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COST OF RECLAMATION AND MINE DRAINAGE ABATEMENT - ELKINS DEMONSTRATION PROJECT

By

Robert B. Scott, Ronald D. Hill & Roger C. Wilmoth

WATER QUALITY OFFICE
ENVIRONMENTAL PROTECTION AGENCY
Robert A. Taft Water Research Center
Cincinnati, Ohio 45226

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Acid mine drainage, discharging from coal beds, has polluted our streams and rivers since early time. These pollutants affect water quality by lowering the pH, reducing natural alkalinity, increasing total hardness, and adding undesirable amounts of iron, manganese, aluminum and sulfates. The tangible damages are the costs involved in replacing equipment corroded by the acid water, additional treatment costs at municipal and industrial water treatment plants, and damages resulting from corrosion of steel culverts, bridge piers, locks, boat hulls, steel barges, pumps, and condensers. Intangible damages, which are real and important, include destruction of biological life of the stream, reduced property values, and streams rendered undesirable for recreational uses.[1]

The major problems of mine drainage occur in the anthracite and bituminous coal regions in Appalachia. However, many of the western mining states have significant mine drainage problems in specific areas, but the overall problem is not as great as in the eastern states.

Pollution studies in Appalachia have revealed that inactive underground mines contribute 52 percent of the acid, active underground mines 19 percent, inactive surface mines 11 percent, and active surface mines 1 percent. Most of the remaining sources are in combination surface-underground mines.[2]

A conclusive report on acid mine drainage was issued by the Committee of Public Works of the U. S. House of Representatives in 1962.

The report pointed out the extent of the problem and stated that elimination of this form of pollution would restore vast quantities of water for municipal and industrial use, propagation of fish, aquatic life, wildlife, and recreational purposes. Previously, methods to abate acid mine drainage had been abandoned because of high costs and technical failure. The committee concluded that mine sealing was the most promising method.[3]

The report recommended: (1) a sealing program directed at sealing abandoned mine shafts and other drainage openings, (2) stepped-up research programs by federal, state, and interstate organizations to develop other abatement measures, and (3) a stream and acid flow regulation program employed where sealing or other methods are unable to sufficiently reduce the acid content of the stream to meet water quality requirements for all legitimate purposes. Funds for a demonstration program were authorized by Congress in 1964.

In March 1964 the first demonstration project site was selected in the Roaring Creek-Grassy Run watersheds near Elkins, West Virginia. The project was a cooperative effort between federal agencies and the State of West Virginia. The selected watersheds lie side by side. One, Roaring Creek, covers about 28 square miles and the other, Grassy Run, about 4 square miles. Both drain into the Tygart Valley River in the Upper Monongahela and Ohio River Basins.[4]

The site is roughly a rectangular area at elevations from 1,850 feet at the mouth of Grassy Run to 3,660 feet on the southeast rim of the Roaring Creek Watershed. The topography is hilly and rough.

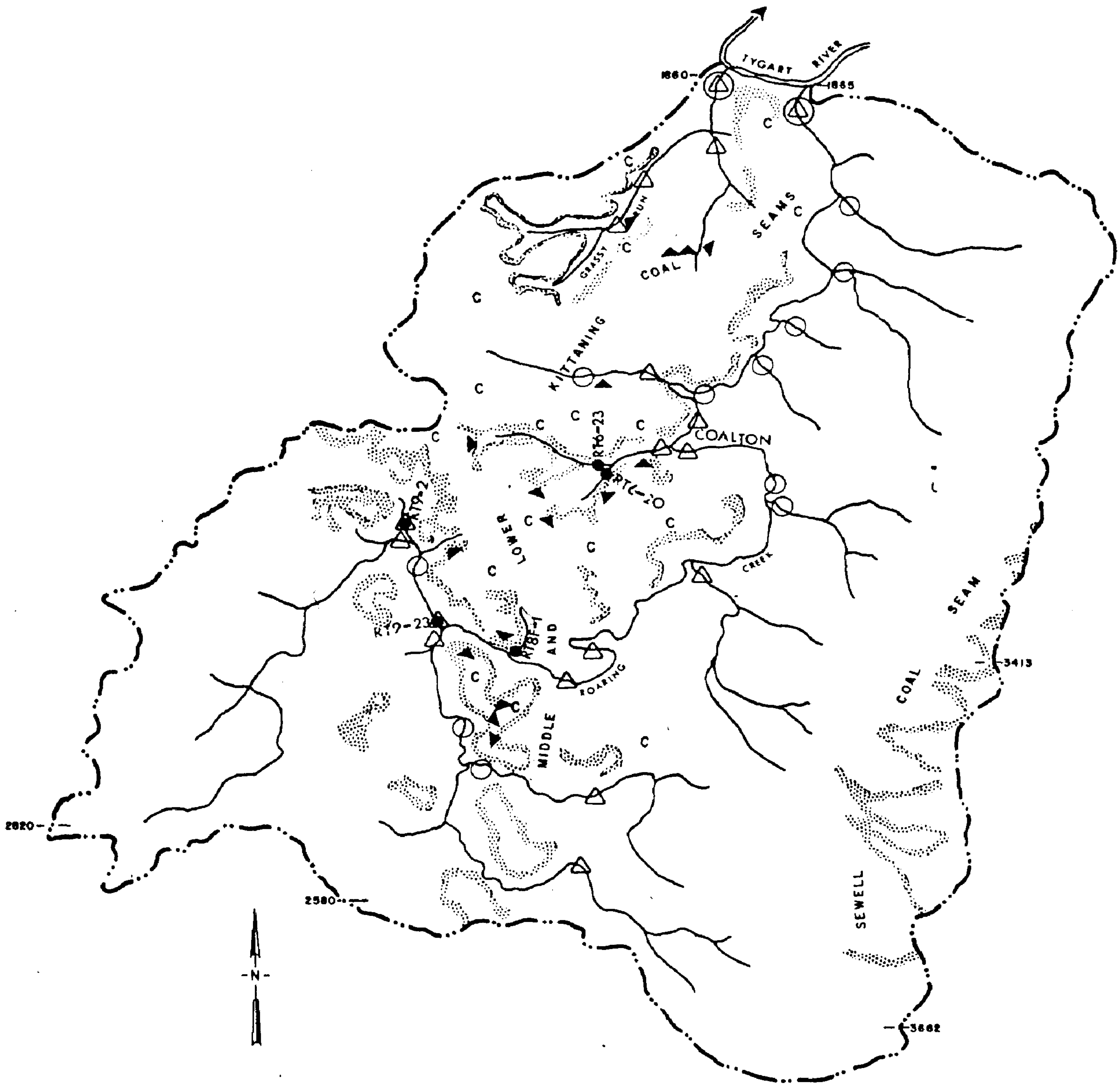
The area contains a large, pillared drift mine (3,000 acres, Kittanning seam), and a number of smaller underground mines (Figure 1). The outcrop had been extensively surfaced mined and contained over 1,000 acres of disturbed land. The surface mines intercepted the underground mine workings of the large mine and diverted water into it. Since the coal dipped from the Roaring Creek watershed toward the Grassy Run watershed, water was diverted from one watershed to the other through the underground mine, resulting in a flushout of pollutants.

Roaring Creek and Grassy Run were discharging over 12 tons per day of acid into the Tygart River. Chemical characteristics of the two streams are presented in Table I.

Table I
Water Quality Characteristics[a]

	Grassy Run		Roaring Creek	
	mg/l	Tons/day	mg/l	Tons/day
pH[b]	2.55	-	3.3	-
Acidity, (Hot), $CaCO_3$	656.	10.6	110	1.8
Iron, Total	110	1.8	5	0.08
Iron, Ferrous	4	0.06	1	0.01
Sulfate	992	16.0	168	2.7
Hardness, $CaCO_3$	446	7.2	99	1.6
Calcium, $CaCO_3$	293	4.7	76	1.2
Aluminum	38	0.6	12	0.2
Specific Conductance[c]	1,723	-	530	-
Flow[d]	6	-	40	-

a. Average values for period March 1965 to June 1966
b. Unit not mg/l, median value
c. Units - Micromhos per cm
d. Units - Cubic feet per second



Demonstration Project No. 1

FIGURE 1

Randolph County, West Virginia

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SCALE

LEGEND

- ● SUBWATERSHED
- C Core drilling site
- Permanent streamgage & quality monitor
- △ Temporary streamgage
- ○ Stream quality sampling point
- Stripmine disturbance
- Mine entrance

Work on the demonstration project was carried out in three phases: (1) site selection, preconstruction evaluation, and reclamation planning, (2) construction of mine seals and regrading and revegetation of surface mines, and (3) project evaluation. Phase 1, begun in March 1964 and completed in July 1966, was devoted to water quality surveillance (FWQA); stream gaging (USGS); surface mapping, investigation of mine conditions, and designing control measures and reclamation planning (USBM); securing land permits (W. Va.); and awarding the construction contract (FWQA, USBM). Sealing of the mines and concurrent reclamation measures (Phase 2) were begun in July 1966 and terminated in September 1967. Disturbed areas were revegetated in the spring of 1968. Phase 3, evaluation of the effectiveness of mine sealing and reclamation measures, is continuing.

Control Measures

During the period of Phase 1, control measures were planned as follows:

1. Air sealing of the underground mine was to be accomplished by filling all boreholes, subsidence holes, and other passages into the mine. "Wet" mine seals, which allow water to leave the mine, but prevent air from entering, were to be constructed at all openings discharging water. Air sealing should prevent oxygen from entering the mine, which would stop the oxidation of pyrite in the mine and reduce the production of iron and acidity.

2. Water is the transport media for carrying acid and iron from the mining environment. Therefore, water diversion would reduce

the amount of water passing through a source or underground mine, thus reducing the amount of pollution. This was to be accomplished by filling subsidence holes, rechannelling streams to establish drainage away from the mines, and constructing solid "dry" seals in portals through which water could not pass.

3. Acid producing spoils and refuse were to be buried whenever possible in surface mine pits to eliminate a major contributor to pollution.

4. Surface mine reclamation was to be performed by regrading strip mine areas to establish drainage away from the mining area and reduce the time the water would be in contact with acid producing material. During regrading, attempts were made to bury the highly acid material.

5. All disturbed areas were revegetated to prevent erosion and stabilize the backfills.

Both "wet" and "dry" seals were constructed from two courses of flyash blocks and coated with urethane foam on both sides to protect the blocks from acid attack. The mine opening was timbered on both sides of the seal to keep the weight of the roof off the seal. Dry seals consisted of one wall, while the wet seals had two or three walls. For the wet seals, one wall was solid except that two blocks were removed from the bottom, the outer wall was approximately 5 feet from the seal, and 2½ feet high. Only two seals had an inner wall which was 12 feet from the seal and 2½ feet high. The latter two walls formed a pool which prevented air from entering the mine. Clay seals were used in areas where the highwall was badly fractured and deep mine workings lay behind the wall. For this type of seal, clay was compacted against the highwall to a height well above the underground mine workings.

Three types of backfills were used on the surface mines --- contour, pasture, and swallow-tail. For a contour backfill, the spoil was graded back as close as possible to the original contour of the land. Usually the top of the highwall was pushed down to complete the backfill. In constructing the pasture backfill, the spoil was graded to form a small slope away from the highwall and the highwall was left standing. The pasture type backfill was used when the highwall was sound. The swallow-tail backfill was similar to the pasture backfill except that a waterway was constructed parallel to the highwall. The waterway was located away from the highwall and final cut which allowed the water to drain over the outer slope at specified low points on the backfill. When possible, soil low in acidity was hauled in and placed on top of the backfill to establish revegetation and reduce acid production. Most of the subsidence holes within 100 feet of the highwall were filled with soil during the backfilling operation.

The project was not completed as originally planned as no reclamation took place in the Grassy Run watershed and north of Coalton, West Virginia, in the Roaring Creek watershed (Figure 1). Practically all the work was performed on the south half (up dip side) of the major mine (3,000 acres) and dealt primarily with water diversion, surface reclamation and air sealing. This change in plans meant that the major mine would not be air sealed. However, a small isolated mine had been sealed and would be available for evaluation. Thus, any improvement in water quality would occur only in the south portion of the Roaring Creek watershed and would give the effectiveness of water diversion and surface mine reclamation and the effectiveness of air sealing and water diversion on a smaller mine. Results of reclamation on the project with respect to water quality have been reported previously. (3) (5)

A summary of the work performed is presented in Table II.

Table II
Reclamation Work Performed

Reclamation	
Surface Mines Reclaimed	12.5 Miles
Backfill, Total	3.6 Million Cu. Yds.
Subsidence Holes Filled	450
Mine Seals	101
Grass Planted Only	322 Acres
Grass Hydroseeded Only	16 Acres
Trees Planted Only	57 Acres
Hydroseeded Grass & Trees Planted	195 Acres
Grass and Trees Planted	120 Acres

Cost Analysis Procedures

The reclamation contract was entered into on June 30, 1966, at an estimated cost of $1,640,382. This contract did not include revegetation nor the filling of subsidence holes beyond 100 feet from the highwall. Due to the many unknown conditions existing in the heavily mined-out areas, the contract was a cost plus fixed fee type.

It was apparent in late summer of 1967 that the entire project would exceed the original estimates, therefore a modified plan was adopted to restrict the first stage of work to the south portion of the mine.

Daily records of labor and equipment were kept by the contractor for work performed on each work area in the project. Attached is Exhibit 1 which shows cost analyses breakdown for (A) Clearing and Grubbing, (B) Reclamation Operation, and (C) Underground Operation. These data were later transferred onto computer cards and a computer program developed to obtain the desired cost breakdown.

Indirect Costs

Indirect costs included everything not directly applied to the work areas, such as office work, supplies, etc., and were distributed to the various work areas on a cost basis. For example, if ten percent of the direct costs were charged to Area 2, then ten percent of the indirect costs would also be charged to that area.

Cubic Yards and Acres

Approximately 650 acres of surface mine were reclaimed during the reclamation contract.

Aerial photographs were taken of the project area during the planning stage and were used to develop contour maps showing the finished grade, acreage, and cubic yards of earthen material to be

Exhibit 1
Cost Analyses Breakdown Codes

A. CLEARING & GRUBBING

1. Cutting & Clearing
2. Grubbing & Clearing
3. Cutting Landowners Timber
4. Handling Landowners Timber
5. Chipping & Hauling
6. Fire Detail
7. Root Rake Hauling
8. Access Road Grading
9. Cleaning Pits & Pit Mouth Entry
10. Drainage Grading
11. Down Time
12. Reporting Time
13. Routine Maintenance

B. RECLAMATION OPERATION

1. Cleaning Pit
2. Cleaning Face of Highwall
3. Scraping SL from Soilbank
4. Backfilling a. pasture b. contour c. swallowing
5. Compaction
6. Subsidence a. drilling & shooting
   b. hauling material
   c. dozing d. shovel
7. Moving Equipment to Area
8. Drainage, Structure Grading
9. Grading Work Sites
10. Drainage Grading
11. Down Time
12. Reporting Time
13. Maintenance
14. Grading Roads
15. Cleanup of Garbage
16. Ditching
17. Borrow Pit a. hauling
18. Carbonaceous Material b. burying
   c. dozing

C. UNDERGROUND OPERATION

1. Cleaning & Temporary Timbering
2. Removal Temp. Timber & Erecting Perm. Timber
3. Concrete Footer Seal Location
4. Provide hitches in roof & ribs at seal location
5. Erect Seal
6. Coat seal inbye side with bitumastic
7. Seal perimeter with Urethane Foam
8. Install rigid plastic tubing
9. Pumping Operation
10. Ventilation
11. Down Time
12. Reporting Time
13. Routine Maintenance
14. Hauling material & supplies to work sites
15. Dismantling & assembling equipment
16. Drilling, blasting, etc.

moved for specified types of backfill on the work areas. Upon completion of the contract, a land survey was made of each work area to determine the total acreage and cubic yards of material moved.

Accuracy of the backfilling quantities is somewhat limited because of the necessity of moving backfill material two or three times in an attempt to separate the toxic spoil from the non-toxic fill material and burying it in the strip pit.

Revegetation

A contract in the amount of $205,911 was awarded to the Tygarts Valley Soil Conservation District on a cost reimbursable basis in September 1967 to revegetate the reclaimed work areas on the project. In the spring of 1968 approximately 710* acres of land distrubed during reclamation were revegetated. Soil samples were taken and analyzed as a guide to the fertilizer and lime requirements and for choosing the best type of vegetation. The District completed the revegetation of the project in one growing season instead of two as originally planned, reducing the contract cost for revegetation to $177,727.

The contractor was required to make a cost analysis at the completion of the contract, therefore accurate and complete records were kept on all phases of work as it progressed. Actual labor and equipment hours expended each day were recorded by work areas. In addition, a daily record was kept of all lime and fertilizer applied and all grass seed and tree seedlings planted in each work area. This

*Increased revegetation acreage due to revegetation of certain disturbed areas which did not require prior reclamation.

was further broken down as to method of application, for example, truck spreading or box spreading of fertilizer and conventional method or hydroseeding of grass seed. In addition, a record was kept of the species of grass seed and tree seedlings planted in each work area.

Each month a summary was made of all data compiled during that month and a cumulative total made of labor and equipment hours and material applied to each work area. Foremen's time and overhead costs were distributed to the different work areas on a basis of direct labor hours worked in each area during the month. Vehicle rental distribution was based on actual hours equipment was used on each work area during the month.

DISCUSSION & RESULTS

Cost of surface mine reclamation, mine sealing, and revegetation is presented in various ways in this report for purposes of estimating cost of future reclamation work. An average overall cost, including both direct and indirect charges, is calculated for surface reclamation and mine sealing. Data are presented in Tables III - IX. Since direct cost (labor, equipment useage, and material) will vary on different reclamation projects depending on the condition and location of unreclaimed area, certain work areas on the project with a variety of working conditions and different types of backfill and seals, were selected for a special study. Data from this study are presented in Tables X and XI. All data from the selected work areas will be designated (SWA).

Costs on these selected areas are shown two ways: (1) without clearing and grubbing to give cost of reclaiming recently mined, unrevegetated areas which would require no clearing and grubbing prior to reclamation and which would reclaim the land to satisfy most existing state mine laws, and (2) including clearing and grubbing to give a cost picture of reclaiming old abandoned strip mine areas which are overgrown with vegetation and would require clearing and grubbing prior to reclamation.

Since equipment rental was a main item of expense (40 percent of the total cost) on the reclamation work, equipment costs were analyzed to determine the best and most economical equipment utilization for each type of work.

Equipment Summary

During the period of the reclamation contract, twenty-six pieces of equipment were leased by the contractor on a monthly basis to perform the reclamation work on the project. The lessor was to be notified by letter thirty days prior to terminating the lease on any of the equipment.

Table III lists the equipment that was utilized during reclamation and shows the work hours, cost per hour, and range of cost per hour for each particular type of unit used.

Range of cost varied considerably for the D-9 dozers due to the necessity for keeping certain dozers on rental during periods of adverse weather. For example, the dozer which showed the highest cost per hour ($79.86) was on rental during four winter months and, because of bad weather, was utilized only 144 hours during the rental period. If this equipment had not been kept on rental, the lessor would have moved it from the project making it unavailable for spring operation.

The LeRoi air compressor was rented for one month but after only sixteen hours of use, it was found to be insufficient for the job; therefore the average cost was extremely high at $100.00 per hour.

The 977 traxcavators were used as a combination hi-lift to explore the strip pits for buried deep mine openings and as a root rake to clear areas prior to backfilling. Utilizing this equipment during the winter months was difficult which resulted in considerable variation in the cost per hour as shown on Table III.

The Koehring shovel was operated at an average cost per hour of $24.21 and was used for stream channeling and establishing drainage from

Table III

RECLAMATION PROJECT
Cost Breakdown

Summary of Equipment Time

Type Equipment	No. of Pcs.	Work Hours	Total Cost	Avg. Cost Per Hour	Range in Cost Per Hour
600 Motor Grader	1	481	$ 10,385	$21.59	0
TD-25 Dozer	2	2,678	29,636	11.06	$ 7.47 - $17.14
D-7 Dozer	1	2,492	28,259	11.34	0
D-8 Dozer	2	2,851	28,358	9.94	8.50 - 10.31
D-9 Dozer	6	10,859	237,360	21.86	12.63 - 79.86
Koehring Shovel	1	951	23,024	24.21	0
Compactor	1	560	16,100	28.75	0
977 Traxcavator	3	5,615	63,315	11.27	7.71 - 16.97
DW-21 Pan	2	3,818	55,883	14.64	14.30 - 14.99
Scraper Pan	2	1,048	25,195	24.04	11.81 - 30.55
John Deere Crawler	1	1,892	4,162	2.20	0
Air Tract Carrier & Attachments	1	396	10,363	26.17	0
Compressor	2	2,294	17,478	7.61	6.27 - 8.94
105 LeRoi Air Compressor	1	16	1,600	100.00	0
Totals	26	35,951	$551,118		

work areas. In February 1967 the shovel was damaged by a highwall fall and was down for repairs for the remainder of the project.

The scraper pans were used mostly in work areas requiring compacted backfill and thus had limited use.

The grader was used exclusively to maintain haulage roads to and from the work areas at an average cost of $21.59 per hour. The compressor, air tract, and crawler were used mostly for underground work pertaining to masonry seals.

Clearing and Grubbing

The first work actually performed on the project was the clearing of certain areas which were covered with volunteer trees and other vegetation established over the 25 years since stripping. This was done to prepare the land for the backfilling and sealing operations and was designated as Clearing and Grubbing.

The following work was performed during this operation:

1. All trees with a diameter less than four inches, measuring 12 inches from the ground, were uprooted, cut, and burned.

2. All trees with a diameter greater than four inches were cut, trimmed to saw log lengths, and stockpiled at a convenient location for the property owner.

3. All stumps and brush were uprooted and burned.

4. Boulders and rocks large enough to impede revegetation were buried in the spoil near the outer slope.

Average overall cost for clearing and grubbing was $330/acre or 16.6 percent of the total cost for surface mine reclamation (excluding revegetation). An average of 32 labor hours/acre was required to clear and grub (Table IV). These costs were higher than originally estimated, partially due to the dense forest in some areas and the extra handling to cut pulpwood for the landowners. Average direct cost (SWA) varied considerably with respect to type of backfill performed on the work areas. For example (see Table X), the average cost/acre for clearing and grubbing prior to contour backfilling on Areas 27, 28, and 44 was quite high and ranged from $127/acre to $367/acre. High costs were incurred in areas containing a fractured highwall. A portion of the highwall was unsafe and had to be cleared so it could be pulled down. Also the material was needed for fill. Generally, low costs were noticed in pasture and swallowtail backfill operations and in stripped areas where toxic spoil had prevented dense foilage and where it was not necessary to disturb vegetation on the highwall.

Surface Mine Reclamation

The average cost for surface mine reclamation was $1,658/acre. Cost of moving earth was $0.35/cubic yard (Table V). These costs are higher than those reported by the U. S. Bureau of Mines for surface mine reclamation at Moraine State Park in Pennsylvania.[6] In their report, the cost/acre for two areas was $780 and $1,402. The average earth moving cost was $0.16/cubic yard. Labor hours (39/acre) were the same for both projects.

The average direct cost (SWA) for surface mine reclamation varied from a low of $472/acre on contour backfill to a high of $1,130/acre for a combination of pasture-contour backfill (Table X).

Average direct cost (SWA) per acre for pasture backfill reclamation was higher than contour backfill costs, an unexpected result. Further studies showed that, in general, the spoil was more highly toxic in the pasture backfill areas than in the contour areas. Because of its toxic nature, the spoil had to be moved several times, thus increasing the cost.

Swallowtail backfill, because of additional earth work, was slightly more costly than pasture backfill.

High costs for all phases of reclamation for a combination of pasture and contour are due to complex problems that existed in the work areas including the six conditions given below:

1. Unknown interrelated conditions between the strip and underground mines which made it necessary to spend considerable time opening up the pit to locate fractures and openings into the underground mine.

2. The contractor was required to separate the toxic spoil from the nontoxic backfill material where feasible and bury the toxic material in the strip pit. This required moving the material two or three times in some areas. As a result, the amount of earthen material actually moved greatly exceeded the 3,060,000 cubic yards determined from before and after cross sections.

3. Approximately 17 percent of the total backfill material moved was used for excavation material to fill subsidence holes on top of the highwall and as clay compacted material for seals.

4. It was necessary in many work areas to establish drainage by rechanneling streams from strip mines prior to reclamation.

5. Adverse weather conditions during the winter months hampered the reclamation work on the project and necessitated payment of rent on equipment which could not be utilized.

6. The highwall, in many instances, was fractured to the extent that it could not be left standing. In such cases, the wall was pulled down and the material used to complete the backfill.

Table IV
Clearing and Grubbing Costs for 651 Acres

	Cost	Hours
Direct Labor, Total	$ 72,662	21,468
Direct Labor, Average/Acre	$ 112	32
Equipment, Total	$ 38,329	3,461
Equipment, Average/Acre	$ 59	53
Direct Cost, Total	$110,991	
Indirect Cost, Total	$103,518	
Total Cost	$214,509	
Average Cost Per Acre	$ 330	

Table V
Surface Mine Reclamation Costs for 651 Acres
-3,060,000 Cubic Yards Moved -

	Cost	Hours
Direct Labor, Total	$ 96,884	25,558
Direct Labor, Average/Acre	$ 149	39
Equipment, Total	$ 457,706	26,028
Equipment, Average/Acre	$ 703	40
Direct Cost, Total	$ 554,590	
Direct Cost, Average/Acre	$ 852	
Direct Cost, Average/Cubic Yard	$ 0.18	
Indirect Cost, Total	$ 524,984	
Total Cost	$1,079,574	
Average Cost Per Acre	$ 1,658	
Average Cost Per Cubic Yard	$ 0.35	

Revegetation Costs

The overall cost for revegetating the reclaimed work areas is summarized in Table VI. Average direct cost was $200/acre and total cost $248/acre.

Cost varied considerably depending on the type revegetation work performed. Higher revegetation costs were incurred (Table VII) in steep areas where it was necessary to use a hydroseeder. This also increased cost (SWA) in contour backfill areas (Table X). The more level areas on which conventional equipment could be used were revegetated at a much lower cost.

Masonry Seals

Forty-three dry masonry seals and 12 wet seals were constructed in the entries to abandoned drift mines at an average cost of $4138/seal (Table VIII).

High equipment cost was attributed to the exploration of the strip pit to locate mine openings and to clearing debris from openings at the face of the highwall. Preparation of seal sites, such as timbering and clearing debris from the seal sites in the mine, was performed manually.

The average direct cost (SWA) for dry seals and wet seals is presented on Table XI and shows that wet seals cost about twice as much as dry seals. Cost of dry seal on Work Area 8 was considerably higher than cost of other seals due to high labor cost involved in opening and timbering the portal prior to constructing seal.

Clay Seals

In areas where the highwall was badly fractured and the stripping operation had intercepted the deep mine workings, openings were sealed by compacting clay against the openings and the highwall with a vibrating sheeps foot compactor. Although 41 openings were sealed this way, data were recorded only for Work Areas 1-9 and 10. These data are summarized in Table IX. The cost/seal in Work Area 10 was higher than in Areas 1-9 due to haulage distance from the borrow pit to the seal site.

Table VI

Revegetation Cost for 709 Acres

	Cost	Hours
Direct Labor, Total	$ 31,860	9,539
Direct Labor, Average/Acre	$ 45	14
Equipment, Total	$ 17,493	4,365
Equipment, Average/Acre	$ 25	6
Material Cost	$ 45,190	
Hydroseeding Contract Cost	$ 47,475	
Direct Cost, Total	$142,018	
Direct Cost, Average/Acre	$ 200	
Indirect Cost, Total	$ 33,709	
Total Cost	$175,727	
Total Average Cost/Acre	$ 248	

Table VII

Cost Breakdown of Revegetation(7)
Dollars/Acre

	Labor	Equipment	Material[b]	Indirect Cost[c]	Total
Conventional Grass[d]	32.65	36.51	63.39	32.07	164.62
Hydroseeding Only[e]	18.23	227.32[a]	61.44	71.49	378.48
Trees Only[f]	39.51	4.20	18.87	21.63	84.21
Hydroseeding Plus Trees[g]	54.47	238.74[a]	76.78	84.93	454.92
Conventional Grass Plus Trees[h]	68.53	23.29	64.80	37.22	193.84

a. Hydroseeding work was subcontracted for $225 per acre which included mulch at one ton per acre.

b. Includes lime, fertilizer, seed, and trees. In some "trees only" areas no fertilizer and/or lime were used.

c. Indirect cost distributed on basis of direct cost.

d. Fertilizer (0.5 ton/acre of 10-10-10), lime (2-4 tons/acre) applied from truck, grass planted by seeder box.

e. Lime (2-4 tons/acre) spread from truck or from farm type fertilizer spreader, hydraulic application of grass seed, fertilizer (0.5 ton/acre of 10-10-10)

f. Hand planted (900-1000/acre).

g. Hydroseeding plus hand planted trees (900-1000/acre).

h. Conventional grass as in d, plus hand planted trees (900-1000/acre).

Table VIII

Cost of 55 Masonry Seals

	Cost	Hours
Direct Labor, Total	$ 65,949	17,932
Direct Labor, Average/Seal	$ 1,199	326
Equipment, Total	$ 50,729	5,602
Equipment, Average/Seal	$ 922	101
Direct Cost, Total	$116,678	
Direct Cost Per Seal	$ 2,121	
Indirect Cost, Total	$110,913	
Total Cost	$227,591	
Average Cost Per Seal	$ 4,138	

Table IX

Clay Compacted Seals

Work Area	No. of Seals	Cu. Yds. Compacted Backfill	Total Cost	Cost per Seal	Avg. Cu. Yd/ Seal	Cost/ Cu. Yd.
1-9	10	10,490	$ 9,500	$ 950	1,049	$0.91
10	6	11,670	$14,160	$2,360	1,945	$1.21

Summary

An acid mine drainage reclamation project was established in the Roaring Creek-Grassy Run watershed near Elkins, West Virginia. During the reclamation, 651 acres of surface mines were reclaimed, 709 acres revegetated, 55 masonry seals constructed, and 41 clay seals installed.

The average overall surface mine reclamation cost was $2236/acre including $330/acre for clearing and grubbing, $1658/acre for reclamation, and $248/acre for revegetation. Overall cost for masonry seals was $4,138 each and clay seals $1,479.

The high costs were due primarily to unknown conditions of the abandoned mines, exploration which was necessary to locate the highwall fractures and openings intercepting the deep mine, and multiple moving of spoil to bury toxic material.

Indirect costs on the reclamation contract appear high due to the inclusion of vehicle rental and foremen's salaries. Because of the data collection system, it was necessary to include these charges, normally considered direct, in indirect costs. A more comprehensive report, to be published at a later date, will present cost data in greater detail.

Stability of the reclaimed area has been exceptional as only eight small subsidence holes have occurred since 1967. Total maintenance costs have been less than $2,000 in the past three years or less than 0.03 percent per year of the construction cost.

Table X

Direct Cost of Surface Reclamation by Various Methods on Selected Work Areas (SWA) on Demonstration Project #1, Norton, W. Va.

Work Area No.	Acres	Type of Backfill	Cost/Acre Reclamation	Type Seeding	Cost/Acre Reclamation + Seeding	Cost/Acre Reclamation + Seeding + Clearing & Grubbing
3	11.9	Pasture	$ 383.	C & H	$ 533.	$ 576.
4	4.7	"	56.	C	140.	174.
5	4.3	"	995.	C	1,126.	1,137.
8	7.9	"	740.	C	840.	1,035.
9	11.7	"	432.	C	523.	559.
37	13.0	"	798.	C & H	912.	1,028.
MEAN	53.5		$ 568.		$ 682.	$ 760.
23 & 24	77.9	Contour	$ 429.	C,H, & T	$ 669.	$ 704.
28	11.0	"	265.	C,H, & T	612.	882.
27	68.0	"	540.	C & H	907.	1,275.
29 & 30	37.7	"	542.	C,H & T	744.	804.
44	26.7	"	410.	C,H & T	684.	812.
MEAN	221.3		$ 472.		$ 754.	$ 918.
1	18.7	Swallowtail	$ 315.	C,H & T	$ 546.	$ 566.
2	40.3	"	706.	C,H & T	815.	843.
MEAN	59.0		$ 582.		$ 730.	$ 755.
10	140.3	Pasture & Contour	$1,060.	C,H & T	$1,236.	$1,425.
11	47.0	"	1,341.	C	1,498.	1,548.
MEAN	187.3		$1,131.		$1,302.	$1,456.

Type Seeding: C = Conventional, H = Hydroseeding, and T = Trees

Table XI

Cost Comparison
Seal Construction
Demonstration Project #1, Norton, W. Va.

Work Area No.	No. of Seals	Type Seal	Direct Cost	Cost per Seal	Maximum	Minimum	Average
2	2	Dry	$4,000.	$2,000.)			
7	3	"	5,298.	1,766.)			
8	1	"	6,376.	6,376.)	$6,376.	$1,358.	$2,212.
14	1	"	1,358.	1,358.)			
27	12	"	23,706.	1,975.)			
30	6	"	14,574.	2,429.)			
10I	1	Wet	$5,031.	$5,031.)			
24	1	"	4,068.	4,068.)	$5,032.	$3,128.	$4,076.
53	1	"	3,128.	3,128.)			

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