the results given by Winget (1980) for his stations UPGTC and GTCAP. In fact the same organisms are dominant in the community (Tables 1 & 2).

At Station 3, which corresponds to Winget's GTC03, the health of the macroinvertebrate community is now better than it was in April, 1980. The average community index (CTQa) is 74 now and it was 97 in 1980, where a lower number indicates better conditions. There were only 7 taxa present in 1980 as compared to 13 in 1989. In addition several more sensitive organisms such as mayflies, stoneflies and caddisflies are present now that were absent in 1980.

Station 4 is actually under the most stress from a biological standpoint. It is completely devoid of mayflies and stoneflies and contains only one hardy caddisfly species. The total number of species is the lowest and it exhibits a high CTQa number (Table 3).

The stations labeled 5 and 6 are quite similar biologically as related to the macroinvertebrate fauna. They contain mayfly and stonefly species as well as more total taxa. The data indicate that definite improvement in habitat quality has already occurred.

Station 7 again shows the signs of negative environmental impacts. Something must be happening in the coal processing area that causes the stream habitat to be degraded. Mayflies are absent and the numbers of other sensitive taxa are reduced. However, two stonefly species were emerging so conditions were at least adequate for these sensitive insects. Conditions overall were much better in this area in 1989 than they were in 1980 (Table 6).

Conclusions

Grassy Trail Creek has historically been impacted by mining and other man-caused practices. Consequently it was listed by the Division of Wildlife Resources in 1980 as a Limited Value Habitat Area: Rating 15, Class 4. Even the upstream portion is impacted by the reservoir and the many beaver dams, which limit the yearly spates that could clean the silt out of the system. Some silt is removed temporarily by the beaver dams but it is reintroduced when the dams decay. However, in 1981 the creek was reclassified as Class 3, unique, because a population of reproducing rainbow trout was found.

Winget (1980) reported on the aquatic resources of Grassy Trail Creek and gave indications to the biological health of the creek based on the composition of the macroinvertebrate fauna. He found that the creek was severely impacted from station GTCAP downstream to GTC05 in April 1980. Our May 1989 data indicate that the creek at stations UPGTC and GTCAP is in good condition. The evidence of stress begins at GTC03 and is most pronounced at GTCRG and GTC05. However, it does not show signs of stress in 1989 that are as severe as those recorded in 1980. Even at Station 4 (GTCRG), which is most heavily impacted the number of taxa present is higher and the CTQa is lower in 1989 (Table 6).

The condition of Grassy Trail Creek in 1989 is not difficult to evaluate. Chemical analysis of both water and silt do not show any major increases except for oil and grease levels, especially in the bottom sediments (Tables 4 & 5). Stations 1 and 2 above the outflow pipe are only slightly stressed. Station 3, which is just below the outflow pipe, shows signs of stress but not as much as the lower stations because of the input from downstream drift. Station 4 is in poor condition and exhibits a high CTQa and a low number of species present. Sensitive taxa such as mayflies and stoneflies are completely absent probably because the man made filter structures are interfering with the drift process. Stations 5 and 6 already show signs of improvement to the level of Station 3. They contain several more sensitive organisms and their CTQa values have dropped. Station 7 again shows the signs of environmental stress with an increase in its CTQa value.

Grassy Trail Creek is a marginal creek, as evidenced by the kinds and numbers of macroinvertebrates present. It has been stressed for many years and the species that are present are resiliant and rebound quickly. The number of more sensitive organisms is small and they are easily killed but they are quickly reintroduced by organisms drifting down from above. This shows that the sources of pollution can have an immediate negative effect, such as oil that can clog the gills of mayflies. However, long term chemical pollution does not seem to be such a problem (Table 4). The major impact problem is oil and grease, which is present at all stations but is highest below the outflow pipe at Station GTC03 (Table 5). Even though Grassy Trail Creek is not large in terms of flow, it recovers quickly from the addition of the above mentioned physical-chemical pollutants.

Since fish were killed in Grassy Trail Creek in March 1989, it follows that some of the macroinvertebrates were also killed. Two months later, the total benthic fauna is already becoming reestablished. If the sludge pond can be cleaned up and the quality of the mine effluent improved there is no reason why the quality of the macroinvertebrate fauna should not continue to improve.

It would be helpful if the silt and silt/oil emulsion layers could be removed from the creek between Stations 3 and 5. The problem is that when these multiple colored layers are disturbed an impact will be caused that will probably kill most of the invertebrates that have become reestablished. Actually the filter structures should be removed and the creek bed flushed with clean water at a time when the invertebrate and fish populations are least susceptible. The best time would probably be in the fall. However, a sudden influx of water from the reservoir would probably break the beaver dams and add an additional heavy silt load to the creek.

The best solution seems to be to remove the filter structures from the creek, clean up the pond and maintain an adequate flow of water in the creek throughout the year. This will enable the natural watershed to cleanse itself downstream and make it possible for more sensitive organisms from upstream to become reestablished. To test the results of this solution a series of macroinvertebrate samples should be taken at the same stions in April or May 1990.

Literature Cited

Baumann, R. W., A. R. Gaufin, and R. F. Surdick. 1977. The stoneflies (Plecoptera) of the Rocky Mountains. Mem. Amer. Ent. Soc. 31:208 pp.

Edmunds, G.F., Jr., S. L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. of Minnesota Press, 330 pp.

Gaufin, A. R., A. V. Nebeker and J. Sessions. 1966. The stoneflies (Plecoptera) of Utah. Univ. Utah Biol. Ser. 14:93 pp.

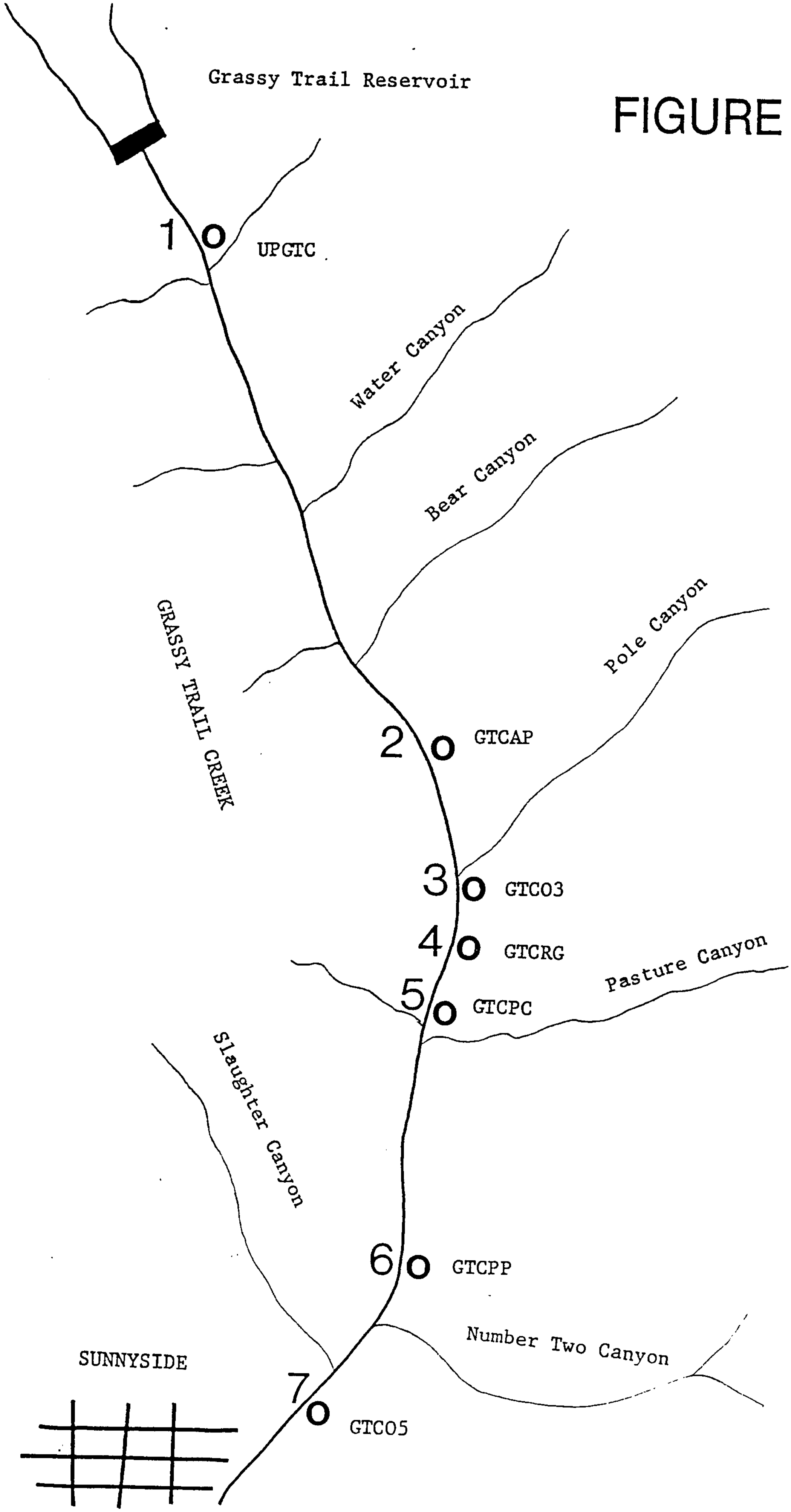
Merritt, R. W. and K. W. Cummins. 1984. An introduction to the aquatic insects of North America. Kendall/Hunt, 722 pp.

Wiggins, G. W. 1977. Larvae of the North American caddisfly genera. Univ. of Toronto Press, 401 pp.

Winget, R.N. 1980. Aquatic resource analysis of Grassy Trail Creek, Carbon County, Utah. Report prepared for Kaiser Steel Corporation, 27 pp.

Winget, R. N. and F. A. Mangum. 1979. Biotic Condition Index: Integrated biological, physical, and chemical stream parameters for management. Aquatic ecosystem inventory: macroinvertebrate analysis, U.S. Forest Ser., Intermountain Region, 51 pp.

FIGURE 1



Grassy Trail Reservoir
1
UPGTC
Water Canyon
Bear Canyon
GRASSY TRAIL CREEK
Pole Canyon
2
GTCAP
3
GTC03
4
GTCRG
5
GTCPC
Pasture Canyon
Slaughter Canyon
6
GTCPP
Number Two Canyon
SUNNYSIDE
7
GTC05

Table 1. List of macroinvertebrates collected May 5, 1989 from Grassy Trail Creek, Carbon County, Utah (Qualitative and Quantitative).

Organism	Habitat	Trophic Level*	Stations: (x = present) 1	2	3	4	5	6	7
Ephemeroptera (Mayflies)									
Epeorus	clinger	Scr	x	x					
Cinygmula	clinger	Scr		x					
Rhithrogena	clinger	Scr		x				x	
Drunella doddsi	sprawler/swimmer	C-G		x					
Drunella grandis	sprawler/swimmer	C-G	x	x	x		x	x	
Baetis	clinger/swimmer	Scr	x	x	x		x	x	
Plecoptera (Stoneflies)									
Capnia confusa	clinger	C-G	x						
Capnia gracilaria	clinger	C-G	x						
Prostoia besametsa	clinger	C-G	x	x					
Zapada cinctipes	clinger	Shr		x					
Isoperla quinquepunctata	clinger	Pred	x	x	x		x	x	x
Isogenoides zionensis	clinger	Pred	x	x					x
Trichoptera (Caddisflies)									
Hydropsyche	clinger/net spinner	C-F	x	x	x	x	x	x	x
Hesperophylax	clinger/case maker	Shr			x				
Psychoglypha	clinger/case maker	Shr	x						
Rhyacophila	clinger	Pred	x	x	x				
Lepidostoma	clinger/case maker	Scr	x						
Coleoptera (Beetles)									
Elmidae	clinger/climber	Scr	x	x	x	x	x	x	x
Agabus	swimmer	Pred							x

Table 1. (Continued)

Organism	Habitat	Trophic Level	Stations: (x = present) 1	2	3	4	5	6	7
Odonata (Damselflies)									
Argia	sprawler/swimmer	Pred			x	x		x	
Diptera (Flies)									
Hexatoma	burrower	Shr		x	x	x	x	x	x
Tipula	burrower	Shr	x		x	x	x	x	
Simuliidae	clinger	C-F		x	x				
Chironomidae	burrower/tube maker	C-G	x	x	x	x	x	x	x
Ceratopogonidae	sprawler/burrower	Pred		x		x		x	x
Empididae	sprawler/burrower	Pred	x	x	x	x	x	x	x
Atherix pachypus	sprawler/burrower	Pred	x						
Stratiomyidae	sprawler/burrower	Pred		x					
Gastropoda (Snails)	clinger/crawler	Scr	x						
Hydracarina (Mites)	clinger	Pred		x	x	x	x	x	x

* C-F = collector-filterers
C-G = collector-gatherers
Scr = scrapers
Shr = shredders
Pred = predators

Table 2. Number of aquatic macroinvertebrates per square meter collected May 5, 1989 from Grassy Trail Creek, Carbon County, Utah.

Organism	Tolerance Quotient	Stations 1	2	3	4	5	6	7
Ephemeroptera (Mayflies)								
Epeorus	21	153	35					
Cinygmula	21		191					
Rhithrogena	21		40				3	
Drunella doddsi	4	11	13					
Drunella grandis	24	11	277	8		11	8	
Baetis	72	7653	654	339		11	8	
Plecoptera (Stoneflies)								
Zapada cinctipes	16		32					
Isoperla quinquepuncta	48	831	401	40		5	8	19
Isogenoides zionensis	24	5	5					5
Trichoptera (Caddisflies)								
Hydropsyche	108	159	344	40	339	565	299	164
Rhyacophila	18	40	56	3				
Lepidostoma	18	22						
Coleoptera (Beetles)								
Elmidae	108	48	1716	414	94	247	13	43
Odonata (Damselflies)								
Argia	108			3	5		3	
Diptera (Flies)								
Hexatoma	72		40	8	13	27	3	5
Tipula	72	113		18	30	32	27	
Simuliidae	108		129	3				
Chironomidae	108	3586	3677	979	3250	7594	2351	1423
Ceratopogonidae	108		5		27		67	250
Empididae	108	35	126	3	207	129	113	220
Muscidae	108	11						

Table 2. (Continued)

Organism	Tolerance Quotient	Stations 1	2	3	4	5	6	7
Atherix pachypus	24	5						
Stratiomyidae	108		3					
Gastropoda (Snails)	108	43						
Hydracarina (Mites)	108		43	8	16	22	22	19

Table 3. Results of aquatic macroinvertebrate analysis from Grassy Trail Creek, Carbon County, Utah, May 5, 1989.

Parameter	Stations 1	2	3	4	5	6	7
Total number of species	15	19	13	9	10	13	10
Mean number/square meter	12721	7790	1867	3987	8648	2924	2125
Standard Deviation	8203	1289	1740	810	4528	867	1036
Dry weight--gm/square meter	3.6	2.0	1.8	6.1	10.8	4.2	1.5
Dominance Community TQ=CTQd	69	65	80	93	86	86	101
Shannon-Weaver Index = $\bar{d}$	1.6	2.5	1.9	1.1	.8	1.1	1.6
Average Community TQ=CTQa	66	61	74	89	76	74	84

CTQa	Scale
below 60	Excellent
60-70	Good
70-80	Fair
above 80	Poor

Table 4. Water analysis data for Grassy Trail Creek, Carbon County, Utah on May 5, 1989 (Chemtech, Murray, Utah).

Parameter	1 UPGTC	2 GTCAP	3 GTC03	4 GTCRG	5 GTCPC	6 GTCPP	7 GTC05
Bicarbonate as HCO_3, mg/l	294	281	355	418	402	377	377
Carbonate as CO_3, mg/l	0	0	0	0	0	0	0
Calcium as Ca, mg/l	40.1	35.2	43.2	39.9	34.1	27.1	24.1
Magnesium as Mg, mg/l	35.8	39.2	27.4	25.8	24.2	21.1	10.4
Potassium as K, mg/l	1.4	2.1	2.6	3.9	3.9	5.2	8.6
Sodium as Na, mg/l	26.5	46.2	130	210	224	229	222
Chloride as Cl, mg/l	11.8	10.4	15.5	26.1	27.7	25.9	25.9
Sulfate as SO_4, mg/l	56.0	110	184	286	286	288	228
TDS, mg/l	434	388	689	952	928	952	957
TSS, mg/l	<1	4.0	2.5	6.4	3.6	1.2	1.2
Settleable Solids, ml/l	$<.1$	$<.1$	$<.1$	$<.1$	$<.1$	$<.1$	$<.1$
Hardness as $CaCO_3$, mg/l	3.32	282	457	355	331	327	316
Oil & Grease, mg/l	3.29	4.47	2.00	3.44	6.40	2.58	4.00
Iron as Fe (T), mg/l	0.530	0.258	0.163	0.093	0.145	0.158	0.020
Magnanese as Mn (T), mg/l	0.015	$<.01$	0.048	0.103	$<.01$	$<.01$	$<.01$
Cation, meg/l	6.14	10.1	7.04	13.3	13.5	13.2	11.9
Anion, meg/l	6.32	10.1	7.19	13.5	13.3	12.9	11.4

Table 5. Sediment analysis data for Grsssy Trail Creek, Carbon County, Utah on May 5, 1989 (Commercial Testing and Engineering, Huntington, Utah).

Element	1 UPGTC	2 GTCAP	3 GTC03	4 GTCRG	5 GTCPC	6 GTCPP	7 GTC05
Arsenic	2 ppb	2 ppb	2 ppb	5 ppb	2 ppb	4 ppb	4 ppb
Barium	131 ppm	305 ppm	141 ppm	107 ppm	63 ppm	40 ppm	39 ppm
Boron	0.04 ppm	0.05 ppm	0.45 ppm	0.09 ppm	0.17 ppm	0.15 ppm	0.24 ppm
Cadmium	<2 ppm	<2 ppm	<2 ppm	<2 ppm	<2 ppm	<2 ppm	<2 ppm
Calcium	2.98 %	5.77 %	2.76 %	5.32 %	6.07 %	5.27 %	4.63 %
Chloride	1.2 ppm	0.7 ppm	3.5 ppm	0.2 ppm	0.4 ppm	0.4 ppm	4.4 ppm
Chromium	62 ppm	47 ppm	31 ppm	<5 ppm	19.4 ppm	51 ppm	40 ppm
Copper	<5 ppm	23 ppm	16 ppm	14 ppm	9 ppm	35 ppm	15 ppm
Flouride	0.7 ppm	1.1 ppm	0.7 ppm	0.8 ppm	1.1 ppm	0.7 ppm	0.5 ppm
Iron	1.10 %	1.6 %	0.60 %	0.55 %	0.31 %	0.54 %	0.47 %
Lead	<10 ppm	<10 ppm	<10 ppm	<10 ppm	<10 ppm	<10 ppm	<10 ppm
Magnesium	0.56 %	0.86 %	0.28 %	0.35 %	0.28 %	0.34 %	0.40 %
Manganese	502 ppm	378 ppm	133 ppm	241 ppm	210 ppm	152 ppm	129 ppm
Mercury	<2 ppb	<2 ppb	<2 ppb	<2 ppb	<2 ppb	<2 ppb	<2 ppb
Nickel	<10 ppm	<10 ppm	<10 ppm	<20 ppm	<10 ppm	<10 ppm	<10 ppm
Potassium	0.76 %	0.99 %	0.50 %	0.37 %	0.22 %	0.35 %	0.40 %
Selenium	2 ppb	<2 ppb	5 ppb	7 ppb	22 ppb	5 ppb	35 ppb
Silica	17.36 %	21.5 %	13.33 %	8.33 %	10.5 %	9.55 %	8.33 %
Silver	<5 ppm	<5 ppm	<5 ppm	<10 ppm	<5 ppm	<5 ppm	<5 ppm
Sodium	1.06 %	1.16 %	0.47 %	0.40 %	0.20 %	0.34 %	0.22 %
Sulfate	0.26 %	0.43 %	0.40 %	0.46 %	0.74 %	0.50 %	0.51 %
Zinc	<5 ppm	30 ppm	<5 ppm	<7 ppm	<5 ppm	<5 ppm	<5 ppm
Oil and Grease	49 ppm	52 ppm	1321 ppm	275 ppm	486 ppm	395 ppm	778 ppm

**See attached Lab Sheets Units were reported in ppm but are actually in units of ppb

Table 6. Comparison of macroinvertebrate community data between April 1980 and May 1989 in Grassy Trail Creek, Carbon County, Utah.

Parameter	1980 1 UPGTC	1980 2 GTCAP	1980 3 GTC03	1980 7 GTC05	1989 1 UPGTC	1989 2 GTCAP	1989 3 GTC03	1989 7 GTC05
No. of taxa	20	13	7	9	15	19	13	10
Mean No./m^2	9934	3110	3260	4250	12721	7790	1867	2125
Mean dry wt, gm/m^2	2.4	2.2	.69	3.6	3.6	2.0	1.8	1.5
Shannon/Weaver = $\bar{d}$	2.4	2.1	1.5	1.1	1.6	2.5	1.9	1.6
CTQa	68	91	97	100	66	61	74	84

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300

SINCE 1908

Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

24 Oct 1989

RECEIVED OCT 26 1989

Carl Housekeeper
SRS, Inc.
P.O. Box 99
Sunnyside, UT 84539

Dear Carl,

I am enclosing amended copies of the sediment sample results that we performed for your company last May. Apparently, we made a mistake on some of the units when we originally reported these to you by using "ppm" on some tests instead of "ppb". The only tests that were affected were the metals determined by atomic absorption - barium, cadmium, chromium, copper, lead, manganese, nickel, silver, and zinc. When these tests are run on the AA, the results are generated in mg/l (except arsenic, selenium, and mercury which are run in micrograms). However, we made an error in transcribing the results somewhere in the stage of changing the results from milligrams to micrograms so that the sheets still carried the milligram designation when they were ready to be typed.

We apologize for the error and any inconvenience it may have caused you. We should have caught the error earlier as the high detection limits on the undetected elements such as lead was one recognizable indication of the problem

We thank you again for your business and hope to serve you better in the future.

Respectfully submitted,

[illegible]

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300

SINCE 1908

Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

SUNNYSIDE RECLAMATION
P.O. Box 99
Sunnyside, UT 84539

Oct. 24, 1989

Sample identification by SRS

UPGTC
May 5 12:30 pm
(amended copy - units corrected)

Kind of sample reported to us: Soil/sludge

Sample taken at: SRS

Sample taken by: SRS

Date sampled: May 5, 1989

Date received: May 6, 1989

Analysis report no. 59-9634

SOIL ANALYSIS

Arsenic	2	ppb	Magnesium	0.56	%
Barium	131	ppb	Manganese	502	ppb
Boron	40	ppb	Mercury	<2	ppb
Cadmium	<2	ppb	Nickel	<10	ppb
Calcium	2.98	%	Potassium	0.76	%
Chloride	1.2	ppm	Selenium	2	ppb
Chromium	62	ppb	Silica	17.36	%
Copper	<5	ppb	Silver	<5	ppb
Fluoride	0.7	ppm	Sodium	1.06	%
Iron	1.10	%	Sulfate	0.01	%
Lead	<10	ppb	Zinc	<5	ppb

Oil and grease 49 ppm

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

464

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300

SINCE 1908

Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

SUNNYSIDE RECLAMATION
P.O. Box 99
Sunnyside, UT 84539

Oct. 24, 1989

Sample identification by
SRS

GTCAP
May 5 2:12 pm
(amended copy - units corrected)

Kind of sample reported to us: Soil/sludge

Sample taken at: SRS

Sample taken by: SRS

Date sampled: May 5, 1989

Date received: May 6, 1989

Analysis report no. 59-9629

SOIL ANALYSIS

Arsenic	2 ppb	Magnesium	0.86 %
Barium	305 ppb	Manganese	378 ppb
Boron	50 ppb	Mercury	<2 ppb
Cadmium	<2 ppb	Nickel	<10 ppb
Calcium	5.77 %	Potassium	0.99 %
Chloride	0.7 ppm	Selenium	<2 ppb
Chromium	47 ppb	Silica	21.5 %
Copper	23 ppb	Silver	<5 ppb
Fluoride	1.1 ppm	Sodium	1.16 %
Iron	1.6 %	Sulfate	0.01 %
Lead	<10 ppb	Zinc	30 ppb

Oil and grease 52 ppm

RECEIVED
OCT 26 1989

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

[signature]

Manager, Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300
SINCE 1908
Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

SUNNYSIDE RECLAMATION
P.O. Box 99
Sunnyside, UT 84539

Oct. 24, 1989

Sample identification by
SRS

Kind of sample reported to us: Soil/sludge

Sample taken at: SRS

Sample taken by: SRS

Date sampled: May 5, 1989

Date received: May 6, 1989

GTC-03
May 5 3:15 pm
(amended copy - units corrected)

Analysis report no. 59-9632

SOIL ANALYSIS

Arsenic	2 ppb	Magnesium	0.28 %
Barium	141 ppb	Manganese	133 ppb
Boron	450 ppb	Mercury	<2 ppb
Cadmium	<2 ppb	Nickel	<10 ppb
Calcium	2.76 %	Potassium	0.50 %
Chloride	3.5 ppm	Selenium	5 ppb
Chromium	31 ppb	Silica	13.33 %
Copper	16 ppb	Silver	<5 ppb
Fluoride	0.7 ppm	Sodium	0.47 %
Iron	0.60 %	Sulfate	0.01 %
Lead	<10 ppb	Zinc	<5 ppb

Oil and grease 1321 ppm

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300
SINCE 1908
Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

SUNNYSIDE RECLAMATION
P.O. Box 99
Sunnyside, UT 84539

Oct. 24, 1989

Sample identification by
SRS

GTC-RG
May 5 4:37 pm
(amended copy - units corrected)

Kind of sample reported to us	Soil/sludge
Sample taken at	SRS
Sample taken by	SRS
Date sampled	May 5, 1989
Date received	May 6, 1989

Analysis report no. 59-9630

SOIL ANALYSIS

Arsenic	5 ppb	Magnesium	0.35 %
Barium	107 ppb	Manganese	241 ppb
Boron	90 ppb	Mercury	<2 ppb
Cadmium	<2 ppb	Nickel	<20 ppb
Calcium	5.32 %	Potassium	0.37 %
Chloride	0.2 ppm	Selenium	7 ppb
Chromium	<5 ppb	Silica	6.33 %
Copper	14 ppb	Silver	<10 ppb
Fluoride	0.8 ppm	Sodium	0.40 %
Iron	0.55 %	Sulfate	0.01 %
Lead	<10 ppb	Zinc	7 ppb

Oil and grease 275 ppm

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300
SINCE 1908
Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

SUNNYSIDE RECLAMATION
P.O. Box 99
Sunnyside, UT 84539

Oct. 24, 1989

Sample identification by SRS

Kind of sample reported to us: Soil/sludge

Sample taken at: SRS

Sample taken by: SRS

Date sampled: May 5, 1989

Date received: May 6, 1989

GTCPC
May 5 4:26 pm
(amended copy - units corrected)

Analysis report no. 59-9628

SOIL ANALYSIS

Arsenic	2 ppb	Magnesium	0.28 %
Barium	63 ppb	Manganese	210 ppb
Boron	170 ppb	Mercury	<2 ppb
Cadmium	<2 ppb	Nickel	<10 ppb
Calcium	6.07 %	Potassium	0.22 %
Chloride	0.4 ppm	Selenium	22 ppb
Chromium	19.4 ppb	Silica	10.5 %
Copper	9 ppb	Silver	<5 ppb
Fluoride	1.1 ppm	Sodium	0.20 %
Iron	0.31 %	Sulfate	0.01 %
Lead	<10 ppb	Zinc	<5 ppb

Oil and grease 486 ppm

RECEIVED
OCT 26 1989

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

464

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300
SINCE 1908
Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

SUNNYSIDE RECLAMATION
P.O. Box 99
Sunnyside, UT 84539

Oct. 24, 1989

Sample identification by SRS

GTC-PP
May 5 5:24 pm
(amended copy - units corrected)

Kind of sample reported to us: Soil/sludge

Sample taken at: SRS

Sample taken by: SRS

Date sampled: May 5, 1989

Date received: May 6, 1989

Analysis report no. 59-9633

SOIL ANALYSIS

Arsenic	4 ppb	Magnesium	0.34 %
Barium	40 ppb	Manganese	152 ppb
Boron	150 ppb	Mercury	<2 ppb
Cadmium	<2 ppb	Nickel	<10 ppb
Calcium	5.27 %	Potassium	0.35 %
Chloride	0.4 ppm	Selenium	5 ppb
Chromium	51 ppb	Silica	9.55 %
Copper	35 ppb	Silver	<5 ppb
Fluoride	0.7 ppm	Sodium	0.34 %
Iron	0.54 %	Sulfate	0.01 %
Lead	<10 ppb	Zinc	<5 ppb

Oil and grease 395 ppm

RECEIVED
OCT 26 1989

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300

SINCE 1908

Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

SUNNYSIDE RECLAMATION
P.O. Box 99
Sunnyside, UT 84539

Oct. 24, 1989

Sample identification by
SRS

GTC-05
May 5 5:27 pm
(amended copy - units corrected)

Kind of sample reported to us	Soil/sludge
Sample taken at	SRS
Sample taken by	SRS
Date sampled	May 5, 1989
Date received	May 6, 1989

Analysis report no. 59-9631

SOIL ANALYSIS

Arsenic	4 ppb	Magnesium	0.40 %
Barium	39 ppb	Manganese	129 ppb
Boron	240 ppb	Mercury	<2 ppb
Cadmium	<2 ppb	Nickel	<10 ppb
Calcium	4.63 %	Potassium	0.31 %
Chloride	4.4 ppm	Selenium	35 ppb
Chromium	40 ppb	Silica	8.33 %
Copper	15 ppb	Silver	<5 ppb
Fluoride	0.5 ppm	Sodium	0.22 %
Iron	0.47 %	Sulfate	0.01 %
Lead	<10 ppb	Zinc	<5 ppb

Oil and grease 776 ppm

RECEIVED
OCT 26 1989

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

[signature]

Manager, Huntington Laboratory