0008

KAISER STEEL

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

To: ~~Jim~~
To Steve

JIM
DEC 10 1982
Then File
ACT/007/007

2 December 1982

Mr Ronald Daniels, Dep Dir.
DIV. OF OIL, GAS & MINING
4241 State Office Bldg.
Salt Lake City, Utah, 84114

re:'82 Veg Test Plot Results
Stip5-81-4 of 1-28-82 Bd Order
Sunnyside Mines
ACT/007/007 #3

Dear Ron,

Please find enclosed the 1982 results from our revegetation test plot, which was done by Ms Marcia Wolfe in August '82. This completes the requirements of Stipulation 5-81-4 per the Board's 1-28-82/5-12-81 Order relative to the Special One Year Coarse Refuse Use Study. May we secure the Divisions written response in concurring that the Special Use Study is completed and finalized. There may be areas the Division would like to see pursued, but let's handle those items separately.

To clarify any questions that may still exist concerning the "formal" vegetation test plot we submit the following:

1. The test plot will remain as is presently for at least a 5yr period.
2. SCS, or other entity, will NOT be constructing an auxillary or additional test plot.
3. Small ditches have been constructed in the opposite direction per L. Kunzler's suggestion.
4. Kaiser Steel Corp does not intend to remove the existing test plot, but may alter the layout, construction, plant species, &/or seeding from time-to-time. (the Div will be notified prior to any changes.)

Hopefully this satisfies the Board's Stipulations and the Divisions concerns.

Sincerely,

John S. Huefner

John S. Huefner, PE
Civil Engineer

RECEIVED
DEC 03 1982
DIVISION OF
OIL, GAS & MINING

Enclosure

cc: Denise Dragoo

1982

S T U D Y   R E P O R T

Revegetation Test Plot

by: Marcia J. Wolfe
Reclamation Engineer

OBJECTIVE

To determine establishment of selected plant species on Coarse coal refuse, coal slurry, Mancos shale, topsoil over refuse, topsoil over slurry, and topsoil alone as a control.

MATERIALS AND METHODS

The plots are situated in a valley bottom adjacent to Grassy Trail Creek and has a slope ranging from 0 - 1%. A 42' x 40' area was excavated in 1980 with a front-end loader to a depth of two feet. The following eight plant growth media were installed:

1. 24" coarse refuse
2. 24" slurry
3. 24" Mancos shale
4. 2" topsoil over 22" of coarse refuse
5. 6" topsoil over 18" of coarse refuse
6. 2" topsoil over 22" of slurry
7. 6" topsoil over 18" of slurry
8. 24" of topsoil

Plant species and seeding rates used are listed in Table 1. These species were recommended by Mary Ann Wright, Utah Division of Oil, Gas & Mining. The plot arrangement is presented in Fig. 1. Seeded species were planted in furrows and lightly raked to cover. Containerized stock was planted in offset rows. All planting was performed on 14 May 1980. Furrow irrigation was applied during the 1980 summer at a rate of one inch of water per week until late August. No fertilization and no further irrigation were applied. The plot was fenced with a six foot chain-link fence.

Vegetation sampling was conducted annually for two years on 21 June 1981, and 11 August 1982. Line intercept was used to measure ground cover of each species along a 2.5m transect. A buffer zone was maintained to minimize edge effects between plots. Vigor was qualitatively evaluated on a 0-5 scale (Table 2).

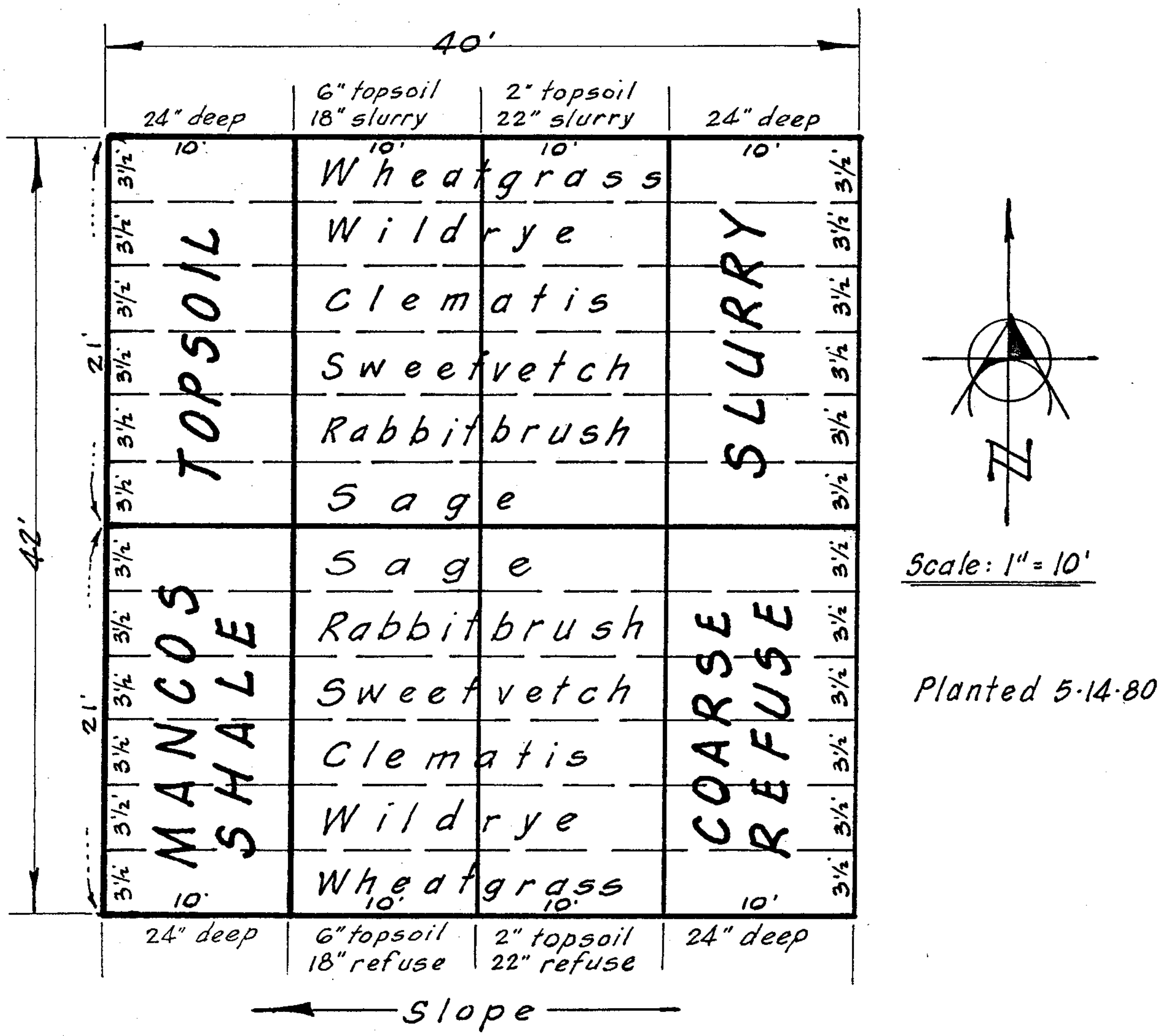
Table 1. Plant Species Used in Sunnyside Mines Revegetation Test Plot.*

Common Name	Scientific Name	Abrev.	Amounts Planted
Streambank Wheatgrass	*Agropyron riparium*	Agri	4 PLS#/A
Salina Wildrye	*Elymus salina*	Elsa	3 "
Western Clematis	*Clematis ligusticifolia*	Clli	2 "
Utah Sweetvetch	*Hedysarum boreale*	Hebo	2 PLS#/A
Rubber Rabbitbrush	*Chrysothamus nauseosus*	Chna	45 plants
Prairie Sage	*Artemisia ludoviciana*	Arlu	45 plants

* All plant material from Native Plants, Salt Lake City, Utah

Table 2. Scale of Plant Vigor

rating	description
0	dead or not present
1	dying
2	poor
3	fair
4	good
5	excellent growth



Layout of the
Revegetation Test Plot

Figure 1.

Sunnyside Mine

In August 1982, soil samples were taken of the slurry, coarse refuse and Mancos shale treatments, from both the surface layer and a 6" depth. The samples were sent to the Colorado State University Soils Laboratory for chemical analysis. Additional samples were taken from all refuse plots in November, 1982, to verify earlier results and expand data from refuse material.

RESULTS

Generally, plant growth on all treatments, except coarse refuse, was satisfactory (Figure 2 & Figure 3).

SPECIES VIGOR

As in 1981, streambank wheatgrass and Louisiana Sage maintained the most vigorous performance across all treatments (Table 3). Salina wildrye performed fairly to satisfactorily on all treatments except slurry. Clematis failed to emerge in any treatment. Neither sweetvetch nor rubber rabbitbrush became established on coarse refuse or on refuse covered with 2" of topsoil. However, they performed fairly vigorously on all other treatments.

The vigor values for all species were the lowest on the three coarse refuse treatments. Two inches of topsoil on refuse did not improve vigor. However, growth of established plants was slightly increased on plots with 6" of topsoil over coarse refuse. Vigors were highest on the topsoil control and Mancos shale. Plant growth on the slurry treatment was improved with the addition of any amount of topsoil.

Compared to 1981 (Table 4), vigors as measured in 1982 were essentially the same, with the exception of some erratic changes by sweetvetch. Sweetvetch became established for the first time in slurry. Vigor values for sweetvetch dropped on all other treatments except with 24" of topsoil on which vigor improved slightly.

PLANT COVER

Total average plant cover of trial species did not change significantly between 1981 and 1982, with the exception of a decrease in cover on coarse refuse (Figure 4). A small decrease in cover on the 2" topsoil over refuse treatment was also deduced[1].

With the exception of good plant cover on the 6" soil over refuse by Louisianna sage, cover of test species was low on all coarse refuse treatments (Table 5). Although several of the sage plants have died, the survivors are spreading rhizomatously.

Cover of surviving test species was good on topsoil, with the exception of sweetvetch. Rabbitbrush, streambank wheatgrass and Louisiana sage had the greatest cover on both shale and 24" topsoil. As stated before, clematis did not become established on any treatment

Average cover of all species, both test and invaded, ranged from 21% to 30% across all treatments, except the coarse refuse plots (Table 6). Total plant cover on each of the latter plots was less than 13% (refuse).

SOILS

Results of some chemical analysis of four plot materials are shown in Table 7. The coarse refuse exhibited an unexpected low pH (average of 6.2) with corresponding high values for iron, manganese and copper. The other three materials had a low basic pH (7.4 to 8.2). Slurry was high in sodium at the 6" depth (16.6 mg/l).

DISCUSSION

The revegetation test plot at the Sunnyside Mine demonstrates the potential of selected trial species to become established on various media with establishment irrigation, and without the addition of soil ammendments. Streambank wheatgrass and Louisiana sage had the best vigor across all treatments. These are native species. Streambank wheatgrass is adapted to moderately alkaline, sandy to clay textured soils (Thornberg 1981). Louisiana sage is

1. See footnote on Table 4.

Figure 2. Treatments on far side of pipe illustrate good plant growth. Left to right: 24" topsoil, 6" soil/ 18" slurry, 2" topsoil/22" slurry, and 24" slurry.

Figure 3. Coarse refuse treatments illustrate almost no plant growth. Front to back they are coarse refuse, 24", 2" topsoil/22" refuse and 6" topsoil/18" refuse. The good growth on the farthest plot is on 24" Mancos shale.

Table 3. 1982 Vigor Measurements of Species Seeded and Transplanted in Sunnyside Mines Revegetation Test Plot.+

species	treatment							
	coarse refuse	2"soil over refuse	6"soil over refuse	Mancos shale	slurry	2"soil over slurry	6"soil over slurry	topsoil
Agri	3	2	2	2	3	3	5	3
Elsa	2	2	1	0	3	2	4	4
Clli	0	0	0	0	0	0	0	0
Hebo	0	0	2	3	3	3	3	3
Chna	0	0	2	3	4	4	5	2
Arlu	2	1	2	3	4	4	3	5

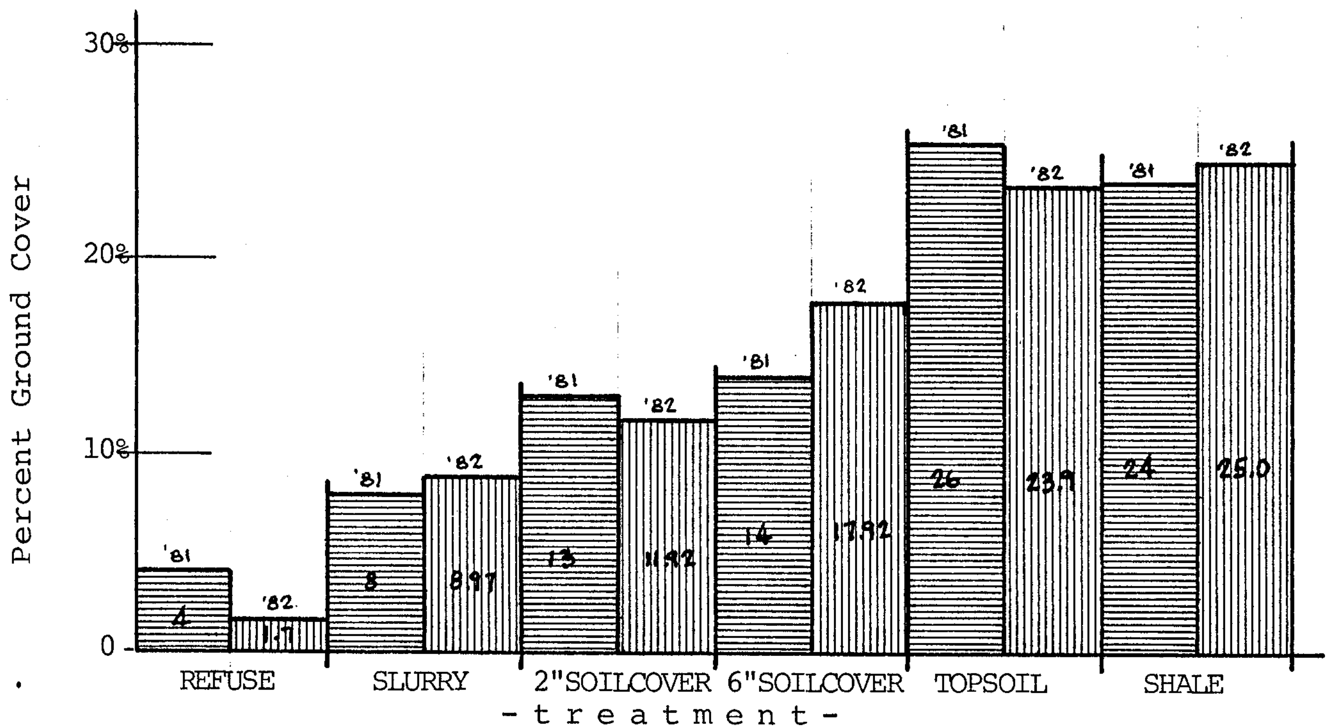
+ See Table 1 for complete names of abbreviations.

Table 4. Comparison of 1981 and 1982 Vigor Measurements

species	coarse refuse 81	coarse refuse 82	slurry 81	slurry 82	Mancos shale 81	Mancos shale 82	2" topsoil 81	2" topsoil 82	6" topsoil 81	6" topsoil 82	24" topsoil 81	24" topsoil 82
Agri	3	3	3	2	3	3	3	2.5	2	2.5	5	5
Elsa	1	2	0	0	3	4	2	2.5	1.5	1.5	4	4
Clli	0	0	0	0	0	0	0	0	0	0	0	0
Hebo	0	0	0	3	4	3	4	1.5	4	2.5	2.5	3
Chna	0	0	4	3	2	2	2	2	3	3	4	5
Arlu	2	2	3	3	5	5	3.5	2.5	2	3	3	3

Note: Data from topsoil over slurry and topsoil over refuse combined as evaluated in 1981. Averaging these two treatments masks the results of the coarse refuse treatment; however, field data for 1981 is lost and figures cannot be separated

Figure 4.



(note: topsoil over refuse & topsoil over slurry
average figures combined together.)

1981 1982

Figure 4. Percent Ground Cover of Trial Species as determined by line intercept.

a highly complex species which has been divided into 7 subdivisions by Keck. It apparently has quite a wide ecologic amplitude. It was the only trial species which did well on one of the coarse refuse treatments (Table 5). Louisiana sage was spreading vigorously in several plots by rhizomatous growth (Figure 5).

Apparent reasons for the failure of clematis to become established on any media were either poor seed (PLS was only 36%) or special germination requirements. Clematis is native to the canyons and valleys of the Sunnyside permit area and was expected to do well on the 24" topsoil treatment.

Rubber rabbitbrush did best on slurry and topsoil. These materials were higher in SAR than the other media. Rubber rabbitbrush is adapted to similar alkaline and salty soils (EPA 9175).

Salina wildrye only did well on Mancos shale and topsoil. Although it failed to establish on slurry, it should be noted that a non-seeded species, Indian ricegrass, accounted for 10 percent cover on the slurry treatment. This species is adapted to sandy loam soils (EPA 1975).

Sweetvetch performed erratically. It did not establish at all on coarse refuse without a 6" soil covering. Redente (1982) found termperatures above 30^{o}C detrimental to germination of sweetvetch. Although it can germinate at low osmotic potentials, high temperatures such as would occur on the black coarse refuse may also be limiting germination of this and other species. However, if high temperature was the primary limitation, it should have been ameliorated by the topsoil overlays. It was not.

Performance of sweetvetch on slurry was poor to excellent with topsoil covering. It did less well on 24" of topsoil perhaps because of competition from yellow sweet clover. Extra scarification of fall seeding is recommended for sweetvetch (Redente 1982), as even when adequate water is available, the hard seed coat can prevent imbibition. Therefore, spring planting may also have minimized establishment of sweetvetch.

Table 5. Percent Plant Cover of Seeded Species in 1982

species	treatment							
	coarse refuse	2"soil over refuse	6"soil over refuse	Mancos shale	slurry	2"soil over slurry	6"soil over slurry	topsoil
Agri	2.0	1.6	.8	12.8	11.2	18.8	9.2	23.2
Elsa	1.0	22	13	12.8	0	5.2	18.8	15.6
Clli	0	0	0	0	0	0	0	0
Hebo	0	0	13	5.2	3	17	24	4.8
Chna	0	0	.2	55.2	11.6	44.8	48	56
Arlu	7.2	1.2	44	64	28	32.4	44	43.6

Table 6. Average Percent Cover of Two Plant Species Groups by Treatment in 1982

species group	treatment							
	coarse refuse	2"soil over refuse	6"soil over refuse	Mancos shale	slurry	2"soil over slurry	6"soil over slurry	topsoil
6 trial species	1.7	4.13	11.83	25.0	8.97	19.7	24.0	23.9
all species	2.7	5.08	12.6	26.4	22.17	30.85	35	30.2

Table 7. Some Chemical Analysis of Slurry, Mancos Shale and Coarse Refuse.

material & sampling depth		parameter									
		pH +	cond.	meg/l Na *	SAR *	lime	ppm Zn #	ppm Fe #	ppm Mn #	ppm Cu #	texture @
Coarse Refuse	2"	6.6	3.6	.3	.1	med	7.0	156.0	28.9	2.1	S
	6"	5.8	3.4	.2	.1	lo	10.3	273	22.5	2.7	S
slurry	1"	7.5	2.7	.5	.2	hi	1.4	15.9	5.6	1.2	LS
	6"	7.4	4.5	16.6	3.2	med	2.8	17.8	2.0	1.1	LS
Mancos shale	1"	7.5	2.7	.7	.2	hi	1.0	16.9	2.1	.9	SCL
	6"	7.9	3.8	4.8	.9	hi	.9	7.0	.3	.6	SCL
topsoil		8.2	1.9	2.6	1.6						CL

\+ saturated paste
* saturated extract (Na in meg/l)
\# AB-DPTA extractable (ppm)
@ estimated

Quality of vigor and establishment was reflected by the amount of plant cover exhibited by each trial species. Generally, the slurry plots, Mancos shale and topsoil demonstrated much more vigorous growth than any coarse refuse treatment. Some eleven non-seeded species have invaded these plots while only 3 species have invaded the refuse plots.

Poor response to the refuse material in all species is grossly evident (Figure 3). Additionally, cover and vigor of species previously established on refuse declined.

A soil sample was taken from the coarse refuse test plot in 1982. Contrary to the results of analysis made of refuse elsewhere in the Colorado Plateau (White et all 1982), refuse at Sunnyside had low pH in both the surface and subsurface, 6" depth, (Table 7). The surface was expected to have a lower pH than at the 6" depth. However, the surface layer had a medium quantity of lime whereas the deeper layers reflected a low quantity. As the surface layer weathered, the lime apparently raised the pH slightly. This change, however, was insufficient to improve plant establishment by the trial species.

As is common in soils of low pH, the tests indicated an increased presence of metals in the refuse. Levels of plant available iron, manganese and copper present in the refuse were usually high.

Native soils of the Sunnyside region tend to be alkaline. Therefore, germination and establishment of the native species on refuse may be adversely affected by low pH. Little information concerning toxicities to native plants is available from the literature. However, soil test research is currently underway to define such information for native plants (Berg 1978). But probability is high that the plant available levels of iron, and manganese revealed by soil analysis are toxic to the trial species. Manganese depresses growth in general (Black 1968). Soil acidity is known to inhibit root growth and concomitantly affects both uptake of water and nutrients (Black 1968).

Figure 5. Louisiana sage, an excellent reclamation species, is seen here spreading vigorously from rhizomes.

DISCUSSION $(cont_3)$

Copper toxicity of agronomic species also increases with soil acidity. Reuther et al (1953) found even spray residues of copper to be toxic to vegetation on soils of low pH.

In addition to apparent toxicity, the coarse texture and potential high temperature created by the dark color of the refuse may affect soil water retention and germination. However, micronutrient toxicities apparently overshadowed these affects, as cover of the material with topsoil only allowed small increases in plant cover. Total cover on all refuse treatments was half that on Mancos shale, topsoil or topsoil on slurry treatments.

The trial plots also reflected the potential for natural plant succession by the invasion of non-seeded species. Invading species on all coarse refuse and 24" shale treatments accounted for only a small addition of ground cover (1 percent) (Table 6). On the other hand, additional cover created by invading species in the slurry plots and 24" topsoil treatment ranged from 6% to 13 percent. Invading species which contributed considerable amounts of cover were Indian ricegrass, yellow sweetclover, bigbract verbena, scarlet globemallow, and curlycup gumweed.

CONCLUSIONS:

Plant growth on Mancos shale, topsoil and slurry were far superior to growth on any refuse treatment. Mancos shale and topsoil are two commonly occuring substrata in the Sunnyside region to which the native species are adapted.

Covering slurry with topsoil slightly improved plant cover. An increase in total cover of pioneer species which invaded the slurry plots indicated some are more adapted to the material than those species tested. Revegetation with species more specifically adapted to the physical and chemical characteristics of slurry (i. e. species more adapted to salinity and less sensitive to conductivities greater than 4 mmhos/l) would undoubtedly be as successful as use of a soil cover.

CONCLUSIONS (cont)

Generally, a topsoil cover was insufficient in treating coarse refuse. Improved growth on refuse may be obtained by liming or the use of a deeper cover of soil material. However, selection of plant species adapted to growth on low pH growth media would probably be a more economical approach. Direct seeding of acid mine spoil has been successful in the eastern United States (Pepperman et al 1980, Campion & Benner 1981). Additional study of coarse refuse to determine the physical and chemical characteristics of the material over time is necessary to better plan revegetation of this material.

Use of a high profile mulch with tackifier could be expected to improve germination and establishment on all sites in general (Wolfe 1981) and on coal refuse (Abbott 1981). Phosphorus fertilizer has also been found to increase biomass and density of native species seeded on coal refuse (Abbott 1981).

LITERATURE CITED:

Abbott, John Parsons. 1981. Revegetation of three disturbed sites in Colorado. Master thesis. Colorado State University, Fort Collins, Colorado.

Aldon, Earl F., David G. Scholl & Charles P. Pase. 1979. Establishing cool season grasses on coal mine spoils in northeastern New Mexico.

Berg, W. A. 1978. Limitations in the use of soil tests on drastically disturbed lands. In: Reclamation of drastically disturbed lands. Eds, Schaller, Frank W. & Paul Sutton, ASA, CSSA, SSSA. Madison, Wisconsin.

Campion, Peter S. A. & David K. Benner. 1981. Establishing permanent vegetation on coal refuse without a four foot layer of topsoil. In: Symposium on surface mine hydrology, sedimentology and reclamation. University of Kentucky, Lexington, Kentucky.

Pepperman, R. E., J. C. Draper & R. J. Houston. 1980. Experimental direct vegetation of a deep coal mine spoil bank in Green County, Pennsylvania. In: Proceedings of the fifth annual meeting, Canadian Land Reclamation Assn, Timmons, Ontario.

Redente, Edward F. 1982. Sweetvetch seed germination. J. range manage. 35(4):469-472.

White, Susan M., Kent Oslter & Cyrus McKell. 1982. Coal refuse - an increasingly serious problem for Colorado Plateau coal production. DOE, Division of Coal Mining. FE-24, Wahington, DC. by Plant Resources Institute, Salt Lake City, Utah.

Wolfe, Marcia Hamann. 1981. Reclamation in the mountains of Northeastern New Mexico. In: Reclamation in mountainous areas. Proceedings of the Sixth Annual meeting of the Canadian Land Reclamation Association and the fifth annual British Columbia Mine Reclamation Symposium. Cranbrook, BC. August 24-27, 1981.