Information Circular 8576

# Methods and Costs of Coal Refuse Disposal and Reclamation

By Staff, Bureau of Mines
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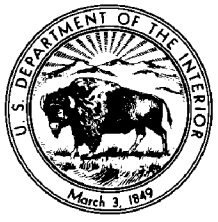


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# METHODS AND COSTS OF COAL REFUSE DISPOSAL AND RECLAMATION

by

Staff, Bureau of Mines


## ABSTRACT

The Bureau of Mines is active in programs pertaining to solid waste disposal and land reclamation. Nine reclamation projects of mining companies and six projects of the Commonwealth of Pennsylvania were investigated to provide information on the procedures, costs, and results obtained from reclamation projects of bituminous coal-waste disposal areas.

Refuse disposal costs of mining companies ranged from 9 to 28 cents per ton-mile, and quantities disposed of ranged from 600 to 4,500 tons per day. Spreading and compacting the refuse at the dump site ranged from 3 to 20 cents per ton. Cost of covering with soil and planting ranged from $750 to $1,646 per acre.

Total costs of reclamation for the Pennsylvania projects ranged from about $1,800 to more than $15,000 per acre. Refuse preparation costs ranged from $772 to $5,550 per acre. Soil covering and planting costs ranged from $1,083 to $5,086 per acre.

The best results were obtained by soil preparation and conditioning prior to planting. The type and depth of soil and effect of climate were also factors.


## INTRODUCTION

Since the passage of the Solid Waste Disposal Act of 1965 (Public Law 89-272, Title II), the Bureau of Mines has been actively engaged with problems of refuse disposal and reclamation. This report was prepared to provide the general public, private industry, and Federal and State Governments with current methods and costs of disposal and reclamation of coal mine refuse.

Coal refuse disposal and reclamation methods and costs are presented for one coal company in Kansas, three in Kentucky, one in Ohio, two in Pennsylvania, and two in West Virginia. Six reclamation projects sponsored by the Commonwealth of Pennsylvania are also included. The procedures, illustrations, and cost data were obtained from interviews with coal company and Commonwealth of Pennsylvania personnel.

Coal mine waste and refuse accumulations resulting from mining and preparation plants are increasing each year. It is estimated that over 100 million tons of refuse is produced from bituminous coal mining operations (5)[1] and nearly a billion cubic yards of coal mine wastes have despoiled the landscape in the anthracite region of Pennsylvania (2).

Every reclamation project is an individual problem. Therefore, the projects described in this report may not be identical to projects and problems that may be encountered elsewhere. Likewise, the methods and costs derived may not be the same for any other similar project. This report is intended to serve as a guide to, and to stimulate activity in, reclamation work as it applies to mine refuse piles.

This report delineates methods and costs of all operations incidental to reclamation of coal refuse and mine waste accumulations of five private companies and six State projects. Two previous Bureau of Mines publications relating to coal mine preparation plant refuse and mine waste reclamation are available (1, 4). One publication describes methods and costs of disposing of preparation plant refuse from two underground coal mines in Kentucky and Alabama; the other summarizes methods and costs of restoring surface mined land to its original contour and esthetic value at Moraine State Park, Pa.

## ACKNOWLEDGMENTS

The authors of this report acknowledge the assistance and cooperation of the coal mining companies and the Commonwealth of Pennsylvania, without whose help this report could not have been written. Special thanks are extended to those persons who arranged for access to their mining properties. The authors are also indebted to those mining company personnel for their review of the draft of the manuscript. Although a great many people contributed to the overall effort, particular recognition is given to Messrs. William Matetich and E. J. Korber, Division Superintendents, Bethlehem Mines Corp.; D. A. Zegeer, Division Superintendent, Beth-Elkhorn Corp.; H. T. Boyles, Superintendent, Eastern Associated Coal Corp.; Cecil Delloma, Vice President, Hanna Coal Co.; Frank J. Foresman, Pittsburg & Midway Coal Mining Co.; and L. Kuchinic, Jr., Manager, Administrative Services Coal Division, U.S. Steel Corp. Gratitude is expressed to A. E. Molinski, District Engineer, Department of Environmental Resources, for his sincere interest and cooperation in assembling the cost data on reclamation projects sponsored by the Commonwealth of Pennsylvania. Finally, we wish to thank Murray T. Dougherty, former employee of the Bureau of Mines, Eastern Field Operation Center.

## FACTORS AFFECTING COSTS OF DISPOSAL AND RECLAMATION

### Capital Investment

The capital investment costs shown in table 1 cover all costs to industry for refuse disposal and reclamation and includes road preparation, loading and

[1]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

transportation equipment for refuse disposal, and equipment used in soil covering and planting. Some of the equipment may have been used previously in the mining operation but, to simplify costs, the investments shown include the cost of new equipment necessary to do only reclamation work. Capital expenditures for waste disposal equipment, in most cases, are estimated on the basis of replacement costs for equipment presently in use by the companies. The size of equipment used is not always described by company information.

TABLE 1. - Capital cost of industry reclamation projects

| Company | Mine location | Mine name and type | Capital investment[1] |
|---|---|---|---|
| Bethlehem Mines Corp... | Barrackville, W. Va. | Idamay mine No. 44 (underground). | $268,000 |
| Do..... | Ellsworth, Pa..... | Mine 60[2] (underground). | 375,000 |
| Beth-Elkhorn Corp..... | Jenkins, Ky..... | Hendrix No. 22 (underground). | 50,000 |
| Do..... | .....do..... | No. 27 mine (underground). | 50,000 |
| Eastern Associated Coal Corp. | Rachel, W. Va..... | Joanne mine (underground). | [3]100,000 |
| Hanna Coal Co..... | Cadiz, Ohio..... | Georgetown Area (strip mine). | 305,000 |
| Pittsburg & Midway Coal Mining Co. | Hallowell, Kans..... | Mine 19 (strip mine). | 300,000 |
| Do..... | Madisonville, Ky.... | Colonial mine (strip mine). | 375,000 |
| U.S. Steel Corp..... | Uniontown, Pa..... | Ginger Hill (underground). | NA |

NA Not available.
[1]Includes land costs and preparation, roads, loading and transporting equipment, and planting equipment.
[2]Abandoned dumps; refuse from Mines 51 and 58 being disposed at Mine 60 dump by aerial tram.
[3]Estimate.

## Refuse Source and Disposal Sites

### Source

Coal refuse consists of waste coal, slate, carbonaceous and pyritic shales, and clay associated with a coal seam. These minerals are separated from the coal during the cleaning and preparation process.

Preparation plant refuse generally consists of fractions ranging in size up to one-quarter of an inch. The coarse waste is sent directly to the refuse dump. The fine wastes are pumped as a slurry to a settling pond where the suspended solids settle.

In 1969, over 435 million tons of raw bituminous coal were processed in cleaning plants; this resulted in more than 100 million tons of coal refuse. An average of 23 percent waste resulted from the cleaning process.

### Disposal Sites

Prior to the passage of reclamation regulations, disposal sites were selected primarily on the basis of size, commensurate with expected refuse. Currently, consideration is given to size and those topographic features that will permit the construction of a refuse disposal site that is amenable to reclamation and near the source of the waste.

In mountainous regions, valley filling with coal refuse is common practice. This method of disposal has several environmental advantages. The refuse can be layered and compacted across the valley floor where two sides are naturally sealed, and the upper and lower ends of the edges can be terraced and sealed.

Reclamation of refuse dumps on flat or level land requires more work and, therefore, tends to be more costly. More machine-time and man-hours are needed to terrace a pile on all sides, more soil is needed to cover the terraced pile, and more vegetation is needed to plant a larger surface area. A pile that is exposed on all sides tends to allow more drainage of water, more siltation to surrounding areas and streams, and more opportunity for spontaneous combustion and burning.

Active and abandoned strip mines can be used for the disposal of both slurried refuse and coarse refuse from preparation plants. Strip mine pits have a distinct advantage over other surface disposal. Refuse is covered with material from the adjacent spoil pile, which makes compacting and terracing unnecessary.

Most coal companies, with existing refuse accumulations, continue to pile refuse on top while reclaiming the edges. Generally, reclaimed piles were terraced, compacted, and covered with soil. Additional improvements may include settling ponds where acid waters may accumulate; this water will then be neutralized and released to a nearby stream.

## Refuse Disposal and Preparation

### Transportation

Transportation of coal refuse by all methods is shown in table 2. Most refuse is disposed of by trucks. Truck size, although not always mentioned in the company reports, depends upon quantity of refuse to be disposed, distances from mine to waste dump, and number of shifts worked per day.

TABLE 2. - Refuse disposal

(Industry)

| Company | Mine location | Mine name and type | Refuse produced, tons per day | Mode of transportation | Distance to disposal site (one way), miles | Refuse disposal cost/ ton/mile |
|---|---|---|---|---|---|---|
| Bethlehem Mines Corp. | Barrackville, W. Va. | Idamay mine No. 44 (underground). | 1,100 | Truck..... | 1.0 | $0.28 |
| Do..... | Ellsworth, Pa. | Mine 60[1] (underground). | 2,800 | Truck and aerial tram. | 1.0<br>.5 | .17<br>.10 |
| Beth-Elkhorn Corp.... | Jenkins, Ky... | Hendrix No. 22 (underground). | 765 | Truck..... | 1.0 | .13 |
| Do..... | .....do..... | No. 27 mine (underground). | 1,170 | Conveyor belt and truck. | 1.0 | .13 |
| Eastern Associated Coal Corp. | Rachel, W. Va. | Joanne mine (underground). | 600 | Truck..... | 1.0 | .16 |
| Hanna Coal Co..... | Cadiz, Ohio... | Georgetown Area (strip mine). | 4,164 | .....do..... | 1.0 | .25 |
| Pittsburg & Midway Coal Mining Co. | Hallowell, Kans. | Mine 19 (strip mine). | 2,400 | .....do..... | 2.0 | .10 |
| Do..... | Madisonville, Ky. | Colonial mine (strip mine). | 1,100 | .....do..... | 2.0 | .10 |
| U.S. Steel Corp..... | Uniontown, Pa. | Ginger Hill (underground). | 4,500 | Underground rail mine cars and carryall. | 4.0 | [2].09 |

[1]Abandoned dumps; refuse from Mines 51 and 58 being disposed at Mine 60 dump by aerial tram.
[2]Direct cost only.

Currently, transportation by aerial tram is used only at one mine included in the study.

Conveyor belts can be used for transporting refuse from the preparation plant to a loading hopper, from there it can be trucked to a refuse dump. The conveyor system would provide constant removal of refuse from preparation plants.

Slurry material from the preparation plants can be transported by pipeline to settling ponds.

### Spreading and Compacting

Preparation of the refuse dump starts with spreading the waste material. "Spreading" consists of smoothing the top surface to the slope desired to conform with the surrounding countryside. On flat reclamation sites, spreading is accomplished by flattening the top and leaving the sides to slope at the angle of repose that will reduce landslides or erosion. If the angle of repose of the banks is too great, it may be necessary to form terraces. For the same reason, terraces are used to prevent water run-off. At some reclamation projects it was necessary to make the top slightly concave to hold rainwater to obtain better growth of plants.

At some dump sites, refuse disposal is a continuous process. The waste is spread as it is dumped. As the pile becomes higher, the sides are compacted and planted at specified intervals.

Bulldozers are primarily used to spread and compact refuse. However, all types of hauling equipment are used to some extent to compact by traveling over previously deposited material.

Compacting the waste is necessary to hold the material in place and to prevent air and water pollution of the surrounding area. Compaction also provides a better base for the soil cover.

Spreading and compacting are two of the least costly operations at the dump site. Costs of these methods are reflected in table 3, which indicates that the handling costs range from 3 to 20 cents per ton, with the average cost being 11 cents per ton.

## Preparation for Planting

### Soil Cover

Soil applied to coal refuse dumps is the most costly part of the reclamation operations. Most soil cover can be obtained from nearby farm land, previously stripped and restored land, or from road scrapings and ditches. Some of the cover might be considered topsoil, but most is clay or subsoil.

TABLE 3. - Refuse spreading and compaction

(Industry)

| Company | Mine location | Mine name and type | Spreading and compaction equipment | Refuse handled, tons per day | Handling cost per ton |
|---|---|---|---|---|---|
| Bethlehem Mines Corp... | Barrackville, W. Va. | Idamay mine No. 44 (underground). | Trucks and bulldozer. | 1,100 | $0.03 |
| Do..... | Ellsworth, Pa..... | Mine 60[1] (underground). | ....do..... | 2,800 | .05 |
| Beth-Elkhorn Corp..... | Jenkins, Ky..... | Hendrix No. 22 (underground). | ....do..... | 765 | .16 |
| Do..... | .....do..... | No. 27 mine (underground). | ....do..... | 1,170 | .13 |
| Eastern Associated Coal Corp. | Rachel, W. Va..... | Joanne mine (underground). | ....do..... | 600 | [2].11 |
| Hanna Coal Co..... | Cadiz, Ohio..... | Georgetown Area (strip mine). | ....do..... | 4,164 | .10 |
| Pittsburg & Midway Coal Mining Co. | Hallowell, Kans..... | Mine 19 (strip mine). | ([3])..... | 2,400 | .20 |
| Do..... | Madisonville, Ky.... | Colonial mine (strip mine). | Bulldozer.. | 1,100 | .12 |
| U.S. Steel Corp..... | Uniontown, Pa..... | Ginger Hill (underground). | Carryall... | 4,500 | ([4]) |

[1]Abandoned dumps; refuse from Mines 51 and 58 being disposed at Mine 60 dump by aerial tram.
[2]Estimated.
[3]Refuse disposed of in pit areas. No spreading or compacting.
[4]Included in the cost of refuse disposal, table 2.

Trucks or carryalls haul the soil material from the source to the waste dumps. Cost of hauling depends upon the availability of soil, distance carried, and size of equipment used. Some of the reported handling costs ranged from 8 to 50 cents per ton. Detailed hauling costs are not reported but are aggregated in table 4 under heading "Soil cover, cost per acre." However, costs shown cannot be correlated with any degree of accuracy to reflect any conclusion as to average cost.

Trucks can be used for transporting soil when reclamation of dumps is done periodically. Trucks may normally be used by mining companies in several facets of mining operation; therefore, purchase of additional equipment for reclamation work would be unnecessary. When reclamation of a refuse area is a continuous operation, equipment such as carryalls and bulldozers may be the least costly method of doing the job.

## Spreading and Compaction of Soil

Trucks hauling soil are capable of spreading the material to some extent and at the same time compact the soil by repeated travel over previously dumped and spread material. However, general practice is to use bulldozers for spreading after the material is dumped. The dumped material is usually spread in layers 8 to 12 inches thick and compacted by repeatedly passing over the spread material. Carryalls and scraper pans are also used for spreading and compacting soil.

## Planting

The compacted surface is cultivated and soil conditioners added to obtain good germination of seeds. After seeding, the surface is recompacted lightly to prevent the seed from blowing or washing away.

Certain varieties of grasses and legumes used in vegetating the soil cover have a good survival rate. It was generally concluded that, with proper soil conditioning, grass seed in combination with legumes gave the best survival results. In a previous investigation by the Bureau of Mines, it was determined that the quantity of grass seed planted should be three to four times greater in weight than legumes. Legumes, which are slow to become established, will take over as ground cover within 2 to 3 years.

Table 4 indicates that Kentucky fescue grass and a legume, usually Serecia lespedeza, was used more often than other combinations and that satisfactory results were obtained. A few companies reported obtaining good results using perennial and annual rye, orchard grass, and love grass. Other legumes that are and could be used include crown vetch and bird's-foot trefoil.

Soil conditioners generally included quantities of lime, depending upon the acidity of the soil, and paper mulch. Various fertilizer formulas were used, depending upon fertility of the cover material. Mulches were used either after planting or in connection with planting to protect the seed and soil from drying.

TABLE 4. - Soil covering and planting

(Industry)

| Company | Mine location | Mine name and type | Soil cover, tons per acre | Soil cover, cost per acre[1] | Vegetation planted | Planting cost per acre[2] |
|---|---|---|---|---|---|---|
| Bethlehem Mines Corp. | Barrackville, W. Va. | Idamay mine No. 44 (underground). | 3,300 | $833 | Grasses, black locust, white pine. | $165 |
| Do..... | Ellsworth, Pa. | Mine 60[3] (underground). | 21,750 | [4]10,900 | White pine, perennial rye, Kentucky fescue, Serecia lespedeza. | [5]442 |
| Beth-Elkhorn Corp. | Jenkins, Ky... | Hendrix No. 22 (underground). | 4,350 | 1,300 | White pine, annual rye, Kentucky fescue, Serecia lespedeza. | 50 |
| Do..... | .....do..... | No. 27 mine (underground). | - | - | White pine, short leaf pine, loblolly pine. | [6]60 |
| Eastern Associated Coal Corp. | Rachel, W. Va. | Joanne mine (underground). | 13,235 | 1,323 | Grasses, locust, white pine. | [7]148 |
| Hanna Coal Co..... | Cadiz, Ohio... | Georgetown Area (strip mine). | 4,538 | 1,598 | Kentucky fescue, orchard grass, crown vetch. | 48 |
| Pittsburg & Midway Coal Mining Co. | Hallowell, Kans. | Mine 19 (strip mine). | 8,700 | 700 | Kentucky fescue, Serecia lespedeza, locust trees. | 50 |
| Do..... | Madisonville, Ky. | Colonial mine (strip mine). | 6,525 | 700 | Kentucky fescue, love grass, Serecia kobe, Serecia lespedeza. | 50 |
| U.S. Steel Corp... | Uniontown, Pa. | Ginger Hill (underground). | 3,263 | 665 | Crown vetch, black locust, pine trees, perennial rye grass, Kentucky fescue. | [8]455 |

[1] Includes soil, transportation, spreading, and compacting.
[2] Costs not footnoted are those for planting grasses and trees on soil cover not conditioned.
[3] Abandoned dumps; refuse from Mines 51 and 58 being disposed at Mine 60 dump by aerial tram.
[4] Privately contracted at 50 cents per ton.
[5] Includes cost of lime, paper mulch, fertilizer, grass seed applied by hydroseeding, and trees planted by hand. Weighted average cost for 1966, 1969, and 1970-71 projects.
[6] Soil cover not used. Trees and grasses planted directly on refuse not previously conditioned.
[7] Includes cost of lime, mulch, fertilizer, seed, and trees.
[8] Includes cost of soil conditioning, hydroseeding, and tree planting. Direct cost only.

Tests made by the Bureau of Mines (3) indicate that Norway spruce, black locust, Japanese larch, pitch pine, white pine, and jack pine trees, in descending order, have the best survival rate. Norway spruce trees are relatively expensive, so most companies used black locust and some variety of pine, generally white pine. Some companies reported that planting trees and seeding was done on an experimental basis and that when failures occurred, additional trials were made, using new methods of soil conditioning and new types of vegetation.

Generally, it was found that a single planting and seeding directly on soil cover without benefit of conditioners was the least costly. Four projects listed in table 4 used this method and the cost of planting was about $60 per acre. This method of planting resulted in a low survival rate.

Most companies planted trees and seeds on soil treated with conditioners. Plantings by hand are greater in cost than those planted by machine. In some cases, hand planting was a necessity--especially for trees planted on steep slopes. The range in costs reported by companies was from $148 to $455 per acre (table 4). Some companies reported using a combination of hand and machine planting. The most popular planting machine was one in which a mixture of water, mulch, fertilizer, and seed was sprayed over the soil.

## INDUSTRY RECLAMATION PROJECTS

### Bethlehem Mines Corp.

#### Idamay Mine No. 44, Barrackville, W. Va.

The reclaimed refuse dump at the abandoned Idamay mine No. 44 covers an estimated 75 acres. The dump and adjacent slurry ponds contain about 8 million tons of coal refuse, which amounts to 16 percent of the 50 million tons of coal produced during the life of the mine. During the last 10 years of the mine operation, about 1,100 tons of preparation plant refuse was produced daily. The refuse was hauled about one-half mile to the dump site in 10-ton trucks where it was leveled and compacted with a front-end loader. The total estimated cost to haul, spread, and compact was 31 cents per ton of refuse (tables 2 and 3).

The result of terracing at this site is shown in figure 1. Each of the 30-foot-high terraces was covered on the top and edges with an average of about 1.5 feet of clay soil. About 250,000 tons of soil cover was dug and hauled from company property at a cost of 28 cents per ton.

The reclaimed refuse site has become an attractive development area. Foundations are being constructed on an adjacent reclaimed slurry pond for the erection of the plastic manufacturing and fabricating plant shown in figure 2. This reclaimed area is also under development as a site for a housing project. Further commercial and housing development for the entire reclaimed 75 acres is expected in the future.

FIGURE 1. - Idamay Mine No. 44 Reclamation Site. Reclaimed, terraced, and planted.

Mine 60, Ellsworth, Pa.

The Bethlehem Mines Corp. has three refuse dumps at this operation. One is located 1 mile from active Mine 60; the other two are one-half mile each from inactive Mines 51 and 58. The disposal site at Mine 60 is located in a valley covering an area of 123 acres. Presently this dump is 128 feet high on the east side and 163 feet high on the west side. Slopes of these sides of the dump are maintained at a 2 to 1 ratio to insure stability. The top surface of the refuse pile is graded to prevent water run-off and slope washing. A band of vegetation is cleared from the base of the dump for fire protection.

Disposal from Mine 51 starts from a bin at the cleaning plant by way of a continuous bucket system to a transfer area; from there the refuse moves by means of a balanced two-tower aerial tram system to a dump site. Mine 58 refuse is disposed of in a similar manner except that the refuse moves from the transfer area to a dump site by means of a single-tower aerial tram system. Refuse from Mine 60 and the preparation plant continue to be disposed of by truck to the active dumping area. As the slopes increase in height, they are vegetated.

FIGURE 2. - Idamay Mine No. 44 Reclamation Site. Reclaimed area being developed for commercial sites.

Starting in 1966, 24 acres of refuse without soil cover were treated with 1,000 pounds of hydrated lime. Each acre of the area was hydroseeded with 75 pounds of perennial rye (grass), 25 pounds of Kentucky fescue (grass), 500 pounds of fertilizer, and 1,200 pounds of combined paper and water used as a mulch. Subsequently, 1,200 pine trees were planted on 6-foot centers. The growth and survival rate of the plantings was discouraging. Planting cost of the 24 acres was $385 per acre.

In 1967, a program was undertaken to determine the sulfur content and temperature of the coal refuse surface on which the plantings were made and to evaluate the findings relative to their detrimental effects on plant growth. Summer temperatures of the refuse surface were as high as 114° F. This high temperature was one of the causes of poor growth.

In 1968, experimental work was done by replanting certain areas with a variety of grasses and trees to determine those with the best growth and survival rate. None had a satisfactory growth or survival rate when planted directly on coal refuse.

In 1969, planting was done on 5 acres of the northwest face of the refuse bank, which was covered to a depth of 10 feet of soil obtained from the surrounding hillside and valley floor. Three scrapers of 30-yard capacity placed the soil in 1-foot layers. The soil was compacted by the scrapers with the aid of a bulldozer and a sheep's-foot roller. A clay soil wall was built 5 feet higher than the actual top edge of the dump in the form of a dike, which served as a guide for the refuse dump trucks and to prevent rainwater from running over the sides. Approximately 21,750 tons of soil were required to cover 1 acre of refuse. The cost of the soil was estimated at 50 cents per ton, based on the availability of the soil, length of haul, and equipment used. Benches were provided at several heights to allow heavy equipment to maintain the slopes and for operation of the seeding equipment. The benches provided additional stability to prevent landslides. Each acre was hydroseeded using 200 pounds of fertilizer, 20 pounds of Kentucky fescue, 20 pounds of perennial rye grass, 10 pounds of Serecia lespedeza (legume), and 1,000 pounds of paper-water mulch. Pine trees were also planted using a density of 1,000 trees per acre. The total cost of the planting was about $500 per acre. The results of planting were good and are shown in the background of figure 3.

FIGURE 3. - Mine 60 Reclamation Site. Results of seeding and tree planting on benches. New mine dump on horizon.

In 1970 and 1971, plantings similar to those done in 1969 were completed on 3 additional acres of the northwest face and on certain of the acres where the previous planting survival rate was poor. Planting cost during this period amounted to about $800 per acre.

## Beth-Elkhorn Corp.

### Hendrix No. 22, Jenkins, Ky.

Hendrix No. 22 produces about 4,200 tons of raw coal per day. The reject rate from the coal preparation plant is 18 percent and results in about 765 tons of coal refuse per day. The refuse disposal area, occupying about 40 acres, is located in a valley 1 mile away from the mine. Refuse is hauled by trucks which usually operate three shifts per day. The trucks dump the refuse, which is then spread by a bulldozer and compacted by both vehicles. The south face of the refuse bank was started at a 15-percent grade, which will be progressively increased as the face is raised. Transportation of the coal refuse to the dump is reported to cost about 13 cents per ton-mile. Spreading and compacting are done for about 16 cents per ton. The refuse disposal area is shown in the background in figure 4.

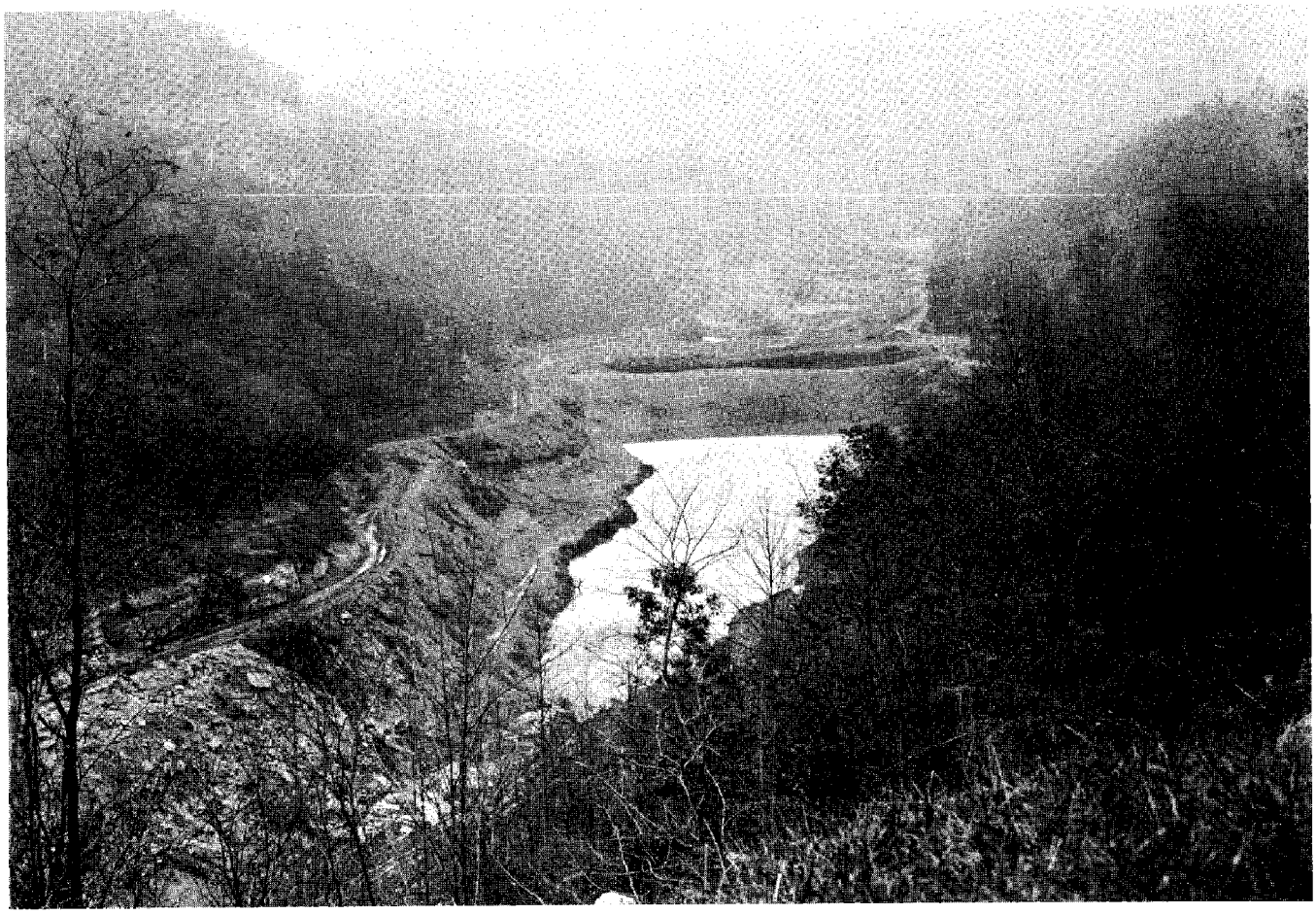

FIGURE 4. - Hendrix No. 22 Reclamation Site. Reclamation complex showing work in progress and slurry ponds.

Located in back of the refuse area, a new pond was constructed to collect and hold surface water. This prevents the natural drainage water from coming in contact with either the slurry or the refuse, preventing the discharge of acid water. An overflow culvert, which discharges the water from the pond into Rockhouse Creek, was built along the east side of the valley to bypass the slurry pond and refuse bank.

As areas of the refuse bank are inactivated, they are covered with clay and seeded. Kentucky fescue, annual rye (grass), Serecia lespedeza, and native white pine trees have been planted. A high survival rate for the grasses was achieved; tree growth, however, was poor. The cost of the soil cover was about 30 cents per ton. Planting costs amounted to $50 per acre.

In 1968, an inactive, 85-foot-high refuse bank, which was located behind the preparation plant (not shown in fig. 4), was leveled, resulting in a flat area of about 4 acres. Refuse had been dumped on the pile for approximately 15 years at an average rate of 700 tons per day. Two bulldozers were employed intermittently over a period of several months to level the pile. Soil cover, which is extremely limited in the area, was obtained from various sources, such as roadways and material from cleaning roadway drainage ditches. It is estimated that it took about 1 year to obtain sufficient soil material to cover the area. The area was planted with Serecia lespedeza and other vegetation (table 4) without the aid of lime or fertilizer. The survival rate was about 80 percent. Due to the intermittent nature of the work, exact cost-data could not be obtained; however, the estimated reclamation costs were about the same as those for Mine 22 described above.

No. 27 Mine, Jenkins, Ky.

This site contains an active preparation plant and refuse dump, both started in 1943. Approximately 4,600 tons per day of raw coal is cleaned, which produces about 1,200 tons of refuse. The reclamation area covers 26 acres of ground and contains between 15 and 20 million tons of waste. The height of the refuse dump is estimated to be about 400 feet. The procedure used is to transport the refuse on a 26-inch belt that is 880 feet long and on a 16-percent slope from the preparation plant to a loading hopper. Refuse is then transferred to a 30-ton truck that dumps the refuse in the active section of the disposal area where it is spread and compacted by a bulldozer and by truck travel. Transportation of the coal refuse is estimated to cost 13 cents per ton-mile. Spreading and compacting of refuse is estimated to cost an additional 13 cents per ton.

Because of the rugged topography of eastern Kentucky, flat land is very scarce and, therefore, valuable. Most refuse is placed in valleys. Soil in the valley is estimated to be less than 1 foot in thickness, which makes the availability of soil inadequate. Therefore, planting is usually done directly on the refuse. The environment of the refuse in many cases results in a very low survival rate of the trees or grasses. It is necessary in some cases to make many plantings to establish growth on the abandoned portions of the bank. The front face of the Jenkins refuse bank was planted eight times using various species of pine trees including short leaf pine, white pine, and loblolly

pine. The number of trees planted each time varied between 1,000 and 5,000. It is estimated that about 20 acres have been planted. The planting was usually done by a contractor and was estimated to cost between $50 and $60 per acre. The trees varied in price but were estimated to cost between $10 and $20 per 1,000, depending on species. It is estimated that tree growth was established on 40 percent of the face slope (fig. 5).

To eliminate siltation on the local stream, portions of the face slopes were terraced. Water runoff is now collected in a holding pond. Portions of the terraces may be seen in the lower right hand corner of figure 5. The active part of the refuse bank is being held 20 feet back from the existing front face slope to provide a bench for access to equipment and to maintain the stability of the refuse bank.

Eastern Associated Coal Corp.

Joanne Mine, Rachel, W. Va.

A reclaimed refuse dump that is 50 feet in height and covers an area of 6.8 acres is shown in figure 6. The dump was constructed in compacted layers 20 feet thick, and each layer was covered with 12 inches of clay soil. The compacting operation was done by the loaded trucks hauling the refuse to be dumped and by bulldozers leveling the refuse after it was dumped. The slope

FIGURE 5. - No. 27 Mine Reclamation Site. Tree growth on reclaimed slopes.

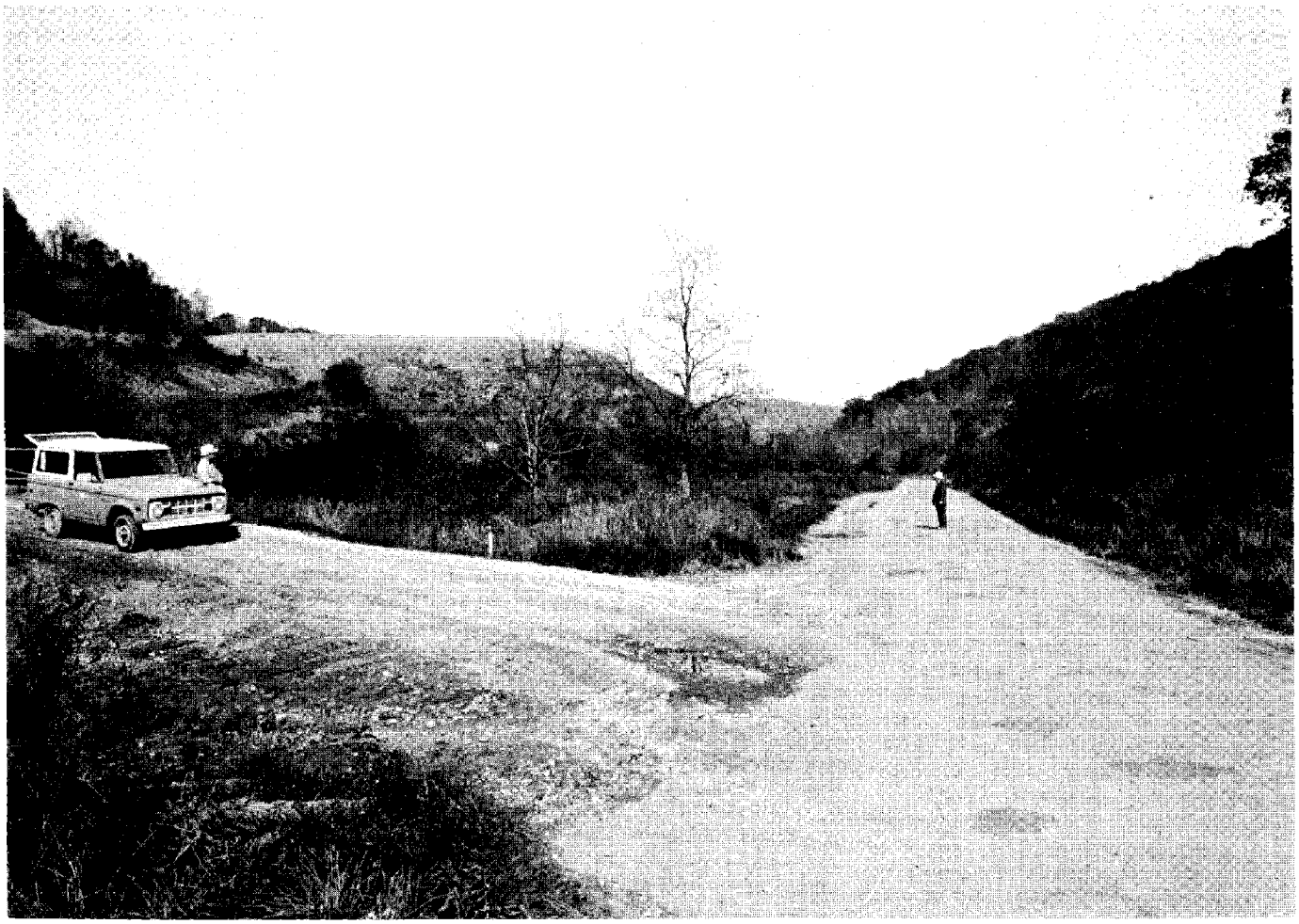

FIGURE 6. - Joanne Mine Reclamation Site. Face of 50-foot refuse bank planted with trees (on the extreme right).

area of the refuse dump was covered with 6 feet of clay removed from an adjacent mountain side. It required some 90,000 tons of clay soil to cover the slope area. The dig-and-haul cost of the soil was 10 cents per ton. The slope area was planted with grasses, 4,000 locust trees, and 4,000 white pine trees and subsequently fertilized and limed. The total cost per acre for soil cover, treating, and planting was about $1,470.

## Hanna Coal Co.

### Georgetown Area, Cadiz, Ohio

The Hanna Coal Co.'s method of disposal of coal refuse from its Georgetown preparation plant is to deposit the refuse in the last cut of a strip mine or dump it in a valley or other low area. The coal refuse is then covered by a layer of soil of varying thicknesses. In most cases, vegetation consisting of Kentucky fescue, orchard grass, and crown vetch is established.

An airport runway and buildings, located 3 miles south of Cadiz, Ohio, was constructed by filling a valley 5,000 feet in length, 300 feet wide, and 40 feet deep with 3.5 million tons of coal refuse. It was subsequently asphalted and deeded by the company to Harrison County, Ohio, for the sum of $1. The completed airport complex is shown in figure 7.

FIGURE 7. - Georgetown Area Reclamation Site. Reclaimed to airport complex.

Grazing land, 4 miles south of Cadiz, Ohio, was established by filling a strip mined area with 1.5 million tons of refuse, then covering it with soil and planting the area with grasses. Currently, 100 head of Hereford cattle graze on the land. The completed project is shown in figure 8. An additional 2 million tons of refuse was used to fill a strip cut and lowlands adjacent to Dickerson Church and Cemetery south of Cadiz, Ohio. The filled areas were contoured and planted with grasses to enhance the esthetic value of the church property.

The average capital investment cost for the three reclamation projects was about $254,000. The average amount of refuse hauled to disposal sites was 4,164 tons per day, and the average disposal cost was $1,041 per day or 25 cents per ton-mile. Refuse spreading was done by bulldozers at an average cost of about 10 cents per ton. Compacting was accomplished by altering the truck route across the fills in addition to the bulldozer's travel. Earth cover was readily obtainable from adjacent land. It was moved about one-fourth mile to the fill areas by carryalls. The average soil cover on the fill was 2.5 feet. The cover per acre averaged 4,538 tons at a cost of $1,598 per acre or 35 cents per ton.

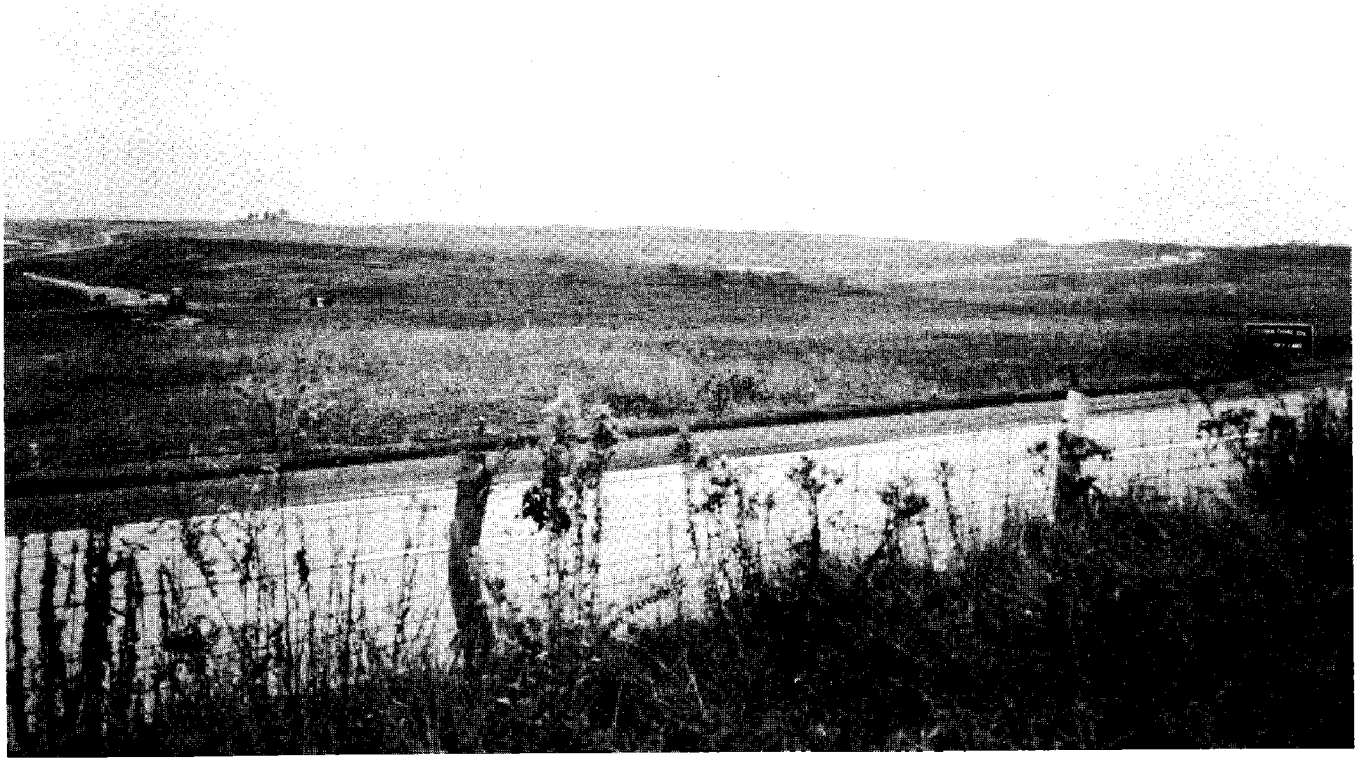

FIGURE 8. - Georgetown Area Reclamation Site. Reclaimed to grazing land.

The reclaimed areas were planted with Kentucky fescue, orchard grass, and crown vetch at a cost of $48 per acre.

Pittsburg & Midway Coal Mining Co.

Mine 19, Hallowell, Kans.

The Pittsburg & Midway Coal Mining Co. has reclaimed 5,000 acres of strip mined land. Currently, coal refuse from the preparation plant is being disposed of in strip mined areas.

The preparation plant, which operates 240 days per year, produces 2,400 tons of refuse per day. The refuse is hauled a distance of 2 miles to a mined-out strip area at a cost of 20 cents per ton. The total cost of refuse disposal annually, excluding the cost of capital investment, is estimated at $115,200. Each acre of refuse disposed in the strip mine is leveled and covered with 8,700 tons of soil at a depth averaging 4 feet and at a cost of $700 per acre. Seed planting followed at a cost of $50 per acre.

Figure 9 shows, in the foreground, a portion of a 250-acre reclaimed area supporting a growth of grass. In the background is an area ready for planting.

Figure 10 shows a good growth of vegetation on land reclaimed a number of years ago.

This reclamation project, underway for the last 20 years, containing many acres of pasture land, is one of the largest in the United States. Plans for

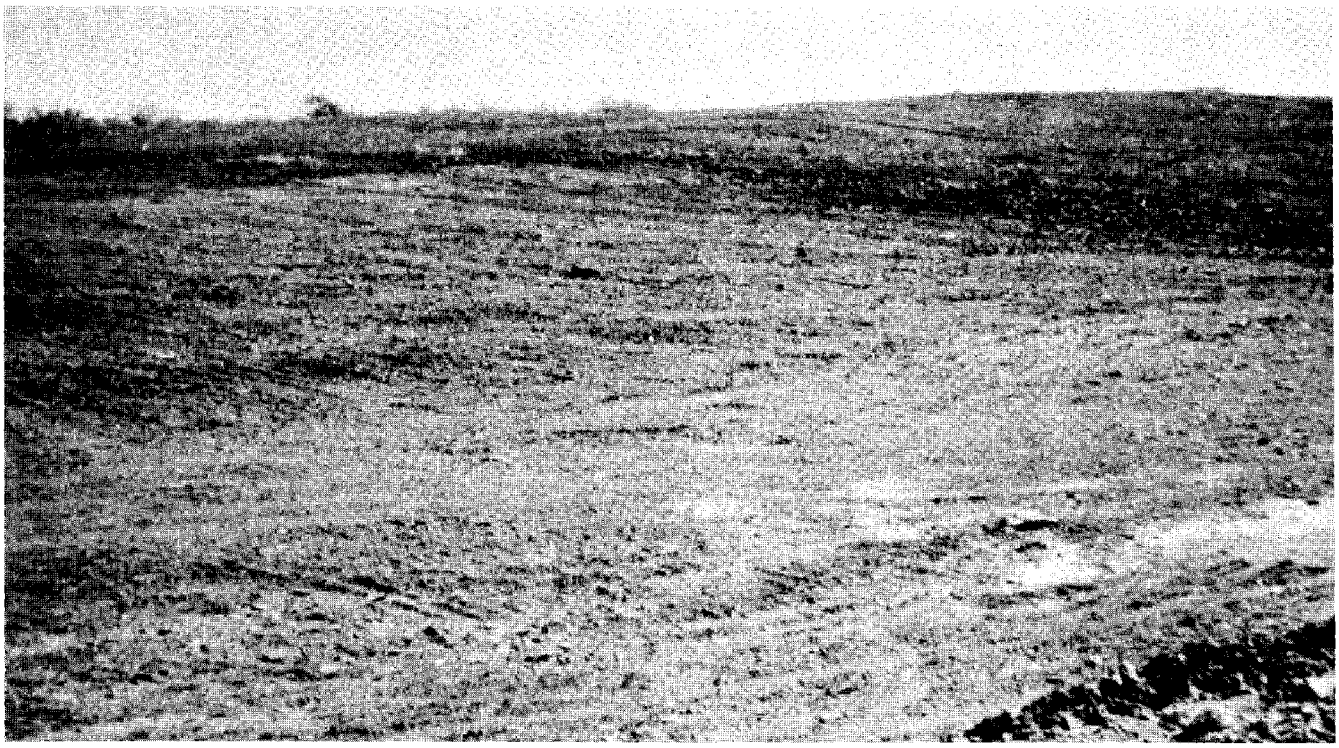

FIGURE 9. - Mine 19 Reclamation Site. Area reclaimed to grass, in foreground, and area ready for planting, in background.

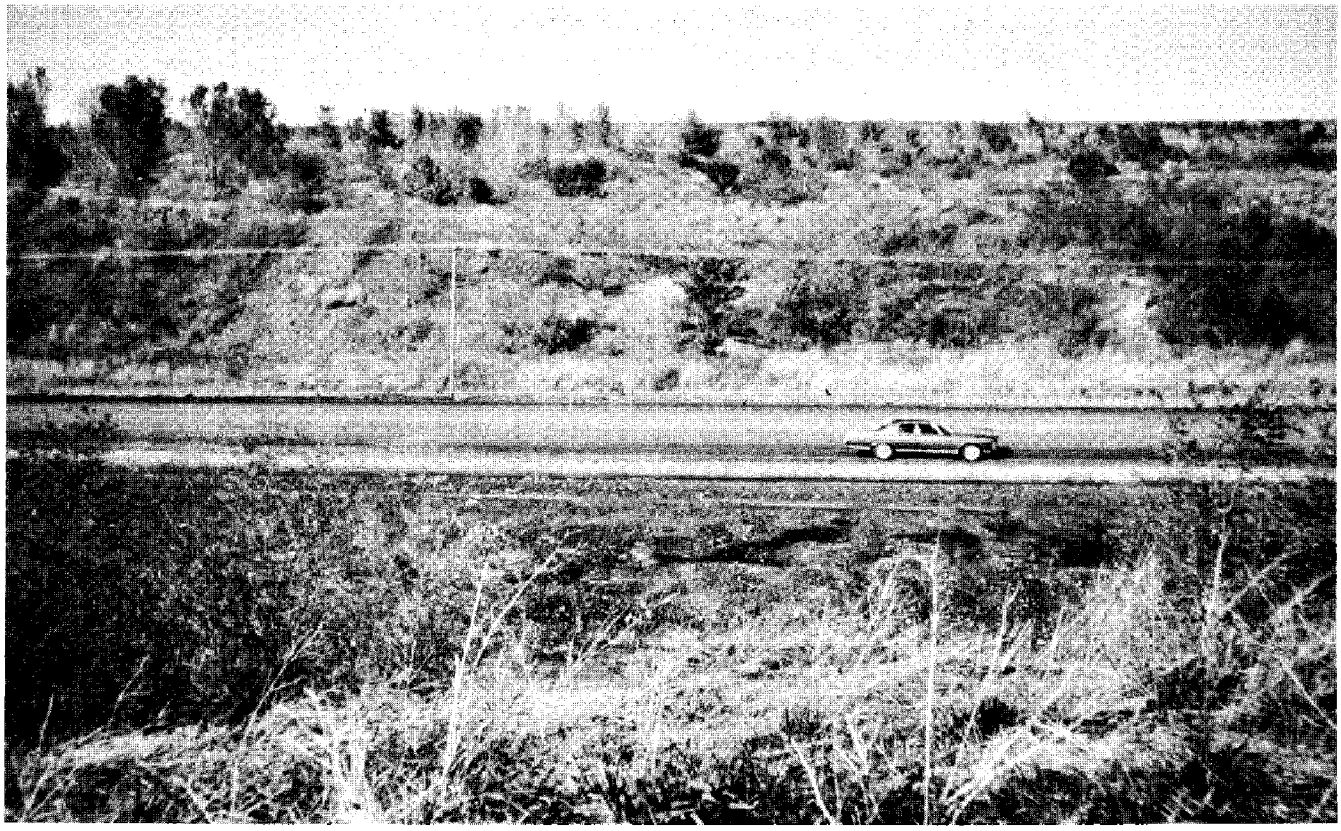

FIGURE 10. - Mine 19 Reclamation Site. Substantial growth of vegetation on land previously reclaimed.

a 300-acre recreation area that will include lakes and land for housing have been made but will not be implemented until mining operations have been completed. Reclamation of worked-out strip areas continues year-round.

Colonial Mine, Madisonville, Ky.

The Pittsburg & Midway Coal Mining Co. method of disposal of coal mine refuse from its Colonial preparation plant is to bury the refuse in certain sections of a strip mine. The coal refuse is hauled from the preparation plant to the disposal site in 85-ton trucks. The average length of haul is about 2 miles. The refuse is dumped at the disposal area and is spread into thin layers by a bulldozer. Compaction of the refuse is done by the bulldozer and alternating the truck route over the refuse.

The complete cost of cover material is $700 per acre (table 4). A minimum of 3 feet of cover is placed over the refuse. This requires about 6,500 tons of cover material per acre. Figure 11 shows a strip mine filled with coal refuse ready for grading, covering, and planting. The cover material is the strip-mined overburden shown in the background.

FIGURE 11. - Colonial Mine Reclamation Site. Strip mine filled with coal refuse ready for grading, covering, and planting.

The overburden removed from the coal during stripping operations is not necessarily soil. Some of the natural soils in this area are acidic, having pH values between four and five. The pH of the overburden material, in many cases, is more alkaline than the natural soil. Therefore, there is an advantage of using overburden material in lieu of soil because lime and fertilizer in many cases are not needed, thus reducing the reclamation cost.

The following seed mixture is used to provide the vegetation cover to the area:

| Type | Pounds per acre |
|---|---|
| Kentucky 31 fescue... | 15 |
| Love grass..... | 2 |
| Serecia lespedeza.... | 10 |
| Serecia kobe..... | 10 |

Prior to planting, the soil is tested to determine if lime and fertilizer are needed. Broadcast seeding is used either with a farm tractor or cyclone-type seeder. The completed area planted in 1970 is shown in the foreground of figure 12. It required no lime or fertilizer and was seeded at a cost of $50 per acre.

## United States Steel Corp.

### Ginger Hill, Uniontown, Pa.

The United States Steel Corp.'s Ginger Hill mine, opened in the late 1950's, is located near Uniontown, Fayette County, Pa. This mine produces metallurgical coal from the Pittsburgh seam for its Clairton coke works.

Because the preparation plant is located within a populated area, the refuse is transported 3.2 miles by underground rail in specially designed mine cars to the shaft at Ginger Hill. There it is lifted 532 feet to the surface by an automatic skip hoist and discharged into a surge bin, from which it is loaded into carryalls and hauled and spread over the disposal area in layers tightly compacted by the carryall traffic. Two carryalls are required, working two shifts per day, to dispose of approximately 4,500 tons of refuse produced daily. Prior to the disposal of any refuse, the ground surface area is cleared of all combustible material and vegetation. Topsoil is recovered for later use in planting. A grader is used to maintain haulage roads at the site and aid in disposal and reclamation work. Slopes of the sides of the refuse area are maintained at inclines that will insure stability. The outer limits of the dump area are maintained at a higher elevation than the dump surface to direct all water run-off toward the center of the disposal area where a pond is located.

To provide erosion control and beautification of the refuse disposal area, a program was initiated several years ago to cover the slopes of the disposal area with clay or topsoil to a depth of about 18 inches and to plant these slopes with stabilizing vegetation. This was considered feasible since the refuse is mildly alkaline.

FIGURE 12. - Colonial Mine Reclamation Site. Reclaimed area in foreground. New refuse fill and soil covered bank in the background.

The soil is transported by the carryalls and is spread over the slopes by a bulldozer and grader. This is usually done each time the refuse area elevation increases about 10 feet. About 7 to 8 acres of new slope area is formed every year.

To date, about 44 acres of slope area have been covered with soil. This is equivalent to about 3 tons of soil per 100 tons of refuse. The direct costs are about $665 per acre.

In addition to controlling run-off water on the refuse dump surface, run-off water from the areas immediately surrounding the disposal site are diverted by ditches to settling ponds on the valley floor. After the silt settles out, the clarified water is checked periodically for acidity, then flows into the local stream.

First attempts at planting in 1966 were not too successful--partially due to an extremely dry summer. Of the 5,000 white pine and 5,000 Austrian pine

(8-to 10-inch high) that were hand planted at a rate of 385 trees per acre, only 20 percent survived. Natural grass and weed growth on the soil-covered areas was satisfactory.

Seeding was first attempted in 1970. As the upper slopes became formed, they were hydroseeded by a contractor. The seeding mixture recommended, which cost about $100 per acre, consisted of the following:

| Material | Pounds, unless otherwise specified |
|---|---|
| Fertilizer..... | 150 |
| Silva fiber mulch.... | 100 |
| Perennial rye grass.. | 50 |
| Crown vetch..... | 7.5 |
| Chopped grass roots.. | 2.5 |
| Black locust seed.... | 1.5 |
| Water (gallons)..... | 750 |

This mixture, with slight variations, has been used on about 30 acres of slope area. Results have been good to poor, based on weather conditions after planting. It is estimated that over 90 percent of the black locust seed germinated, but the crown vetch and rye grass did not survive as well.

In 1971, to permit hydroseeding at more selective times, 800-gallon bantam hydroseeding equipment was purchased for about $5,000. From the experience gained thus far with this equipment, it is apparent that by seeding at more opportune times and by watering and applying additional fertilizer as needed, a much more successful program is possible. A new seeding mixture, which costs about $200 per acre, is now being used.

| Material | Pounds, unless otherwise specified |
|---|---|
| Fertilizer..... | 500 |
| Silva fiber mulch.... | 200 |
| Hydrated lime..... | 200 |
| Crown vetch..... | 75 |
| Kentucky fescue grass | 50 |
| Water (gallons)..... | 1,600 |

Mechanical equipment used in seeding is shown in figure 13. An additional step taken to improve the appearance of the reclamation site was to screen the area by planting 94 large trees costing about $20 each. This tree planting program will be continued to screen the active disposal areas from public view as much as possible. Through the implementation of detailed planning to include esthetic, as well as structural requirements, the construction of this refuse disposal area blends with the surrounding area, making it unobtrusive in appearance (fig. 14). The only noticeable indication that it is a refuse disposal area is the incremental layering of refuse at the top before the exposed slope is covered with soil and seeded.

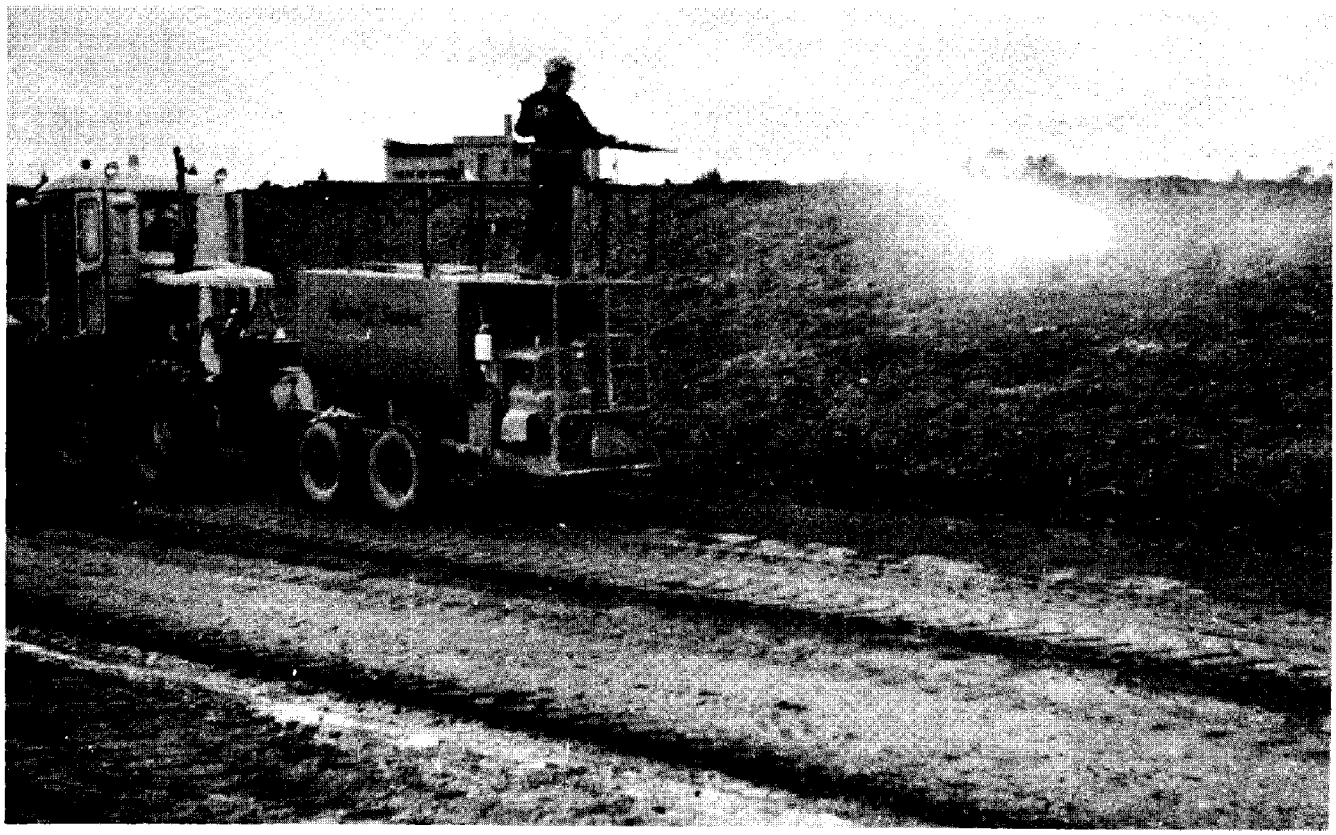

FIGURE 13. - Ginger Hill Reclamation Site. Hydro-Seeder in action.

FIGURE 14. - Ginger Hill Reclamation Site. Area of reclaimed coal refuse.

## COMMONWEALTH OF PENNSYLVANIA RECLAMATION PROJECTS

The following descriptions of reclamation work are examples of State programs for the purpose of reclaiming land to prevent coal refuse bank fires, air pollution, siltation, and acid water drainage.

Methods used in preparing refuse dumps, spreading and compacting soil cover, and planting and seeding are similar to those used by the private companies previously mentioned. However, costs shown in tables 5 to 7 are expressed differently from those of industry because the State used a different system of accounting.

Table 6 shows that in contrast with private company plantings, the State planted no trees and only in one instance were legumes used. The State preferred the use of rye and fescue for grass plantings, which evidently gave the best results.

TABLE 5. - Refuse site preparation costs

(Pennsylvania)

| Project location | Area reclaimed, acres | Contouring and grading cost | Drainage system | | Refuse preparation costs |
|---|---|---|---|---|---|
| | | | Installation, feet | Cost | |
| North Strabane project, North Strabane Township, Washington County..... | 30.0 | $36,750 | 1,700 | $4,420 | $41,170 |
| Imperial Keystone project, Cherry Hill Township, Indiana County..... | 26.0 | 40,800 | 2,350 | [1]25,225 | 66,025 |
| Coal Tipple project, Cherry Hill Township, Indiana County..... | 10.0 | 30,000 | 1,275 | [2]25,500 | 55,500 |
| Clymer Borough project, Clymer Borough, Indiana County..... | 3.5 | 500 | 6,978 | 13,956 | 14,456 |
| Panther Tipple project, Snowshoe Township, Centre County..... | 5.5 | 4,000 | 800 | 1,600 | 5,600 |
| Unity Township project, Unity Township, Westmoreland County..... | 7.0 | 4,400 | 600 | 1,002 | 5,402 |

[1]Includes collector channel lined with limestone riprap.

[2]Includes riprap waterway.

TABLE 6. - Soil cover and planting costs

(Pennsylvania)

| Project location | Transporting, spreading, and compacting[1] | | Planting costs[2] | Vegetation established | Total cover and planting costs |
|---|---|---|---|---|---|
| | Cubic yards | Cost | | | |
| North Strabane project, North Strabane Township, Washington County. | 96,800 | $32,912 | $5,880 | Rye grass and red fescue. | $38,792 |
| Imperial Keystone project, Cherry Hill Township, Indiana County. | 154,000 | 40,040 | 10,000 | Crown vetch, perennial rye, Kentucky fescue, red fescue. | 50,040 |
| Coal Tipple project, Cherry Hill Township, Indiana County. | 38,300 | 36,300 | 5,625 | Rye and fescue grasses. | 41,925 |
| Clymer Borough project, Clymer Borough, Indiana County. | 18,200 | 16,400 | 1,400 | .....do..... | 17,800 |
| Panther Tipple project, Snowshoe Township, Centre County. | 5,000 | 10,000 | 5,400 | .....do..... | [3]15,400 |
| Unity Township project, Unity Township, Westmoreland County. | 10,400 | 4,160 | 3,420 | .....do..... | 7,580 |

[1]Soil cover thickness 1.5 to 2 feet for all projects.
[2]Includes cost of lime, mulch, fertilizer, and plantings.
[3]Includes cost of spreading and compacting a 1-foot layer of limestone.

TABLE 7. - Total reclamation costs

(Pennsylvania)

| Project location | Refuse site preparation costs from table 5 | Cover and planting costs from table 6 | Miscellaneous reclamation costs[1] | Total cost | Total cost per acre |
|---|---|---|---|---|---|
| North Strabane project, North Strabane Township, Washington County..... | $41,170 | $38,792 | [2]$25,530 | $102,612 | $3,420 |
| Imperial Keystone project, Cherry Hill Township, Indiana County..... | 66,025 | 50,040 | [3]14,200 | 126,765 | 4,876 |
| Coal Tipple project, Cherry Hill Township, Indiana County..... | 55,500 | 41,925 | [4]54,200 | 151,625 | 15,165 |
| Clymer Borough project, Clymer Borough, Indiana County..... | 14,456 | 17,800 | - | 32,256 | 9,216 |
| Panther Tipple project, Snowshoe Township, Centre County..... | 5,600 | 15,400 | 5,000 | 26,000 | 4,700 |
| Unity Township project, Unity Township, Westmoreland County..... | 5,402 | 7,580 | - | 12,982 | 1,855 |

[1]Includes soil borrow area, clearing, and grubbing.
[2]Includes $19,650 for extinguishing refuse fire prior to reclamation.
[3]Includes excavation of drainage system.
[4]Includes excavation and grading slurry fines.

## North Strabane Project

The North Strabane project resulted in a 70-acre park area. Of this area only 30 acres containing coal refuse was reclaimed. The reclamation of the 40 acres of strip mined land is not considered in the cost study. Figure 15 shows a portion of the 30 acres of refuse containing 3,388,000 cubic yards of waste. This refuse accumulation was reclaimed during the period December 1970 to July 1971.

Work started by grading and contouring the refuse bank to establish a drainage system. Following preliminary work, the refuse bank was covered with a layer of soil to prevent infiltration of surface waters and to aid in the growth of vegetation, which stabilized the soil cover material.

FIGURE 15. - North Strabane Reclamation Site. A portion of 30 acres of coal refuse.

Contouring and grading of the coal refuse bank was done at a cost of $1,225 per acre. A 16-acre borrow area, from which 86,800 cubic yards of cover material was obtained, was cleared and grubbed at a cost of $3,000. The transportation, spreading, and compacting of the soil cover cost 34 cents per cubic yard. The length of haul from the borrow area varied but usually did not exceed 1,000 feet. The soil cover was placed in successive layers to a total thickness of 18 to 24 inches. Cost for drainage was $4,420.

Preparation of the soil cover on refuse bank and the borrow area included the addition of 500 pounds of fertilizer per acre and pulverized ground limestone at the rate of 2 tons per acre. Subsequently, the areas were seeded with 10 pounds of rye and 15 pounds of red fescue per acre. The 16-acre borrow pit was planted at a cost of $180 per acre. The total contract cost amounted to $3,420 per acre, including work performed by heavy equipment, construction of drainage systems, and revegetation.

## Imperial Keystone and Coal Tipple Projects

The Imperial Keystone project (Contract No. 109-1B) and the Coal Tipple project (Contract No. 109-1C) in Cherry Hill Township, Indiana County, were part of Operation Scarlift[2] to reduce acid mine water drainage from these

[2]Launched in March 1967, "Operation Scarlift" was a program of mine area restoration initiated by the Pennsylvania Department of Mines and Mineral Industries.

refuse banks into Buck Run, a tributary of Two Lick Creek. The Buck Run watershed is about 5.5 miles long and covers approximately 3.5 square miles including all of its tributaries. Buck Run discharges into Two Lick Creek about 1,692,000 gallons per day, which is about 7 percent of the flow of the creek. However, Buck Run contributed 65 percent of the acid, 51 percent of the iron load, and 25 percent of the sulfate load of Two Lick Creek; most of it came from the Imperial Keystone and Coal Tipple refuse banks.

The Imperial Keystone coal refuse bank occupies about 26 acres of land. The average height of the bank was 70 feet. It contained 2,936,000 cubic yards of refuse. Figure 16 shows the coal refuse accumulation prior to reclamation and figure 17 reflects the finished project, complete with water diversion ditches. The vegetation growth of both the refuse bank and the borrow pit was aided by the addition of lime at the rate of 2 tons per acre, fertilizer in the amount of 1/2 ton per acre, and mulch composed of hay anchored with emulsified asphalt, which was spread at the rate of 2.5 tons per acre. Seeding was done with a mixture of crown vetch, perennial rye, Kentucky fescue, and red fescue, at a rate of 22, 25, 20, and 10 pounds per acre, respectively.

The Coal Tipple project involved the reclaiming of a refuse bank containing 645,000 cubic yards of material and a slurry pond containing 47,500 cubic yards of refuse. The refuse bank was contoured and covered with 18 to 24 inches of soil obtained from the borrow pit. A drainage system consisting of a riprap waterway was installed. The slurry pond material was removed and deposited in an adjacent valley. This operation increased the total cost of

FIGURE 16. - Imperial Keystone Reclamation Site. Refuse accumulations prior to reclamation.

FIGURE 17. - Coal Tipple Reclamation Site. Completed reclamation showing drainage system.

reclamation to more than $15,000 per acre. The cover of both of these reclamation areas was treated and planted somewhat similarly to the Imperial Keystone project.

## Clymer Borough Project

The Clymer Borough project was designed to eliminate the pollution of Two Lick Creek caused by acid water draining from a refuse dump located in the residential area of the borough.

The refuse dump occupied about 3.5 acres with an average height of 25 feet. It was estimated to contain 161,000 cubic yards of refuse. The reclamation of this dump was accomplished by recontouring the area and sealing the outer edges with clay. Drainage was provided throughout the area by constructing drain tile along the edges and providing the necessary catch basins. Subsequently, the area was covered with clay to prevent seepage of water into the pile. The area was planted to various grasses and currently serves as a recreational area for Clymer Borough. The method of transporting, spreading, and compacting the soil is shown in figure 18. The completed project is shown in figure 19.

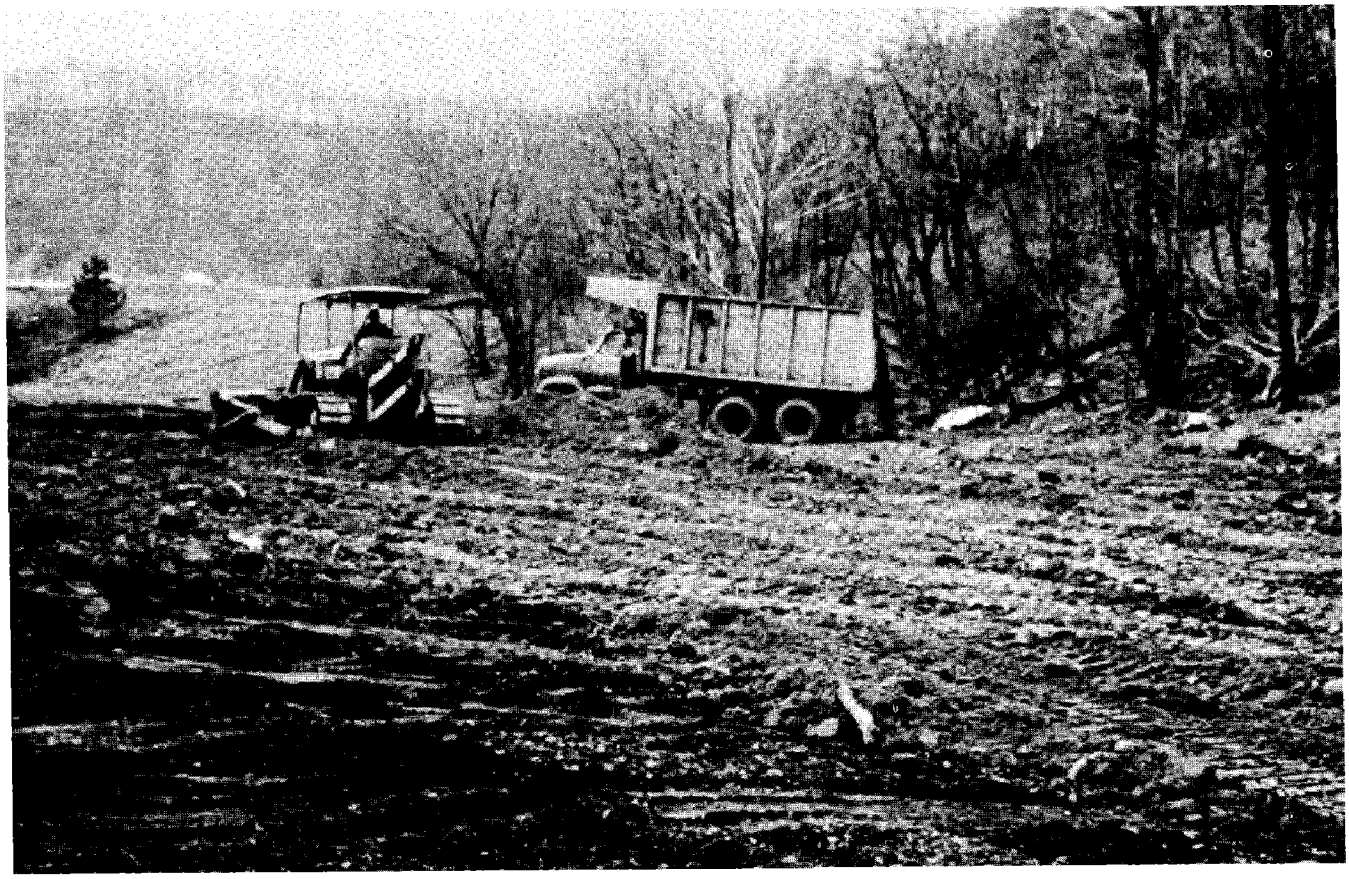

FIGURE 18. - Clymer Borough Reclamation Site. Transporting, spreading, and compacting of soil cover.

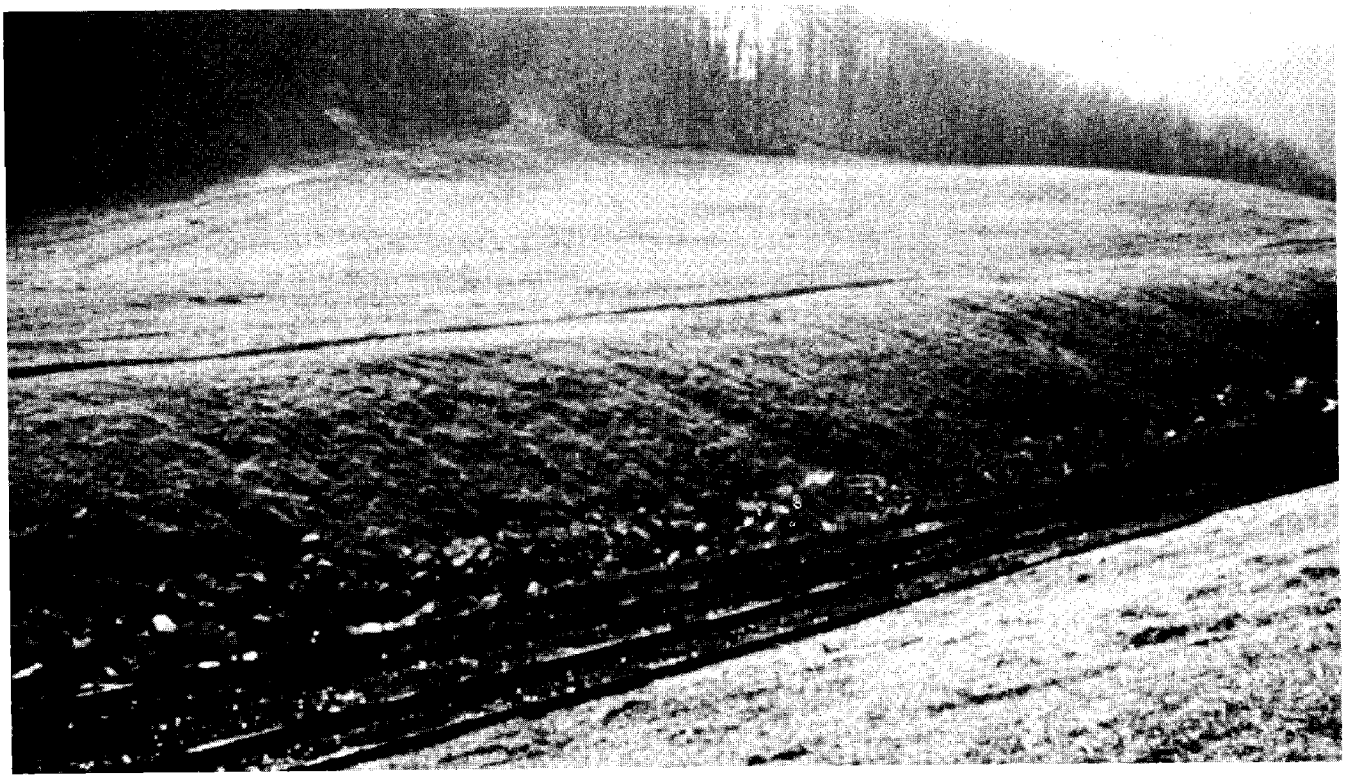

FIGURE 19. - Clymer Borough Reclamation Site. Completed project.

## Panther Tipple Project

Reclamation of the Panther Tipple coal refuse bank in Centre County was undertaken as a demonstration project for the control and abatement of acid water by using wastes from the limestone industry.

The Panther Tipple coal refuse bank occupied about 6 acres of land. It had an average height of 60 feet and was estimated to contain 581,000 cubic yards of material.

Drainage from the refuse bank, located at the bottom of a draw, was adding pollution to Beech Creek. The bank discharged acid water during periods of high precipitation. This problem was attacked by placing a 1-foot layer of limestone waste on the surface of the graded refuse pile before placing the soil cover material. The purpose of this was to neutralize the material at the outer surface of the refuse bank so that it would enhance the growth of the cover grasses. The results were very successful. Two hundred tons of lime sludge were obtained at no cost. It was hauled 40 miles from a limestone plant to the Panther Tipple project by coal trucks that were returning to the active mine operation after coal deliveries. Figure 20 shows a portion of the refuse bank prior to reclamation. Soil preparation prior to seeding is shown in figure 21.

FIGURE 20. - Panther Tipple Reclamation Site. Refuse bank prior to reclamation.

FIGURE 21. - Panther Tipple Reclamation Site. Soil preparation prior to seeding (white surface is pulverized limestone).

FIGURE 22. - Unity Township Reclamation Site. Reclaimed area planted to grass.

## Unity Township Project

The Unity Township project was initiated to eliminate water infiltration and acid water run-off from a refuse bank into Monastery Run. The refuse bank occupied 7 acres and was about 30 feet high. As in the previously described projects, the bank was leveled and graded, drainage systems were installed, and the soil cover was treated and planted. The results of the reclamation are shown in figure 22.

## CONCLUSIONS

Reclamation methods of hauling, spreading, compacting, soil covering, and planting are standard for both private and Government projects.

The application of reclamation equipment including trucks, carryalls, bulldozers, and scrapers vary only in size.

Industry costs for the same type of reclamation differ because some companies use equipment already available; others purchase equipment specifically for the reclamation project, which must be charged to the operation.

Costs for Government-sponsored projects, as reported, were greater than those of private companies because all of the reclamation work was performed by contractors who must import labor and equipment and purchase soil cover.

Industry planting and seeding directly on soil cover without benefit of conditioners was the least costly but resulted in a low survival rate.

Reclamation using mechanical equipment to condition and plant on soil cover was the most costly but produced the highest survival rate.

Coal mine refuse reclamation projects properly planned and implemented produce results that prevent air, water, and land pollution.

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