RECOMMENDATIONS

GENERAL RECOMMENDATIONS

Introduction:

Coal is a major source of energy and thus a major factor in the economy. Coal mining provides jobs which, along with the income from sales result in initial benefits to the economy of the mining area. Unfortunately, during recovery of the coal we disturb the natural environment. If the mined area is not properly reclaimed, the disturbed and polluted environment can be as detrimental as the original mining activity was beneficial.

Abandoned deep mines produce acid mine drainage when percolating water passes through the disturbed coal and associated strata containing sulfur minerals which are oxidized, picking up the resulting acid and heavy metal compounds and carrying them to surface streams. Abandoned strip mines produce acid mine drainage primarily when surface runoff waters erode the acid spoils and carry the resulting products off into streams. Also some acid is carried in percolating water through the spoil to emerge as wet weather seeps and springs of polluted water. Since the acid production on strip mines is associated primarily with exposed, eroding acid spoil, it comes from a source area rather than a point source, and is thus usually harder to accurately locate for abatement.

General Solutions to the Problem of AMD:

Possible solutions to the problem of acid mine drainage include chemical and physical treatment of polluted runoff waters, and source abatement by numerous techniques designed to prevent the acid formation or its transportation from the mined area including deep mine sealing, acid spoil burial and regrading and revegetation of strip mines.

A number of processes have been studied for the treatment of acid mine drainage waters. The most common methods used on a field scale include a neutralization process, usually using limestone or hydrated lime, followed by some physical process to remove the iron precipitates that form during the neutralization process. The greatest advantage of this approach is that the processes have been proven to produce stream water that will support normal aquatic life. However, this approach has a number of serious disadvantages. First, without putting a treatment plant on every polluted tributary, the total pollution problem cannot be solved. Secondly, on any natural drainage area, the fluctuations in flows which must be handled are so great that a plant capable of handling the peak flows would run at a small fraction of rated capacity most of the time, making it very inefficient, and plants designed to bypass the peak flows may not solve the problem. Flow regulating reservoirs could be used to solve this last problem, but they are expensive and would only create a polluted lake upstream from the treatment plant. Third, this type of treatment increases the hardness of the effluent waters. Finally, the acid and iron in the stream water are not the real source of the problem, and the treatment would be required continuously for as long as the real source continues to exist.

In deep mines the most successful method off source abatement is flooding by sealing all openings which will let water out below the highest point in the workings. This keeps most oxygen away from the coal and gob material except for dissolved oxygen in the water. The method is generally only partially successful because of the difficulty of obtaining an adequate seal on all seepage points. However, to date no better alternative has been developed.

The acid formation is basically a surface phenomona. Once a surface layer of mine spoil has been oxidized it must be removed to expose the next layer in order for the acid formation to continue. In the natural situation on a strip mine, this continued exposure of new material is accomplished by soil erosion. Any reclamation and vegetation which will reduce the rate of erosion of the mine spoil will reduce the rate of acid mine drainage pollution from that area.

The rate of soil erosion which can be tolerated on cropland is much greater than the minimum rate necessary to promote the production of acid on surface mines. Therefore, the level of erosion control needed on strip mined areas is much higher than that required for sediment control.

Experience at Elkins, West Virginia, and on Muddy Creek, upstream from Moraine State Park in Pennsylvania has indicated that a combination of regrading and vegetation with good water management practices can be very beneficial in reducing pollution from surface mined areas. These observations are confirmed in areas in the Big Scrubgrass Creek Watershed where adequate reclamation has been achieved. (See Figures 1 and 25).

The advantages of source abatement for acid mine drainage control are in the long term costs and benefits. The disadvantage is the lack of assurance that it will work in a given situation. The success depends on the interaction of many natural processes occuring on the watershed. Changes in the complex movement of ground water which are difficult or impossible to predict may allow pollution to continue, possibly only moved in location within the mined area. This is particularly possible in deep mine sealing. Seeps from spoil areas on strip mines are scattered and the exact origin of the pollution in the seepage water is difficult to determine. There is no guarantee that surface restoration measures will clean up all seeps. In addition, on strip-mined areas, successful source abatement depends on the development of a good stand of vegetation. Strip mine spoil is a hostile environment for most vegetation and several attempts may be required to obtain a good cover. (See Figure 26). However, particularly in the case of strip mines, reclamation has enough benefits in addition to water quality improvement to make it desirable as a first attempt at acid pollution control so long as there is good evidence to indicate its probable success.

The separation of the three ingredients involved in acid mine drainage formation will prevent the reaction from occurring and thus abate the pollution problem. There is enough water in the form of vapor in the air to cause the oxidation reaction to take place without the presence of liquid water. Therefore, the elimination of runoff water and percolating water from a mined area will not substantially reduce acid formation, although it will retard its transportation to the streams. The most feasible approach to source elimination is to prevent oxidation by covering the acid producing material with neutral soil or by submerging it under water.

Most soils contain soil air with some oxygen content which decreases with depth and which also decreases with increased organic matter content, moisture content and lower permeability. Therefore, soils with a vigorous plant growth in the surface layer will have less oxygen available to react and form acid. This is an important concept in strip mine reclamation. Even in areas where there is little vegetation, very little acid formation occurs below a depth of four feet. Some oxygen dissolved in water will reach buried or flooded sulfur minerals causing the formation of acid, but the maximum concentration of dissolved oxygen in water at normal soil temperatures is so small (about 10 parts per million) that the rate of acid formation would not create an unnatural load on the stream system of the area.

Figure 25. This area on Mine Site No. 33 has been planted with grasses and has developed a good cover which is preventing acid formation on the old spoil material. A few scattered bare spots do exist which should be planted and the area should be treated periodically with lime and fertilizer to insure continued growth and development of the sod.

Figure 26. This area on Mine Site No. 9 on the northern side of Bullion Run was planted to grass. However, an inadequate stand has developed and the area continues to be a source of acid mine drainage. The area should be top dressed with lime and fertilizer and overseeded with grass to fill in the sod cover.

Economic Comparison of Strip Mine Reclamation and Runoff Treatment:

The following economic analysis assumes that strip mine reclamation will be as successful as treatment of the runoff water in improving the stream water quality of the watershed. It is included here to give a general comparison of the long term costs of each.

There are approximately 2200 acres of unreclaimed strip mines in the Big Scrubgrass Creek Watershed. If we regraded and seeded all of this to sod it would cost approximately 2.2 million dollars initially. Amortized over a 20-year period at 5 percent compound interest, this is equivalent to $176,660 per year. Further assuming that during the 20-year period a follow-up application of lime and fertilizer is required every 5 years at a cost of $200 per acre, the average annual cost of this follow-up would be $101,630. At the end of 20 years, the land should be in a natural condition where no additional applications would be required, and the total cost would have been $278,290 per year.

The main sources of pollution on the Big Scrubgrass Creek Watershed are Trout Run, Brink Run, Gilmore Run and the upper reaches of the main stream. These source areas cover a total of 8.6 square miles. The watershed has an average annual runoff of approximately 22 inches per year, so that the total annual runoff from these areas would average 3311.28 million gallons per year. To treat this runoff chemically would cost at least 10 cents per 1000 gallons, or a total annual treatment cost of $331,128. This chemical treatment of the stream would probably be required every year for an indefinite period of time, and even over a 20-year period would have cost $52,840 per year more than the land restoration procedures. Also, current data indicates that the treatment cost could be as much as four times the assumed value of ten cents per 1000 gallons. If both the follow-up applications and the runoff treatment were assumed to continue for 50 years, the annual savings would increase to $108,928 for land reclamation over runoff treatment. Thus, even if follow-up work is required beyond the 20-year period, this method would obviously be cheaper for the watershed.

In the analysis of the watershed, we have determined that part of the 2200 acres of strip mines do not require additional reclamation and therefore, the actual initial cost should be much less than 2.2 million dollars. Likewise, only a small part of the 2200 acres will require follow-up soil treatment, thus adding to the savings. Since the estimated cost of treatment of the runoff water is a very minimum figure, the actual savings realized by using land reclamation on this watershed should be significant.

Strip Mine Reclamation:

The basic approach on strip-mined areas is regrading and revegetation to reduce the surface formation of acid by controlling the amount of acidic material exposed through erosion. The factors which affect the rate of erosion on a watershed are the rainfall intensity, duration and frequency; the erodability of the material, the length of slope from the ridge to the valley, the steepness of that slope, and the condition of the surface. The rainfall and soil factors are natural and virtually unchangeable. The length of slope, steepness of the slope and condition of the surface can be changed by regrading and vegetation.

Vegetative measures which improve the condition of the soil surface in its ability to resist the erosion forces of running water are the most effective methods for control of acid formation and transport. In this watershed, an established grass and legume sod will keep the rate of erosion at an acceptably low level for control of acid formation on slopes up to 20 percent over any length, and on slopes up to 50 percent over lengths of less than 100 feet. An established stand of trees with a complete canopy and a good accumulation of forest litter under it will accomplish about the same level of erosion control as a sod.

The period of establishment of the protective layer is very important. The soil fertility, pH, moisture content and temperature must be kept within limits or the young plants will not survive. Also during this period, the seedbed is unprotected and particularly susceptible to erosion. Heavy overland flows with high flow velocity must be prevented during the establishment period or the seed and seedbed may be washed completely away. During the period of establishment, the pollution problem from the area may be as bad or worse than it was before restoration began. Therefore, it is important that this period be made as short as possible.

An adequate grass and legume cover can be established on a good seedbed in most areas within one growing season. An adequate tree cover takes much longer. Therefore, even in areas where trees are the desired ultimate cover, grasses and legumes are generally recommended for initial revegetation.

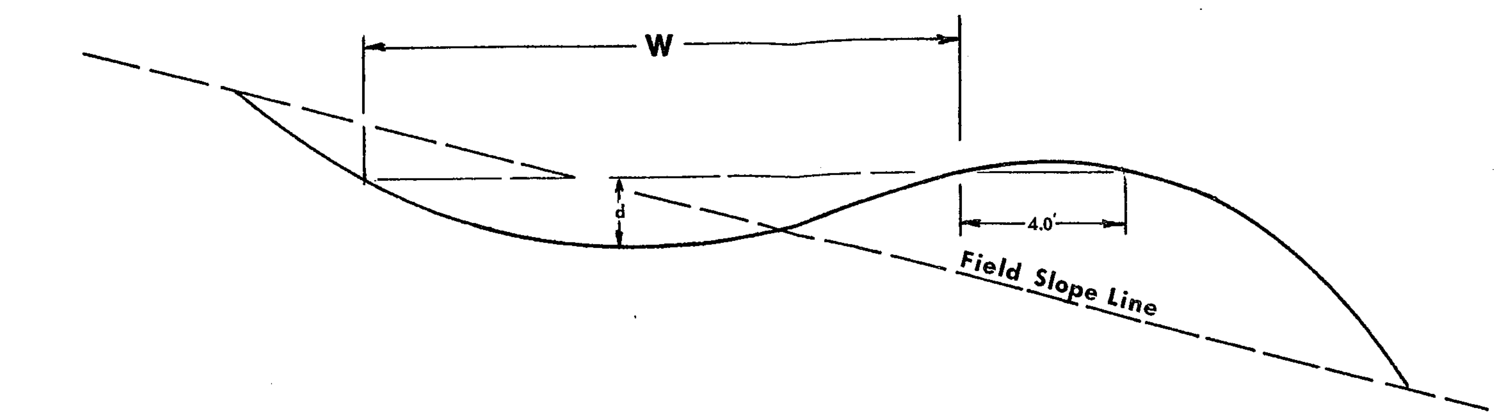
In the Soil Conservation Service report on sediment and erosion control for the Big Scrubgrass Creek Watershed a list of soil revegetation method alternatives was included, detailing the type of vegetation and the methods of application recommended. Detailed descriptions of these methods are included at the end of this section of this report, and one or more of these alternatives are recommended for specific areas on each mine site where reclamation is needed. The grasses and legumes recommended will do best on soils that have a pH greater than 4.5, and will need a soil with pH no lower than 4.0 to grow satisfactorily. Where the spoil material has a pH below 4.0, it must either be buried under less acid soil, or limed frequently to maintain the required pH until the plants become well established. On most of the spoil materials some type of organic soil conditioner will be needed to provide an adequate seedbed, and an initial application of lime and fertilizer will be required to achieve satisfactory seed germination. The recommended seeding rates apply to pure viable seed, and increased application rates will be needed for seed sources that have low purity and germination rates.

Seeding should be done in late summer or early spring so that germination can occur during cool weather and the young seedlings can get a start before any hot, dry conditions can occur. Application to control the soil pH should include both hydrated lime for quick response and some coarse ground limestone for longer lasting effect. Soil tests should be used to determine the fertilizer requirements on each individual area. Improper seedbed preparation or timing of seeding could result in wasted money with the area continuing to be an acid source.

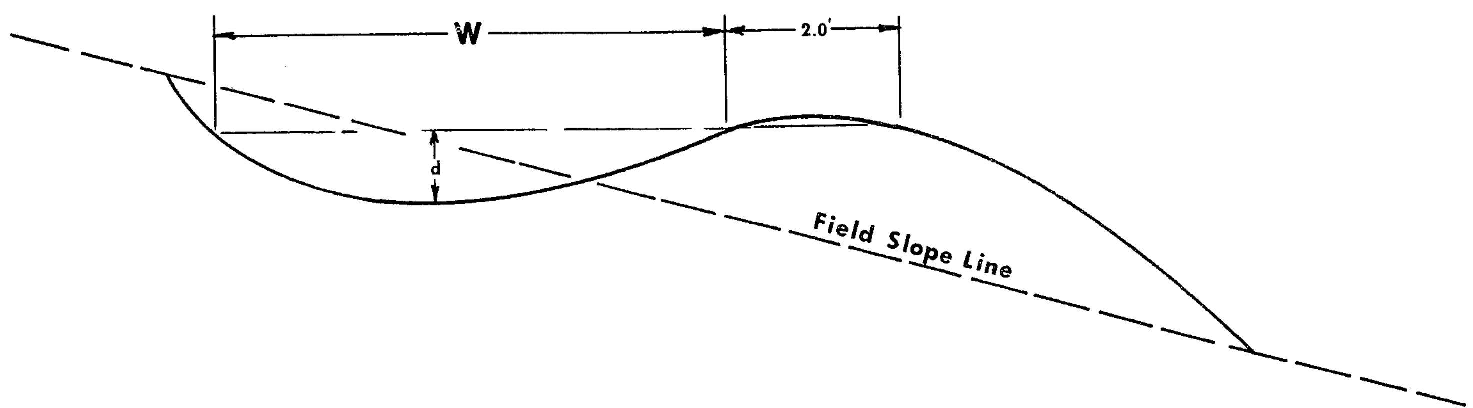
Adequate erosion control through water management practices is essential during the revegetation period to protect the stream system from sediment and acid pollution and to prevent the seed, young plants, and fertile seedbed from being eroded off the slopes. Neglect of this phase of mine reclamation was probably the single most important factor contributing to failure in the past. Adequately designed diversion channels should be constructed at the top of all slopes where there is more than three acres of drainage area. Where possible, the outlets to these diversion channels should be outside the mined areas. Where this is not possible, waterways and drop structures should be provided to carry the water through the disturbed area in a manner which will prevent gully formation. Figure 27 shows suggested design standards for these structures.

Diversions and waterways should also be provided to prevent erosion from runoff water originating within the mined areas. Where the length of slope would exceed 100 feet on slopes less than 20 percent, or 50 feet on slopes greater than 20 percent, diversions should be provided to reduce the slope length to these limits. When constructed on newly disturbed areas they should not have a drainage area greater than 3 acres. Adequate outlets are essential for successful functioning of the system. Figure 27 shows additional suggested design standards for these diversions and outlets.

A system of diversions collects overland flow from a large area and concentrates it in a small channel. When these channels are not designed properly, so that the channel capacity is exceeded frequently or the flow velocities are high enough to cause erosion in the channel, the results can be as bad as having no erosion control system. It is essential that all diversions and waterways be adequately designed to prevent them from becoming points of excessive erosion, and thus sources of acid production.

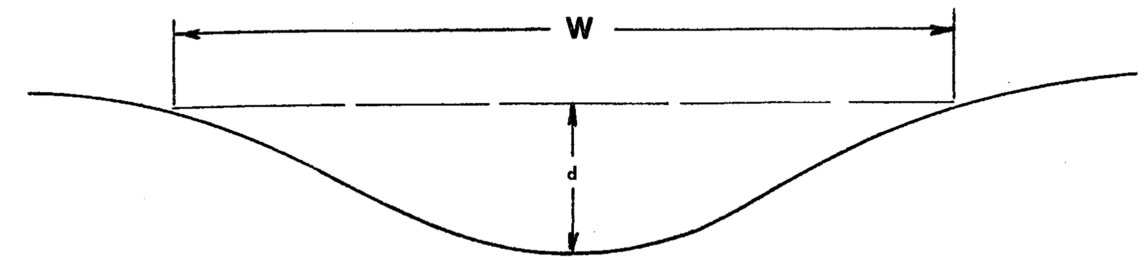


<u>Design Standards for Diversions with Drainage Areas Greater than 3 Acres</u>. Use parabolic cross-section, A = 2/3 Wd, minimum area - 8 ft.^{2} Design for maximum velocity of 4 feet per second, using Manning Equation with roughness factor of 0.03 for peak flow of 2 CFS per acre of drainage area or from specific hydrologic analysis. Maximum depth - 2.0 ft. Maximum channel slope over any 100 ft. section = 2.0%.

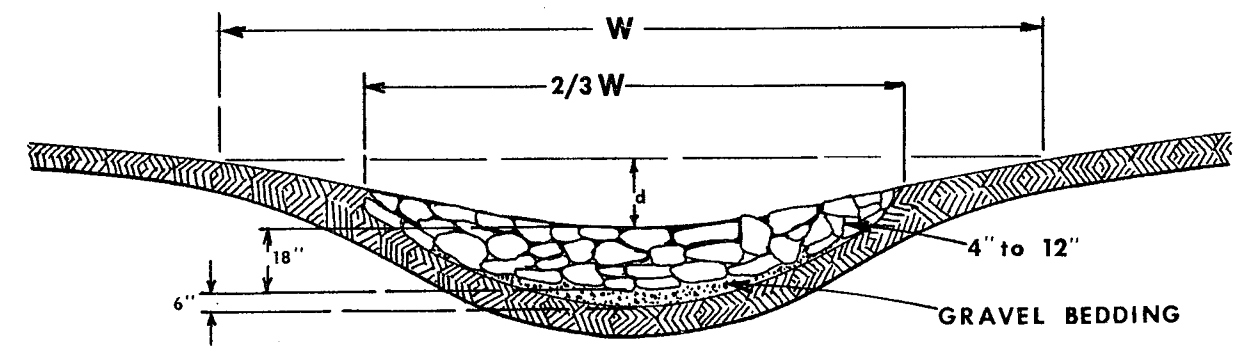


<u>Design Standards for Diversions with Drainage Areas Less than 3 Acres</u>. Use parabolic cross-section, A = 2/3 Wd, minimum area - 3 ft.^{2} Max. Depth = 1.0 ft. Design for maximum velocity of 2 feet per second using Manning's Equation with a roughness factor of 0.03 for a peak flow of 2 CFS per acre of drainage area or from specific hydrologic analysis. Max. Channel Slope - 1%. All areas to be planted with sod at completion of construction.

Hydraulic Radius of a Parabolic Open Channel with Width Much Larger than Depth, R = 2/3 d.



<u>Design Standards for Sod Waterways</u>. Use parabolic cross-section. Design for maximum velocity of 6 feet per second using Manning's Equation with roughness coefficient of 0.02 for a peak flow of 2 CFS per acre of drainage area or from specific hydrologic analysis. Channel to be sodded immediately following construction. Maximum Channel Slope = 12%.



<u>Design Standards for Stone Center Waterway</u>. Use where design standards for sod waterways cannot be met. Where slope exceeds 20 percent use concrete to hold stone in place and provide plunge pool at base of slope for energy dissipation. 25% of rock used should be 12 inch and larger. Maximum slope = 100%. Use corrugated metal drop structure for steeper slopes.

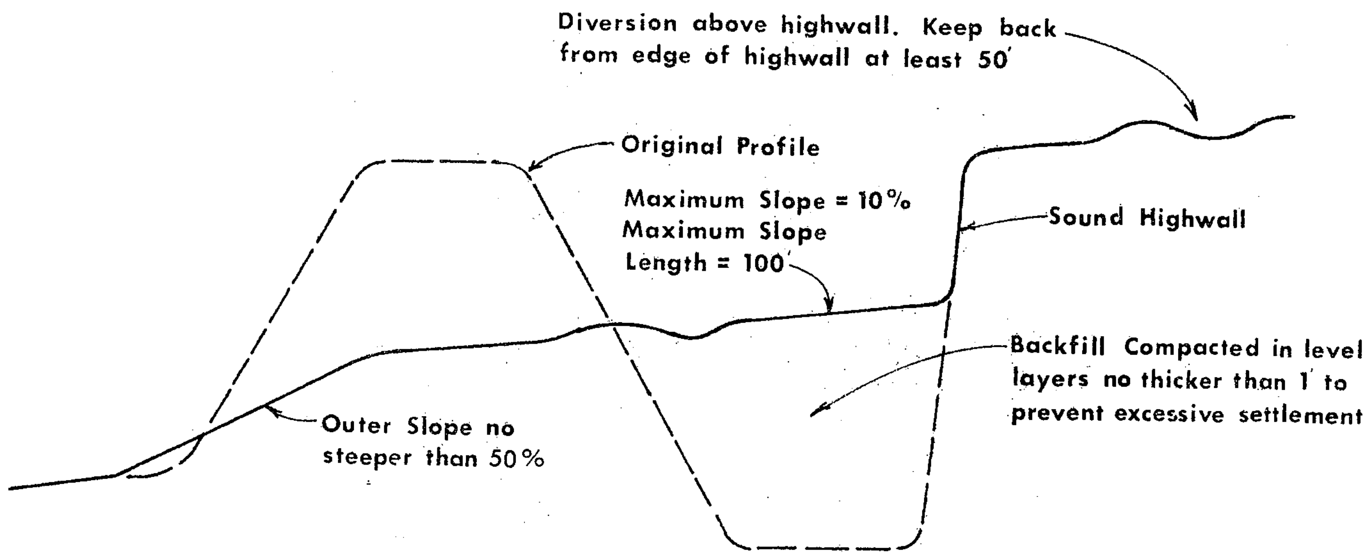
COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES BIG SCRUBGRASS CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT	DESIGN STANDARDS FOR WATERWAYS AND DIVERSIONS	
	PANTECH ENGINEERS, INC.	FIGURE NO. 27

The degree of regrading needed on strip mines is determined by the existing condition causing acid formation. Some regrading may be necessary to bury excessively toxic or stony material which cannot be treated satisfactorily with lime, fertilizer or soil conditioners to provide an adequate seedbed for establishment of vegetative cover. Other areas may require regrading to develop an adequate water handling system. Undrained depressions which collect runoff water and hold it long enough to drown vegetation, and which have a fluctuating water level tend to be acid sources. These areas should be provided with adequate surface drainage by regrading. Stands of vegetation can be established more quickly on areas with uniform topography where a good seedbed can be prepared, and in some areas regrading will be necessary to accomplish this. Regrading is recommended on some areas to improve the erosion resistance in case adequate stands of vegetation do not develop.

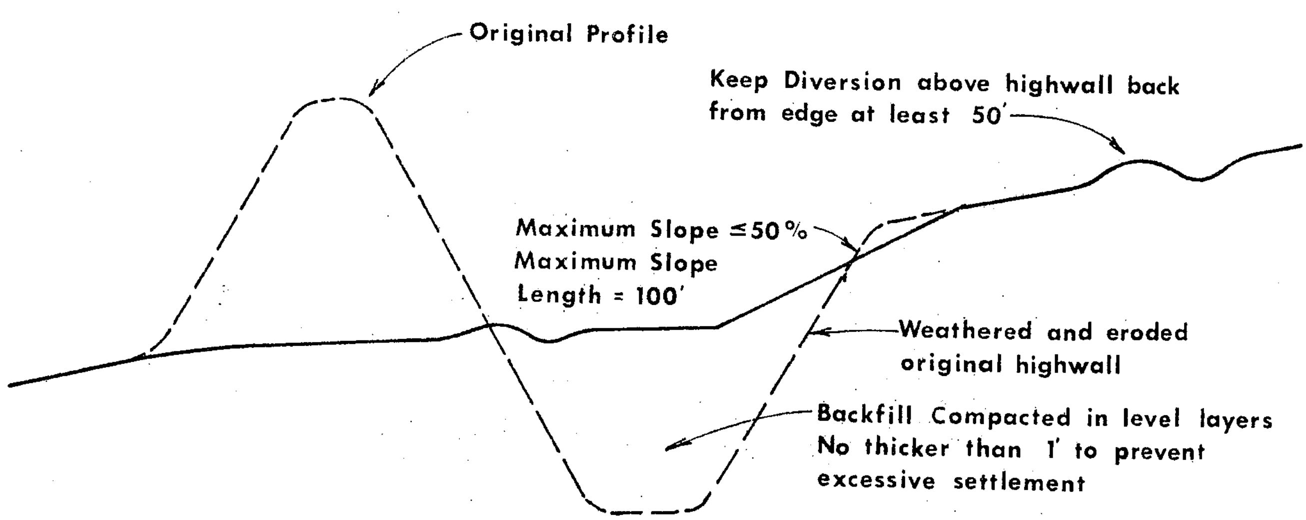
Three types of regrading were considered: contour, terrace, and selected grading.

Contour backfilling involves pushing the spoil to the top of the backfill and regrading to contours which fit with the natural contours of the area as closely as possible. This type of regrading would be recommended where the highwall is weathering badly and is a source of acid production.

Terrace backfilling involves constructing benches of nearly level land with steep slopes between. The high wall



TYPICAL PROFILE FOR TERRACE REGRADING



TYPICAL PROFILE FOR CONTOUR REGRADING

FIGURE 28

would remain standing with drainage away from the base of the highwall.

Selected grading involves only enough regrading to reduce problem slopes and provide adequate water handling with drainage of any depressions which may be sources of excessive infiltration of acid water.

The choice of the type of regrading will depend on the requirements to stabilize the area to eliminate acid formation. Where more than one method would work the one which requires the least amount of disturbance of the existing surfaces should be used, since any disturbance will cause an increase in stream pollution from the runoff water during and for a period following construction. In all cases the final grade should be away from the foot of any highwalls and, except for the rock face of a sound highwall, no slopes within the mined area should be left greater than 50 percent. Where slopes are found to be steeper than this they should be regraded and reseeded. Figure No. 28 shows typical details for regrading methods.

<u>Source Abatement for Deep Mines:</u>

The approximate location of 38 old deep mine openings are shown on the maps included in the subwatershed sections of this report. Most of these were located from strip mine permit applications on file with the Pennsylvania Department of Environmental Resources. Where the stream quality data indicated acid mine drainage problem areas, field checks were made and a number of additional mine openings were found.

These field investigations showed that many of the openings indicated in the strip mine permit applications are no longer visible after the stripping operations were completed, and most others do not show any significant discharges. In those areas where stream quality sampling indicated no acid mine drainage problem, extensive field investigations were not conducted to establish exact locations and conditions of the deep mines.

From the information which was available on deep mining in the watershed, it appears that all the mines were small, and most were operated for family fuel supplies. Also most of these were shallow drift mines in the same seams that were later stripped. Since these mines were in existence before the streams in the watershed became polluted, it can reasonably be assumed that the strip mining, rather than abandoned deep mines, is the source of most pollution. With several minor exceptions, the field investigations have justified this assumption. Some deep mine sealing may be beneficial, but the amount of pollution involved gives this work a low priority in the overall pollution abatement plan. Most of these sources are located in areas where the major receiving streams are net alkaline, further reducing their overall importance in the project.

Where deep mine openings have significant acid discharges the particular situation should be investigated in detail before a final design is made. Those openings which are associated with later strip mining should be investigated to determine if backfilling the cut areas on the strip mine with compacted fill to prevent deep percolation, and regrading the area to eliminate depressions which collect surface runoff, will not adequately reduce the acid seepage from the deep mine opening as well. Where percolating water from strip mines does not appear to be the source of the deep mine seepage, a detailed program of exploratory drilling and pressure testing should be carried out around the opening and along the associated outcrop line. From the information obtained, a grout curtain should be installed where needed along the outcrop line and around the opening, and a hydraulic wet seal similar to those used in the Moraine State Park area should be installed in the opening. Where the openings are inaccessible due to caving, these can be installed by injection through bore holes from the surface. These seals and grout curtains should be made adequate to maintain the water table in the mined area above the coal seam at all times.

Other Pollution Problems on the Watershed:

A large part of the Big Scrubgrass Creek Watershed is underlain by the Bullion-Clintonville Oil Pool, and the area is covered by both producing and abandoned oil wells. Oil seepage and spills around the producing wells are a source of pollution to the watershed although this is a problem only in the immediate vicinity of the wells and storage tanks. Although traces of oil can be found occasionally on pools in the main stream there is no evidence of oil coating on the stream bottom and banks except on small tributaries within a few feet of a well or storage tank. Most of these oil spill points are found in the Southwest Tributaries and the South Branch Subwatersheds. A number of abandoned well casings in these same subwatersheds are discharging water which is alkaline with some iron and sulfate content. There are numerous small bogs in the stream valleys in these areas which show a fairly large accumulation of oil and iron precipitate. These wells appear to be a major source of alkaline water which helps to neutralize the strews in these areas. No oil wells were found discharging acid water, and all had a sulfate content less than 100 parts per million. Those which are discharging oil pollution should be properly sealed.

Follow-up:

Since limited data is currently available on the relative success of various source treatment procedures, a program of follow-up study should be developed and carried out to evaluate the success of these recommendations. This should include regular sampling similar to that done in this study, although on a less frequent schedule to determine water quality on the main stream and the important tributaries. In addition each site should be inspected at least once a year to determine the condition of the vegetation and water handling system and the presence of any polluted seepage. Where follow-up revegetation or soil treatment is indicated from these inspections, it should be completed as soon as possible.

There is much unmined coal remaining in the watershed which undoubtedly will be mined to some extent in the future. Great care should be taken to make sure that this future mining does not contribute pollution to the area. This could best be accomplished by limiting the extent of the active mining at any one time and by providing local surveillance to insure that the mining activities and reclamation work are adequate to protect the watershed. Since the final condition of a mined area affects the entire region, by the AMD potential and possible esthetic degradation, it should not be left to the discretion of the miner and landowner, but should be controlled by representatives of the entire community.

SPECIFIC RECLAMATION PLANS

The specific reclamation plans are organized according to subwatershed areas. Seven areas were defined to provide abatement on natural tributary groups which were affected by common source mines. Bullion Run was treated as a separate project area and submitted as a recommended Quick Start Project because of its possibilities as a trout fishing stream in its own right. Trout Run, Gilmore Run and the Upper Main Stream are the major area contributing pollution to the watershed, and the consideration of each as a project area will contribute a predictable amount to the improvement of the water quality of the overall watershed. The Brink Run Subwatershed was divided between Trout Run and Gilmore Run because its source areas were shared with these two major tributaries. The Gilmore Run area was submitted as recommended Quick Start Project. The Southwest, South Branch and East Tributaries are less significant to the overall pollution problem of the watershed and only limited reclamation is recommended in these areas. Figure No. 29 shows the subwatershed divisions used in this report. The stream water quality and specific reclamation plans for each are described in individual sections of this report. Figure No. 30 located on the last page of this section shows the symbols used on the individual site maps.

Basis for Cost Estimates:

Cost estimates for mine reclamation work were reviewed from several references including the Appalachian Regional Commission Report, the Moraine State Park Report, the Elkins, West Virginia data, and the Soil Conservation Service Sediment and Erosion Report. Strip mine reclamation includes spoil regrading, refuse burial, soil neutralization and fertilization, planting of vegetation and construction of water handling facilities. Where existing trees must be removed before regrading, this added cost must be considered. The factors which would effect the costs include the amount of material to be moved during regrading and burial and the haul distance involved, the area involved in soil revegetation, the length and type of water handling structures required, and the accessibility of the area. Generally, a lower unit cost would result where a large amount of the same type of work is involved. Regrading prices may vary from approximately $400 to $3200 per acre and revegetation costs may vary from $20 to $500 per acre. Generally, where very little regrading is done, the cost of revegetation will be higher and visa versa.

Diversions and vegetated waterways may cost up to $1/foot and lined channels up to $5/foot. Where toxic materials must be buried under impervious compacted fill or deep mine workings encountered in strip mine cuts must be surface sealed, an additional cost will be required, depending on the extent of the work. Generally, the average total cost for all restoration should range between $2000 and $3000 per acre.

Deep mine sealing involves drilling and pressure testing prior to final design plus the cost of installing a seal in each opening and a grout curtain around the opening and along the outcrop where seepage may occur. Each seal will cost $7000 to $10,000 and the grout curtain will cost approximately $150 per lineal foot. For this report an estimate of $20,000 per opening was used to cover all associated drilling, pressure testing, sealing and grouting.

Alternative Soil Revegetation Methods:

The following revegetation methods were developed by the Soil Conservation Service for strip mine spoil to achieve soil erosion control. The tree species recommended are those which have proven ability to survive and grow with minimum soil treatment. In some cases more extensive soil neutralization and fertilization would allow establishment of more commercially valuable timber growth than is indicated in the recommendation. Where extensive costs are not warranted and soil pH is too low for seeding, mixtures may be changed in accordance with the recommendations in the Pennsylvania Strip Mine Planting Guide.

Method #1:

This method was selected for areas where lime and fertilizer can be bulk spread using conventional equipment (farm tractor, disc, and grain drill) for seeding.

a. Prepare a seedbed by harrowing or discing. Plowing or deep scarification may be necessary if spoil is too compacted.

b. Lime according to test and work spoil material as deeply as practicable when preparing seedbed. Do not apply more than four tons of limestone per acre in one application.

c. Fertilize to spoil test or apply 600 pounds of 10-20-20 or equivalent per acre.

d. Seed with 10 pounds of Empire Birdsfoot Trefoil, 5 pounds of Weeping Lovegrass, 5 pounds of Kentucky 31 Tall Fescue, 5 pounds of Perennial Ryegrass and 5 pounds of Orchardgrass.

e. Band seeding in early spring, before May 15 is preferred. However, broadcast seedings at this time have been satisfactory. Late summer seedings may be made between July 15 and August 20.

f. For maintenance, lime and fertilize annually according to spoil test. In absence of spoil test, apply fertilizer every third year at the rate of 0-60-60 per acre where legumes predominate.

   Where grasses predominate, apply fertilizer annually at the rate of 60-60-60 per acre when spring growth begins.

   Estimated establishment cost per acre is $300.00.

Method #2:

This method was selected for areas too steep or rough for conventional equipment.

a. Area to be hydroseeded with no seed bed preparation.

b. Seeding in early spring, before May 15 is preferred. Late summer seedings may be made between July 15 and August 20,

c. Lime according to spoil test.

d. Fertilize to spoil test or apply 600 pounds of 10-20-20 per acre.

e. Seed with ten pounds of Empire Birdsfoot Trefoil, five pounds of Weeping Lovegrass, five pounds of Kentucky, 31 tall fescue, five pounds of Perennial Ryegrass and five pounds of Orchardgrass.

f. Mulch with 1½ tons of straw per acre and tie down with 150 gallons per acre of non - toxic asphalt emulsion uniformly applied.

g. For maintenance, lime and fertilize annually accordingly to spoil test. In absence of spoil test, apply fertilizer every third year at the rate of 0-60-60 per acre where legumes predominate. Where grasses predominate, apply fertilizer annually at the rate of 60-60-60 per acre when spring growth begins.

   Estimated established cost per acre is $600.00.

Method #3:

a. Plant Arnot Bristly Locust in rows on a four foot spacing. Rods should be on the contour and using staggered spacing between individual rows.

   Estimated establishment cost per acre is $130.00.

Method #4

a. Plant a minimum of three rows of Arnot Bristly Locust on a four foot spacing with four feet between rows immediately above the top of the highwall.

b. Between the Bristly Locust planting and the edge of the disturbed area, plant one of the following in rows parallel to the disturbed area:

(1) Cardinal Autumn-Olive,	spaced 6 by 7 feet;
(2) Tatarian Honeysuckle,	spaced 4 by 4 feet;
(3) Anur Honeysuckle,	spaced 4 by 4 feet;
(4) Arrowood,	spaced 4 by 4 feet;
(5) Silky Dogwood,	spaced 4 by 4 feet;

Estimated establishment cost per acre is $120.00.

Method #5:

a. Plant a minimum of three rows of Arnot Bristly Locust in a four foot spacing with four feet between rows immediately above the top of the highwall.

b. Between the Bristly Locust planting and the edge of the disturbed area, reseed using Method #1.

Estimated establishment cost per acre is $230.00.

Method #6:

a. Plant European White Birch (Betula Pendula) using 6 by 6 foot spacing. Plantings should be done along general contour lines, and can be machine planted.

   Estimated establishment cost per acre is $130.00.

Recommended Priorities:

Table 8 is a summary of the specific reclamation plans for the watershed. Total acid production from each site was determined from flow measurements and water quality samples at point sources where such measurements were possible and estimated from field inspection and downstream water quality sampling where more exact measurements were not possible on area-type sources. Implementation of the recommended measures was assumed to be 75 percent effective in reducing each point source unless unusual conditions suggested otherwise.

The recommended priority system is based on the estimated quantity of acid originating from each source. Sources of 200 pounds of acid per day or more are given first priority. Second priority projects are sources of from 100 to 200 pounds of acid per day. All sources of less than 100 pounds of acid per day are recommended for third priority.

Table 9 shows the estimated costs and acid reduction to be achieved by implementation of first priority recommendation only, by implementation of first and second priority projects, and by implementation of all recommended restoration work. Implementation of first priority projects alone would reduce the acid sources by 3188 pounds per day or approximately 57.7 percent. First and second priority projects together would reduce the acid sources by 3864 pounds per day or approximately 70 percent. The implementation of all recommended projects would result in a total reduction of 4107 pounds per day of acid at the sources or 74.3 percent. The

Bullion Run, Gilmore Run, Southwest Tributaries, South Branch and East Tributaries subwatersheds also have significant alkaline sources which cause approximately 50 percent of the acid load to be neutralized within the streams below the sources. If the proposed abatement measures don't significantly reduce the alkaline discharges in these areas the implementation of only first priority projects could result in net alkaline streams over most of the watershed. The implementation of all recommended measures should result in net alkaline discharges on all major tributaries within the Big Scrubgrass Creek Watershed.

TABLE 8. SUMMARY OF SPECIFIC ABATEMENT PLANS

Watershed	Site No.	Acid Production (PPD)	Net Acid Reduction (PPD)	Abatement Cost ($)	Cost Per Pound Reduction	Priority
	1	Neg.*	0	0	0	NR**
	2	Neg.	0	0	0	NR
	3	Neg.	0	0	0	NR
	4	200+	150	30200	201	1
BULLION	5	400+	300	102600	342	1***
RUN	6	5±	4	600	150	3
	7	Neg.	0	0	0	NR
	8	Neg.	0	0	0	NR
	9	100+	75	19700	263	2
	12	20+	15	5300	353	3
	Totals	725±	544	$158400	$291.18 Av.	
	18	300+	225	22800	101	1
TROUT	19	100±	75	9800	131	2
RUN	20	10+	8	500	63	3
	29	20+	15	5600	373	3
	Totals	430±	323	$ 38700	$156.05 Av.	
	13	400+	300	81700	272	1
	14	Neg.	0	0	0	NR
	15	400+	300	65300	218	1
	16	20+	15	6800	453	3
GILMORE	17	1300±	975	100700	103	1
RUN	26	300+	225	29300	130	1
	27	Neg.	0	0	0	NR
	38	Neg.	0	0	0	NR
	33	10+	8	2600	325	3
	Totals	2430±	1823	$286400	$157.10 Av.	

* The Amount of acid mine drainage originating from these mines was considered negligable.
** No treatment recommended on these sites for control of acid mine drainage.
*** Deep Mine Sealing in this mine is priority 2.

TABLE 8. SUMMARY OF SPECIFIC RECLAMATION PLANS

(Continued)

Watershed	Site No.	Acid Production (PPD)	Net Acid Reduction (PPD)	Abatement Cost ($)	Cost Per Pound Reduction	Priority
	10	300+	225	118600	527	1
	11	150+	113	10900	97	2
	21	100±	75	11300	151	2
UPPER	22	Neg.	0	0	0	NR
MAIN	23	200+	150	43900	293	1
STREAM	24	250±	188	24200	129	1
	25	150±	113	15500	137	2
	59	Neg.	0	0	0	NR
	Totals	1150±****	864	$224400	$259.72 Av.	
	32	Neg.	0	0	0	NR
	36	200+	150	26900	179	1
	37	Neg.	0	0	0	NR
	38	100+	75	6100	82	2
SOUTHWEST	39	Neg.	0	0	0	NR
TRIBUTAR-	40	50±	38	9300	245	3
IES	41	Neg.	0	0	0	NR
	42	50±	0	0	0	NR
	43	Neg.	0	0	0	NR
	55	70±	53	10900	206	3
	58	Neg.	0	0	0	NR
	Totals	470±	316	$ 53200	$168.35 Av.	

**** Additional acid load was measured at Sampling Station No. 14 at the lower end of this watershed which could not be assigned to definite source areas.

TABLE 8. SUMMARY OF SPECIFIC RECLAMATION PLANS

Watershed	Site No.	Acid Production (PPD)	Net Acid Reduction (PPD)	Abatement Cost ($)	Cost Per Pound Reduction	Priority
SOUTH BRANCH	44	Neg.	0	0	0	NR
	45	Neg.	0	0	0	NR
	46	10±	0	0	0	NR
	49	Neg.	0	0	0	NR
	50	50±	38	41700	1097	3
	51	Neg.	0	0	0	NR
	52	Neg.	0	0	0	NR
	53	24±	18	45800	2545	3
	56	Neg.	0	0	0	NR
	60	10±	8	10300	1288	3
	Totals	94±*****	64	$97800	$1528.13 Av.	
EAST TRIBUTARIES	30	Neg.	0	0	0	NR
	31	Neg.	0	0	0	NR
	34	200+	150	12300	82	1
	35	30+	23	20000	870	3
	47	Neg.	0	0	0	NR
	48	Neg.	0	0	0	NR
	54	Neg.	0	0	0	NR
	57	Neg.	0	0	0	NR
	Totals	230±******	173	$32300	$187.70 Av.	

***** Additional acid load was measured at Sampling Station No. 18 at the lower end of this watershed which could not be assigned to a definite source area.

****** Additional acid load was measured at downstream stream sampling station in this subwatershed which could not be assigned to definite source areas.

TABLE 9. COMPARISON OF ESTIMATED ACID REDUCTION AND ABATEMENT COSTS FOR SUBWATERSHEDS BY PRIORITY GROUPINGS

Subwatershed	Ave. Acid Load (PPD)	Est. Acid Red. (PPD)	Acid Red. %	Treatment Cost	Average Cost/PPD
Bullion Run	725				
Priority #1		300	41.4	72800	243
Priorities #1 and #2		525	72.4	152500	291
Priorities #1, #2 & #3		544	75.0	158400	292
Trout Run	430				
Priority #1		255	52.3	22800	102
Priorities #1 and #2		300	69.8	32600	109
Priorities #1, #2 & #3		323	75.1	38700	120
Gilmore Run	2430				
Priority #1		1800	74.1	277000	154
Priorities #1 and #3		1823	75.0	286400	158
Upper Main Stream	1371				
Priority #1		563	41.1	186700	332
Priorities #1 and #2		864	63.0	224400	260
Southwest Trib.	470				
Priority #1		150	31.9	26900	180
Priorities #1 and #2		225	47.9	33000	147
Priorities #1, #2 & #3		316	67.2	53200	169
South Branch	303				
Priority #3		64	21.1	97800	1529
East Tributaries	320				
Priority #1		150	46.9	12300	82
Priorities #1 and #3		173	54.1	32300	187

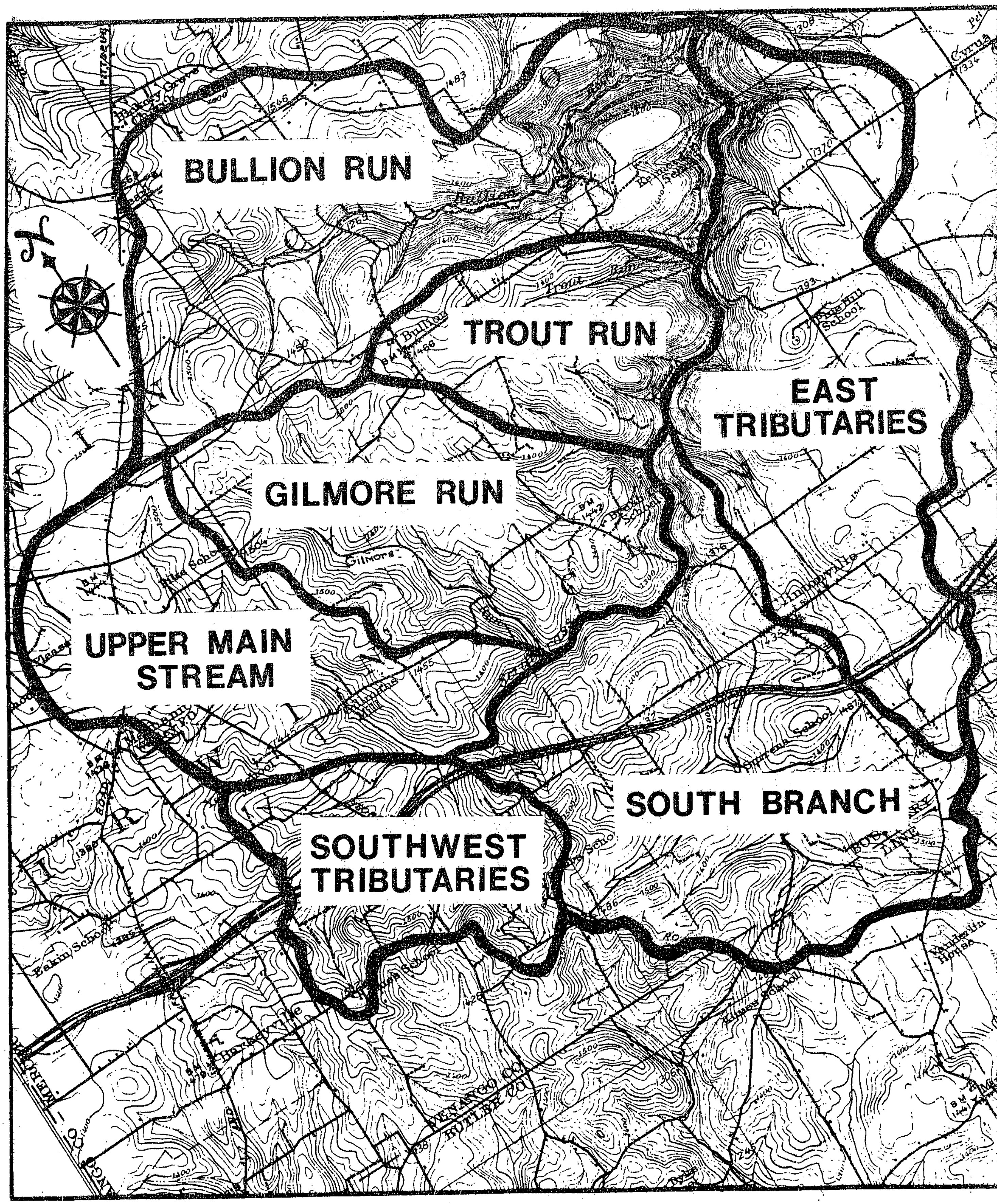
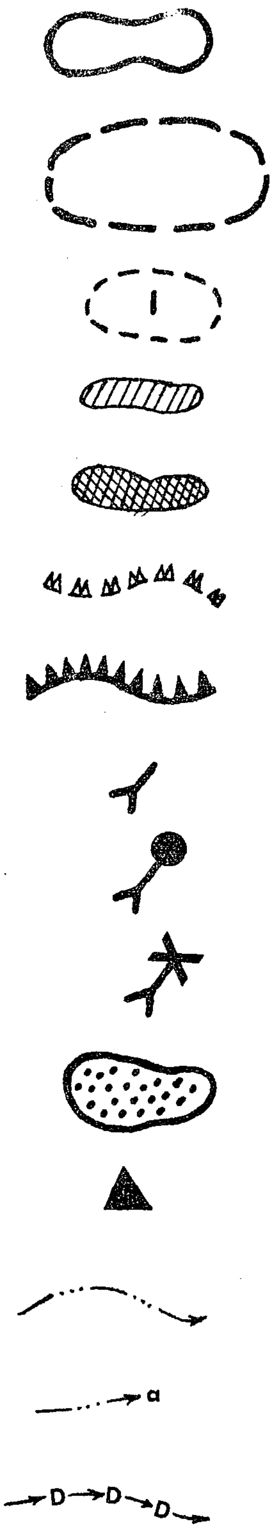


FIGURE 29. Key Map Showing the Subwatershed Divisions
Used to Develop Specific Abatement Plans

BIG SCRUBGRASS CREEK WATERSHED



Strip Mine Area Boundary

Approximate Boundary of Mine Drainage Permit on an Active Mine

Reclamation Area Boundary

Pond Area

Piled Topsoil

Highwall

Steep Slope of Spoil Material

Deep Mine Opening - Acid Problem

Deep Mine Opening - No Acid Problem

Deep Mine Opening - Workings Stripped Out

Gob Pile

Air Shaft

Drainage Channel with Arrow Showing Direction of Drainage

Defined Seepage Point

Suggested Location of a Diversion

KEY TO SYMBOLS USED ON MINE SITE MAPS
Scale: 1 inch = 400 feet

FIGURE 30