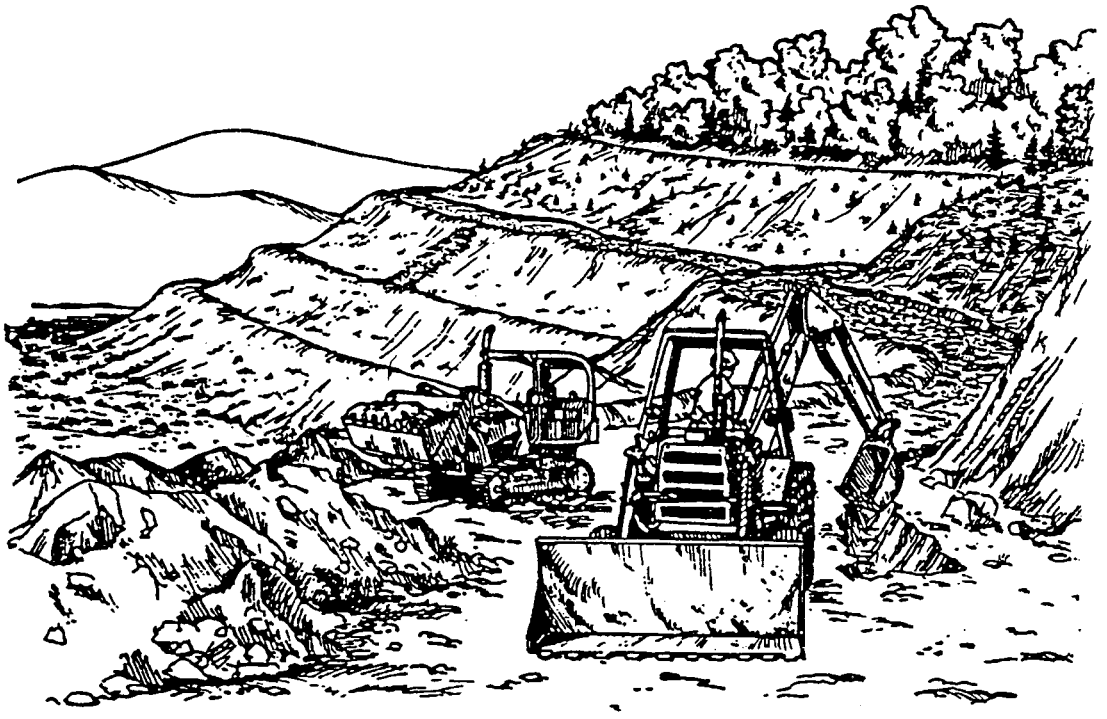
KENTUCKY COAL MINING PRACTICE GUIDELINES

FOR WATER QUALITY MANAGEMENT



Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Division of Water
and the Agronomy Department
University of Kentucky

March 1996

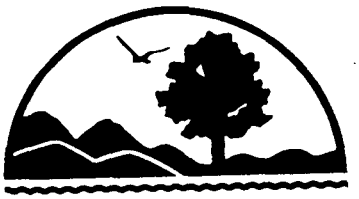
ABSTRACT

Current coal mining regulations require environmental protection measures to be taken before, during, and after mining. This handbook's purpose is to give coal mine operators the information needed to successfully meet those regulations. It also should be useful for those persons engaged in reclaiming abandoned mine sites as well. However, space does not allow detailed information often associated with site-specific conditions, but hopefully it does give all the basic principles involved. The first major section (III) introduces the problems of mine site preparation, erosion control, acid mine drainage, and related water pollution problems. The next three sections provide sources of information, guides, and principles of Best Management Practices as well as discussions related to pollution prevention and control measures. Section VII includes the specifications and details associated with drainage, roads, topsoil and overburden handling, and revegetation. The methods, called Best Management Practices, are presented in a manner hopefully understandable by the practicing mine operator. The last three sections include references to provide back-up and additional sources of information for further help. The glossary includes definitions of the terms used in the handbook, andt the last part is a complete index of the handbook.

Funding for developing this handbook was provided, in part, by a grant from the U.S. Environmental Protection Agency, as authorized by Section 319 of the Federal Clean Water Act Amendments of 1987 (PL100-4). The mention of trade names or commercial products does not constitute endorsement. Nothing in this document shall be used as a means to circumvent existing laws or regulations. This document was printed on recycled paper. The Natural Resources and Environment Cabinet does not discriminate on the basis of race, color, national origin, sex, age, religion, or disability and provides, on request, reasonable accommodations including auxiliary aids and services necessary to afford an individual with a disability an equal opportunity to participate in all services, programs, and activities. These materials can be provided in an alternative format, please contact: Division of Water, Nonpoint Source Section, 14 Reilly Road, Frankfort Kentucky 40601 Telephone: (502) 564-3410.

KENTUCKY COAL MINING PRACTICE GUIDELINES

FOR WATER QUALITY MANAGEMENT



Natural Resources and Environmental Protection Cabinet
Division of Water
and the Agronomy Department
University of Kentucky

March 1996

Table of Contents

Abstract ..... Inside Cover

Table of Contents iv

Acknowledgments 1

I. Statement of Purpose 2

II. Introduction 2

III. Water Pollutants 4

A. Debris 4

B. Sediment 4

C. Acid Drainage 6

IV. Sources of Information 7

V. Guide to Best Management Practices 7

VI. Best Management Practice Principles 9

VII. Best Management Practice Specifications 9

A. Drainage 10

1. Mine Drainage Treatment 11
2. Diversions 16
3. Sedimentation Ponds 20
4. Channel Protection 22
5. Silt Fences 28
6. Vegetative Filters 31

B. Roads 33

C. Topsoil and Overburden Handling 40

1. Topsoil Removal and Storage 41
2. Temporary Spoil Storage 44
3. Backfilling and Grading 46
4. Scarification 49
5. Topsoil Redistribution 51
6. Acid/Toxic Spoil 52
7. Non-coal Mine Waste 54
8. Excess Spoil Disposal 55

D. Revegetation 61
1. Soil Amendments 62
2. Non-Woody Plants 64
3. Woody Plants 76
4. Mulch 83

VIII. Appendices 85

A. Kentucky Division of Water 86
B. Kentucky Department for Surface Mining Reclamation and Enforcement 87
C. U.S. Office of Surface Mining 88
D. Kentucky Division of Forestry 89
E. Kentucky Soil and Water Conservation Districts 90
F. Kentucky Agriculture Extension Agents 92
G. Slope Measurement 94
H. Design Storm Data 95
I. Supporting Documents 96

IX. Glossary 106

X. Index 125

List of Tables

Table 1.	Reagent Selection Considerations	12
Table 2.	Common Neutralization Reagents	13
Table 3.	Maximum Slope Lengths for Straw Bale Check Dam	25
Table 4.	Depth of Sub-Base Materials	35
Table 5.	Culvert Spacing with Grade	38
Table 6.	Water Bar Spacing	39
Table 7.	Timing of Backfilling and Grading Operations	47
Table 8.	Minimum Drain Segment Cross-sectional Dimensions	58
Table 9	Limestone Rates for Soil-buffer pH Readings	62
Table 10.	Fertilizer Requirements for New Seedings	63
Table 11.	Useful Grasses and Legumes for Kentucky	67
Table 12.	Suggestions for Seed Mixes and Rates for Kentucky	74
Table 13.	Recommended Tree Seedlings for Kentucky	76
Table 14.	Recommended Shrubs for Kentucky Wildlife Habitat	79
Table 15.	Mulching Guide	84

List of Figures

Figure 1.	The process of erosion and sedimentation.	4
Figure 2.	Three types of land-based erosion: sheet, rill, and gully	5
Figure 3.	Guide for Best Management Practices selection	8
Figure 4.	Example of mine drainage neutralizing device -- AquaFix	14
Figure 5.	Upslope diversion ditches route runoff from undisturbed surfaces around disturbed areas	17
Figure 6.	Diversions within the disturbed area reduce slope length and minimize velocity of runoff	18
Figure 7.	Cross-sectional geometry of diversion ditches	19
Figure 8.	Grass linings	23
Figure 9.	Riprap linings.	24
Figure 10.	Cross-section of straw bale barrier.	25
Figure 11.	Log check dams.	26
Figure 12.	Rock check dam.	27
Figure 13.	Gabion.	27
Figure 14.	Silt fence installation.	30
Figure 15.	Silt fence weir.	30
Figure 16.	Roadbed crossfall on hilly terrain.	37
Figure 17.	Construct stream crossings by providing a culvert or bridge.	37
Figure 18.	Cross-drain culvert construction.	38
Figure 19.	Schematic soil profile.	42
Figure 20.	Soil storage.	44
Figure 21.	Typical surface mine cross-section before mining.	45
Figure 22.	Backfilling and grading.	47
Figure 23.	Head-of-hollow fill.	56
Figure 24.	Schematic cross section of 70-foot deep, V-shaped rock chimney for infiltration basin.	59
Figure 25.	Seedling planting techniques.	81-82

Acknowledgments

This manual on coal mining guidelines for water quality management represents an update and revision of the 1984 publication titled Best Management Practices for Coal Surface Mining. The text and graphics from the original document as written and developed by Sarah L. Cunningham were used as a springboard in the preparation of this manual. Revisions in the form of technical advances reported in the literature and regulatory updates were incorporated.

Thoughtful guidance, review, and recommendations were provided by the staffs of the following agencies through their participation as members of an Advisory Committee formed by the Natural Resources and Environmental Protection Cabinet:

Kentucky Department for Surface Mining
Reclamation and Enforcement
Kentucky Division of Abandoned Lands
U.S. Geological Survey
Kentucky Geological Survey
University of Kentucky Water Resources
Research Institute
MAPCO Coal
Kentucky Resources Council
Kentucky Division of Water.

The Department of Agronomy at the University of Kentucky prepared the document on behalf of the Kentucky Division of Water. Principal compilers of the revised manual were Richard I. Barnhisel and Judith M. Hower. Appreciation goes to Marsha Short for typing, to Gerald Haszler for assistance with the figures, and. Ray Harmon, Heather Vice and Karen Schell for their assistance with assembly of the final copies

STATEMENT OF PURPOSE

In order to protect the surface waters of the Commonwealth, the Natural Resources and Environmental Protection Cabinet established surface water standards under 401 KAR 5:031. This regulation sets forth water quality standards that consist of the designated legitimate uses of the surface waters of the Commonwealth and the associated water quality criteria necessary to protect those uses. These standards are minimum criteria that apply to all surface waters in order to maintain and protect designated uses. The Cabinet strives to meet these water quality standards through both mandatory and voluntary use of Best Management Practices (BMPs).

The purpose of this document is to provide a capsule presentation of the Best Management Practices for protecting water resources from nonpoint source water pollutants stemming from coal mining activities and reclamation of abandoned mine lands. Neither these practices nor this manual are in any way intended to prevent the mining of coal. Rather, these BMPs are provided to aid industry in meeting environmental standards and as a measure to help safeguard the quality of our water resources.

INTRODUCTION

Under Section 319 of the Federal Clean Water Act Amendments of 1987, states are required to develop management programs for the control of nonpoint sources of pollution from a variety of land uses, including mining. The Kentucky Nonpoint Source Management Program identifies Best Management Practices recommended for use in Kentucky to control mining-related nonpoint source pollution. Also described are steps by which to achieve implementation of BMPs.

Implementation of BMPs is often required as a part of a Water Quality Certification. The BMP plans are required as a part of all individual Kentucky Pollution Discharge Elimination System (KPDES) permits issued, as remedial actions resulting from enforcement actions and will be included on the reissuance of the General KPDES permit as of 1997. Such plans must be in accordance with NPDES Best Management Practices Guidance Document (EPA, 1981).

Best Management Practices as applied to coal mining and reclamation of abandoned mine sites are structural or nonstructural methods that minimize the movement of debris, sediment, and acid drainage from the land to surface and ground water. These practices have been developed to achieve a balance between water quality protection and coal production within natural and economic limitations.

This manual is intended for use by coal mine operators, engineering consultants, state regulatory personnel, landowners, land users, planners, and persons involved in reclamation as a technical reference. Methods are detailed for the identification, planning, and treatment of existing or potential nonpoint sources of pollution resulting from coal mining activities and reclamation of abandoned mine sites.

Physical disturbance and/or filling of wetlands and streams, both perennial and intermittent, are regulated by the Federal Clean Water Act under sections 404 and 401. Section 404 gives the U.S. Army Corps of Engineers primary regulatory responsibility over this area.

Most proposed discharges within streams or wetlands will require a Nationwide Section 404 permit or an Individual Section 404 permit from the U.S. Army Corps of Engineers. More often than not, Nationwide Permit numbers 21 or 26 will apply to mining operations for such disturbances. A 401 Water Quality Certification will be required from the Division of Water whenever a Section 404 permit is required; if more than 200 linear feet of a blue-line stream (as depicted on a U.S. Geological Survey 7.5 minute quadrangle map) will be impacted or more than one (1) acre of jurisdictional wetland will be impacted. In addition, for

mining operations resulting in a permanent stream loss, a stream restoration/mitigation plan must be submitted to the division if the watershed above the toe of the farthest downstream permanent structure is greater than 450 acres. A restoration/mitigation plan must also be submitted for proposed disturbances of one (1) acre or more to jurisdictional wetlands.

The application of BMPs is required for active mine operation planning. Under the 1990 Kentucky Surface Mining Law (KRS 350) and the Permanent Program Regulations for Surface Coal Mining and Reclamation Operations and Coal Exploration Operations (405 KAR Chap. 7-24), certain BMPs are specified; other times operators may choose practices during the development of their permit application to ensure performance standards are met.

A valid permit is required for every coal mining operation. To obtain a permit, the operator must submit an application to the Department for Surface Mining Reclamation and Enforcement (DSMRE) of the Kentucky Natural Resources and Environmental Protection Cabinet. This application must contain a Mining and Reclamation Plan (MRP), which includes sections covering:

- topsoil handling
- backfilling and grading
- spoil disposal
- acid and toxic material handling
- surface water control and monitoring
- ground water control and monitoring
- revegetation

Note: For public lands, a permit will need to be obtained through the U.S. Office of Surface Mining.

Each section of the MRP specifies those BMPs the operator intends to use to meet regulatory performance standards. A variety of criteria are involved in the BMP selection process. These criteria are addressed within the context of technical considerations discussed under BMP specifications later in this manual. The terms of the permit and the MRP must be upheld throughout the mining process: site preparation, mining and reclamation, and the five-year period of extended responsibility.

The regulatory requirements reflect those current as of March 1994. Regulations change periodically in response to changes issued by the U.S. Office of Surface Mining. If doubt exists concerning the legal acceptability of any BMP specification discussed in this manual, the Kentucky Department for Surface Mining Reclamation and Enforcement should be contacted for resolution. The use of this manual does not relieve the operator of any responsibilities under state or federal regulations applicable to surface mining reclamation.

WATER POLLUTANTS

Without conscientiously applied management practices, three water pollutants can stem from coal mining activities and reclamation of abandoned mine sites: 1) debris, 2) sediment, and 3) acid drainage. A discussion of each of these pollutants and the processes involved in their formation follows.

Debris

Clearing and grubbing is the first stage of site preparation in the development of a coal mine. During this stage, trees and brush are removed. This debris is then sometimes disposed of by windrowing. Alternate forms of disposal include chipping for future use as mulch and controlled burning or incineration in accordance with 401 KAR 63:005. Improper placement of debris has the potential for clogging stream channels.

Sediment

Sediment deposited in stream channels is the consequence of the processes of soil erosion and sedimentation caused by rainfall (Figure 1). These processes are accelerated in disturbed watersheds. Disturbances that include the removal of vegetation and earth moving have the potential to accelerate erosion. According to the Kentucky Division of Water (1994), nonpoint sources linked with resource extraction comprise the largest source of siltation of Kentucky streams and waterways.

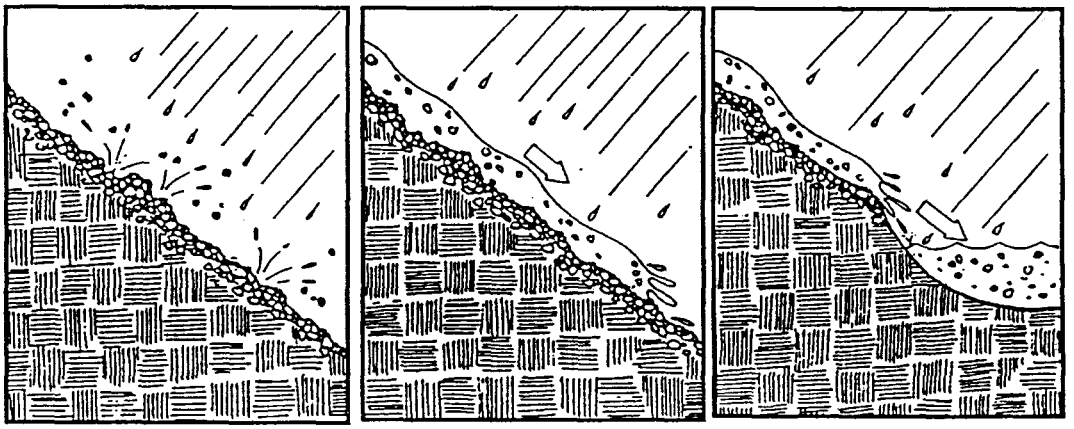


Figure 1. The process of erosion and sedimentation

Erosion begins upon the impact of raindrops with the ground. The impact of the raindrop itself serves to detach the soil, destroys soil granulation, and initiates soil transport. Erosion by water can then be classified as 1) sheet, 2) rill, or 3) gully (Figure 2). In sheet erosion, soil is removed more or less uniformly across a slope. Small channels often develop in sheet erosion. These are referred to as rills. The formation of larger channels or gullies serves to further concentrate the runoff water.

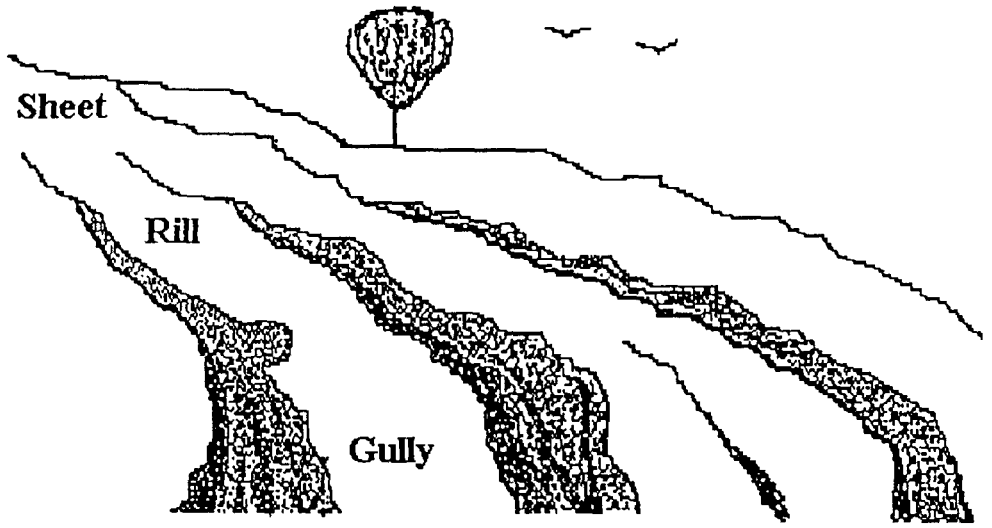


Figure 2. Three types of land-based erosion: sheet, rill, and gully

Soil that is being carried by runoff water during the erosion process can be referred to as suspended solids. When the speed of runoff water decreases, solids in suspension gradually settle to the bottom of the stream channel. At this time, the soil becomes sediment, and the process of soil deposition following erosion is known as sedimentation (Brady, 1990). Sedimentation problems can be minimized through the construction of sediment ponds, grass filter strips, and other BMPs. The suspension may enter a lake or sediment pond where the particles may be removed or a grass strip where the vegetation serves as a filter.

Many factors influence the rate of soil erosion on both undisturbed and disturbed soils. The Revised Universal Soil Loss Equation (RUSLE) has been developed to estimate quantities of soil lost via sheet and rill erosion. Predicted soil loss is calculated by taking the product of the series of factors as follows (Renard and others, 1991):

A = RKLSCP
A = computed soil loss
R = climatic erosivity (rainfall and runoff)
K = soil erodibility
L = slope length
S = slope gradient or steepness
C = cover and management
P = erosion control practice

A computer program to calculate the RUSLE is available through the U.S. Agricultural Research Service (ARS) and the Natural Resources Conservation Service (Renard and others, 1991).

The environmental consequences of soil erosion and sedimentation are substantial, especially with respect to the effects on water quality and aquatic habitat. Sediment from eroded lands causes significant damage to treatment plants for domestic water supplies, reduces the life span of water reservoirs, and fills in river channels (Brady, 1990). Suspended solids and sediment can decrease light, reduce water oxygen levels,

smother stream bottom organisms, and cause reductions in food supplies. In addition to these water-related effects, soil losses diminish the agricultural value of lands affected through direct soil loss and associated reductions in essential plant nutrients such as nitrogen, potassium, and phosphorus.

Acid Drainage

The most frequent cause of acid drainage is the prolonged exposure of pyrite (FeS_2) to air and water. Pyrite is a mineral that is frequently found in association with coal seams. The oxidation of pyrite produces both ferric hydroxide ($Fe(OH)_3$) and sulfuric acid (H_2SO_4) according to the following series of equations (Caruccio and Geidel, 1990):

$$FeS_2 + H_2O + 7/2\ O_2 \text{ ---> } Fe^{+2} + 2SO_4^{-2} + 2H^+ \quad (1)$$

(Pyrite) ---> (Ferrous Sulfate) + (Sulfuric Acid)

$$Fe^{+2} + O_2 + 4H^+ \text{ ---> } Fe^{3+} + 2H_2O \quad (2)$$

$$3Fe^{+3} + 9\ H_2O \text{ ---> } 3Fe(OH)_3 + 9H^+ \quad (3)$$

$$FeS_2 + 14Fe^{+3} + 8H_2O \text{ ---> } 15Fe^{+2} + 2SO_4^{-2} + 16H^+ \quad (4)$$

(Pyrite) + (Ferric Iron) ---> (Ferrous Iron) + (Sulfate) + (Acid)

Decline in stream pH levels because of acid drainage can result in the destruction of aquatic biota. Low pH levels can result in the solubilization of heavy metals in stream channels further resulting in conditions toxic to aquatic life.

Coal mining activities and the reclamation of abandoned mine sites have the potential to accelerate the production of three pollutants in our environment: vegetative debris, sediment, and acid drainage. Conversely, aggressively applied management practices have the potential to control the production of these pollutants and safeguard the Commonwealth's water resources.

SOURCES OF INFORMATION

A considerable amount of information and assistance is available through state and federal agencies to help expedite the development of MRPs, and to selectively apply BMPs as appropriate. In particular, agencies knowledgeable in BMPs for the protection of water resources include:

- Kentucky Division of Water
- Kentucky Department for Surface Mining
  Reclamation and Enforcement
- Kentucky Division of Forestry
- Kentucky Soil and Water Conservation Districts
- Kentucky Agricultural Extension Agents
- Kentucky Department of Fish and Wildlife Resources
- Natural Resources Conservation Service
- Consolidated Farm Services Agency
- U.S. Forest Service
- U.S. Environmental Protection Agency
  - National Research Center, Mining Pollution Control Branch
- U.S. Geological Survey, Water Resources Division
  - (Coal Hydrology Program Report Series)
- University of Kentucky
  - Institute of Mining and Mineral Research
  - Water Resources Research Institute

Addresses and phone numbers of field offices of selected agencies within the eastern and western Kentucky coal fields appear in the Appendices.

GUIDE FOR BEST MANAGEMENT PRACTICES

The following chart (Figure 3) illustrates the relationship between coal mining activities and pollutants and identifies Best Management Practices which address each set of circumstances. It also applies to reclamation activities associated with abandoned mine sites. One or more BMPs may be necessary to adequately address a given set of conditions.

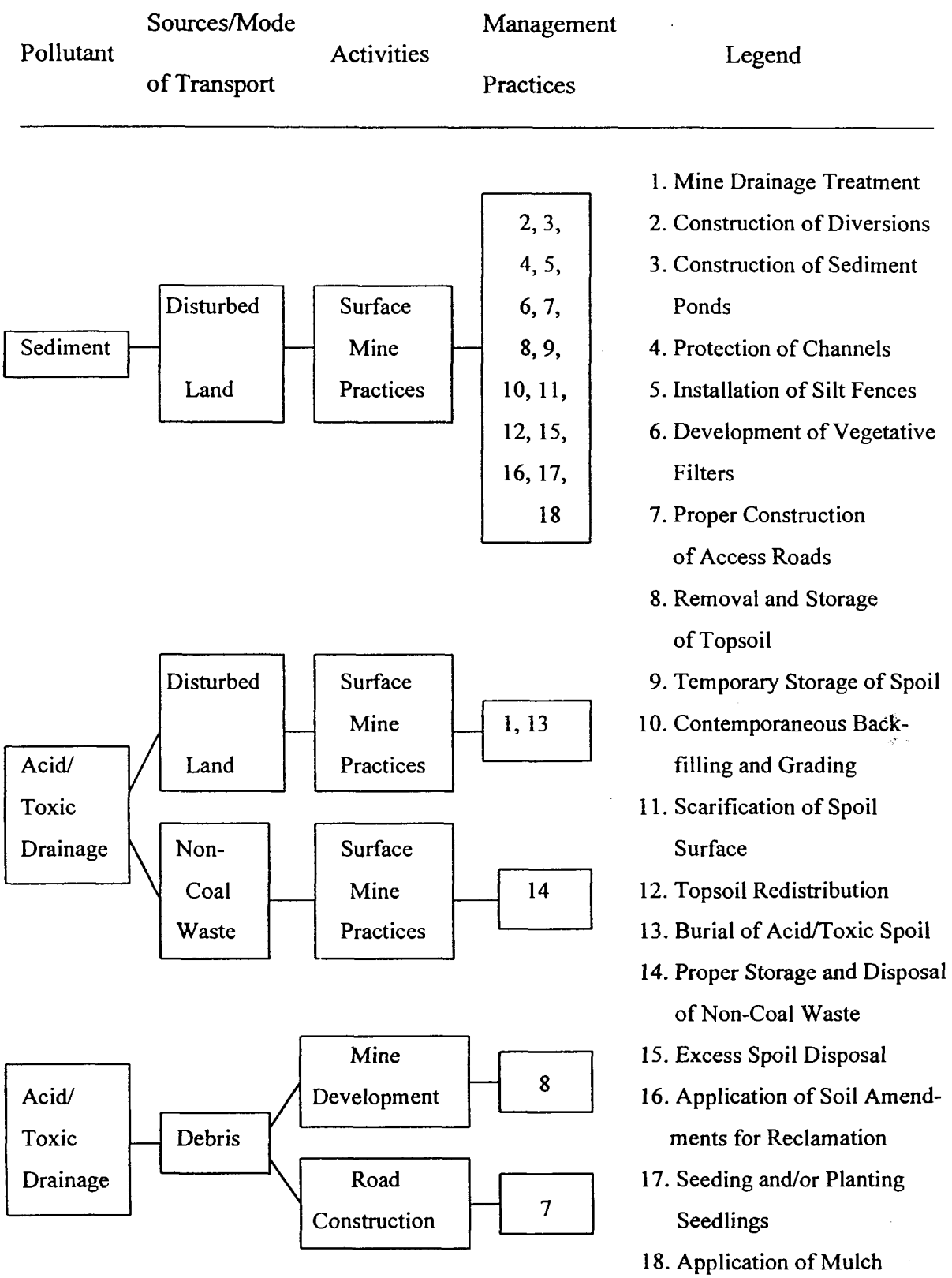


Figure 3. Guide for Best Management Practices selection.

BEST MANAGEMENT PRACTICE PRINCIPLES

The best way to prevent pollution of streams with debris, sediment, and acid drainage is to keep rainfall runoff and ground water away from debris, bare soil, and acid spoil. An operator can do this by using BMPs. BMPs can be vegetative, structural, or both. Basic principles to remember in the application of BMPs follow (Wang and Grubbs, 1990):

- Preplan water and sediment control strategies.
- Time grading and construction to minimize soil exposure.
- Retain existing vegetation whenever feasible.
- Vegetate and mulch denuded areas (including exposed C horizons of soils in advance of mining).
- Divert runoff away from disturbed areas.
- Install diversions and vegetated waterways in advance of mining to allow time for vegetation to mature.
- Minimize length and steepness of slopes.
- Minimize runoff velocity.
- Minimize size of disturbed area at any one time (both replaced spoil and soil).
- Trap sediment on site.
- Leave buffers or filter strips between land disturbances and natural waterways.
- Prepare drainage ways and outlets to handle increased runoff.
- Preferentially select local materials and native plant species in reclamation.
- Inspect and maintain erosion control structures

BEST MANAGEMENT PRACTICE SPECIFICATIONS

Technical specifications for Best Management Practices for coal mining follow. Four specific areas are identified: Drainage, Roads, Topsoil and Overburden Handling, and Revegetation. Under these general headings are more specific topics with BMPs outlined for each. Guidelines for the application of each practice are included, together with performance considerations. The format for discussion of each BMP is as follows:

- Definition
- Purpose
- Regulatory Requirements
- Implementation
- Maintenance

DRAINAGE

- **Mine Drainage Treatment**
- **Diversions**
- **Sedimentation Ponds**
- **Channel Protection**
- **Silt Fences**
- **Vegetative Filters**

MINE DRAINAGE TREATMENT

DEFINITIONS

Acid drainage is water with a pH lower than 6.0, which the total acidity exceeds the total alkalinity. Dissolved heavy metals are often associated with acid mine drainage (AMD) because the solubility of metals increases as pH decreases.

PURPOSE

Treatment of acid drainage is necessary to meet discharge standards applicable to the coal mining industry and to prevent degradation of water quality.

REGULATORY REQUIREMENTS

All surface drainage from disturbed areas must pass through a sedimentation pond (or series of ponds) and meet the requirements of 405 KAR 16:070 and 401 KAR 5:065. Adequate measures, along with sedimentation ponds, must be installed, operated, and maintained to ensure discharge from the permit area is in compliance with KPDES effluent limitations.

IMPLEMENTATION

Technology for the treatment of acid mine drainage typically includes:

- pH adjustment/metals removal
- aeration
- settling

The use of constructed wetlands also warrants consideration alone or in association with traditional technologies. Discussions of these technologies and their applications follow. Refer to the Mining and Reclamation Plan (MRP) for site-specific recommendations.

With all chemicals, use care in handling. Ask the mining engineer or chemical salesperson for detailed instructions about handling to prevent employee accidents and pollution of the environment. Large quantity storage on-site may require construction of spill contaminant structures.

pH Adjustment/Metals Removal

The first step in AMD treatment is the addition of an alkaline reagent (chemical) to increase the pH of the water. As the water pH rises, most metal ions become increasingly insoluble and precipitate out of solution. Available treatment reagents are primarily either calcium-containing or sodium-containing. In very general terms, the factors that influence the selection of a reagent from one of these two groups are summarized in Table 1.

The calcium- and sodium-based reagents, mechanisms of reaction, and quantities required to neutralize one pound of sulfuric acid are summarized in Table 2. A brief discussion of their potential use follows (Smith, 1991).

Table 1. Reagent Selection Considerations*

Factor	Calcium Compounds	Sodium Compounds
Solubility	Slow, Less Soluble	Fast, More Soluble
Application	Requires Mixing	Diffuses Well
Hardness	High	Low
Gypsum Formation	Yes	No
High Total Suspended Solids	Helps Settle Clay	Disperses & Keeps Clay Particles in Suspension
Chemical Cost	Lower	Higher
Installation and Maintenance Costs	High	Low

* Skousen (1989)

Table 2. Common Neutralization Reagents (adapted from Smith, 1991)

Reagent	Chemical Reaction	Wgt. Needed to Neutralize One Pound H_2SO_4
Hydrated Lime (calcium hydroxide)	$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$	0.76
Crushed Lime (calcium carbonate)	$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$	1.02
Quick Lime (calcium oxide)	$H_2SO_4 + CaO \rightarrow CaSO_4 + H_2O$	0.57
Caustic Soda (sodium hydroxide)	$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$	0.82
Soda Ash (sodium carbonate)	$H_2SO_4 + Na_2CO_3 \rightarrow Na_2SO_4 + H_2O + CO_2$	1.08

- **Hydrated Lime** is the reagent most commonly used (Smith, 1991). It can be applied in a dry or liquid form and is relatively inexpensive. As such, it is often used in situations where large amounts of AMD with high acidity must be treated over long periods of time (i.e., greater than 3 years). Figure 4 illustrates an example of a mechanism devised to mix lime with mine drainage as regulated by drainage flow rate. A fluffy sludge is produced with slower settling rate than that produced by crushed limestone.

- **Crushed Limestone** is the cheapest reagent on a "by weight" basis, but its usefulness is impaired by its limited solubility and low reactivity at upper pHs. Because crushed limestone is unable to raise the pH of AMD much beyond 7.5, it is inadequate to trigger the precipitation of most heavy metals. Nevertheless, it is less caustic than lime and cannot be overdosed. Therefore, the feed rate does not require exact regulation. Because it yields a much denser sludge, it settles faster.

  Passive treatment of acid mine drainage has been successfully accomplished (Turner and McCoy, 1990) through use of an anoxic alkaline drain treatment system. Such a system offers a low-cost AMD treatment alternative and is based on intercepting the drainage in a low dissolved oxygen state and directing it through limestone that contains a high percentage of calcium carbonate. Shallow trenches are excavated within mine backfill areas partially filled with limestone, covered with plastic sheeting, and capped with clay at the surface. Treatment using such a system is expected to extend greater than 20 years.

- **Quick Lime** is seldom used in industry because the formation of gypsum ($CaSO_4$) in the neutralization process can result in the clogging of conduits used in the discharge of drainage following treatment. Handling is more difficult because large quantities of heat can be generated as it reacts with water. Dust may cause serious eye injuries.

- **Caustic Soda** offers a benefit over the calcium-based compounds discussed previously in that it can raise drainage pH above 10.0 thus fostering the precipitation of manganese where necessary. Conversely, caustic soda produces a ferric hydroxide sludge with gel-like characteristics.

- **Soda Ash** is most commonly used to treat AMD characterized by low flow rate and low acidity. Soda ash can be used in a solid or slurry form. Commonly, AMD is channeled to flow over briquettes contained in a box or other structure.

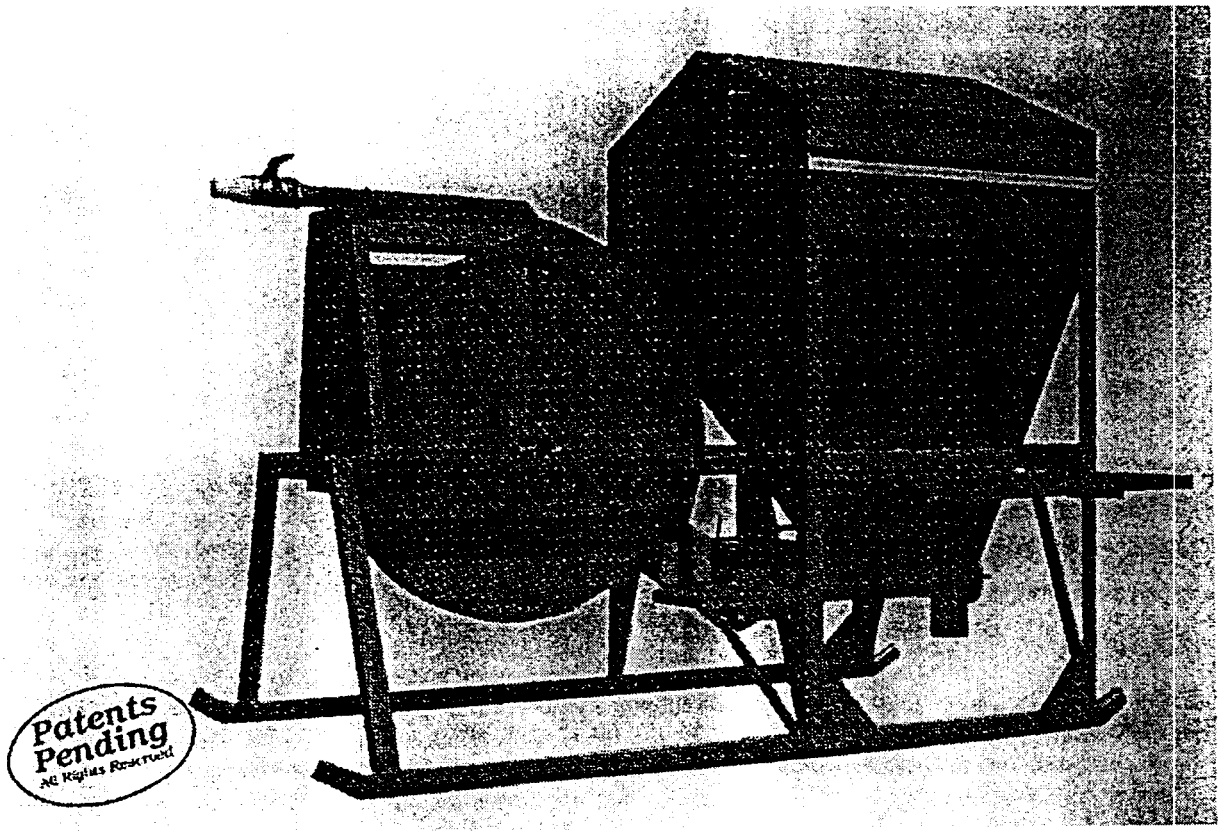


Figure 4. Example of mine drainage neutralizing device -- AquaFix

Metals Removal

For metals remaining in solution after neutralization is complete, potassium permanganate ($KMnO_4$) is the chemical of choice for removing iron (Fe) or manganese (Mn), which occur in concentrations that exceed effluent limitations. In instances where Mn concentrations are especially high, briquettes composed of both soda ash and $KMnO_4$ are available. Otherwise, $KMnO_4$ can be used alone following the neutralization process.

In the application of an anoxic alkaline drain treatment system, metals are oxidized and precipitate out at the drain outlet.

Aeration

During the neutralization process, oxidation of soluble metal compounds occurs, which acts to accelerate the formation of insoluble metal precipitates. For this reason, any activity that increases the oxygen transfer rate, and in turn the oxidation rate, is desirable. Aeration is the term applied to such activities.

Aeration is usually accomplished by spraying water through air or by allowing water to flow or cascade down a staircase trough or sluice way. This can be done during or following neutralization. Larger systems may employ the use of diffused air systems, submerged turbine generators, or surface aerators.

Settling

The Division of Waste Management should be consulted to determine if treatment product sludge should be analyzed to determine if it is hazardous prior to use as backfill. The treatment of AMD necessitates the settling of insoluble metal precipitates and sludges. The quantity and settling characteristics of any sludge produced will be dependent on the neutralization reagent used. The sedimentation process can be accomplished in a sedimentation pond or pond series or by means of a clarifier. Clarifiers allow increased control over detention time.

Chemical additives called flocculants are sometimes used to settle particles in an efficient manner. These are especially useful in settling fine particles. Synthetic polyelectrolytes are most frequently used for this purpose. Consult the MRP for site-specific recommendations.

Sludge is usually disposed of on mined out sections of the active mine. Typically, containment areas are excavated, which afford the opportunity for drying the sludge before backfilling and regrading. Site-specific decisions related to sludge disposal are dependent on land costs, hauling distances, slope, and equipment, labor, and maintenance costs. Under select circumstances, rather than discharging treated water directly into streams, some operators have obtained permission to reuse the water for irrigation purposes. This can provide a number of benefits for the operator and the environment, including water for dust control of haul roads.

Constructed Wetlands

Construction of an artificial wetlands system has the potential for reducing post-mining and mine drainage treatment costs although its use is currently not sufficient in itself for achieving bond release. Such a system would use the microbes contained in a wetland ecosystem to trigger the deposition of heavy metals from mine drainage. Metals would be removed from solution and fixed in the underlying soils in an insoluble state. If correctly designed and constructed, such a system makes use of indigenous cultures in a balance that is self-sustaining and thus ideally capable of providing long-term passive treatment (Davison, 1994).

Constructed wetlands are not a proven technology at this time and alone are not fully effective under all conditions. For these reasons, conventional back-up technology must be available if effluent limitations are not met.

Considerations in the design of constructed wetlands include the following (Pennsylvania DER, 1988):

- Methods for site preparation, including clearing and grubbing, grading and stabilization. All outslopes should be mulched and seeded upon construction.
- Number and dimensions of wetland cells.
- Base construction materials and the thickness and order in which these materials should be placed.

- Water depth and freeboard.
- Baffle design and flow routes within and between cells.
- Location of discharge points.
- Species to be planted, spacing, and method of planting, and chemicals to assist plant colonization.
- Water quality monitoring plans for the periods of:
  - construction
  - plant community establishment
  - long-term maintenance.

MAINTENANCE

Water quality should be monitored regularly and more frequently than minimum KPDES self-monitoring equipment provides. Be proactive in identifying problem areas as they may arise. Promptly adjust drainage treatment as required and maintain water level. Monitor condition of vegetation; remove accumulated solids, as necessary. Add conventional treatment to constructed wetlands system if necessary.

DIVERSIONS

DEFINITION

A diversion is a channel, embankment, or other manmade structure constructed to route water from one area to another (405 KAR 8:001). Diversions may be temporary (installed as an interim measure to control runoff and soil erosion) or permanent (approved for post-mining land use). Diversion ditches are point sources if they divert water that falls within the permit area to a water of the Commonwealth without passing through a sedimentation pond.

PURPOSE

Diversions are used to minimize contact of runoff with disturbed surfaces and acid spoils:

- Upslope from the mining operations, diversions are built on disturbed surfaces to route runoff around surface disturbances and thus reduce the size and number of sediment ponds required (Figure 5). Runoff from undisturbed areas may be directed to the normal receiving stream.
- Within disturbed areas, diversions are used to reduce slope length and minimize velocity of runoff (Figure 6).
- Around the downslope periphery of the operation, diversions are used to collect untreated water in sediment ponds for overland flow and ephemeral streams.

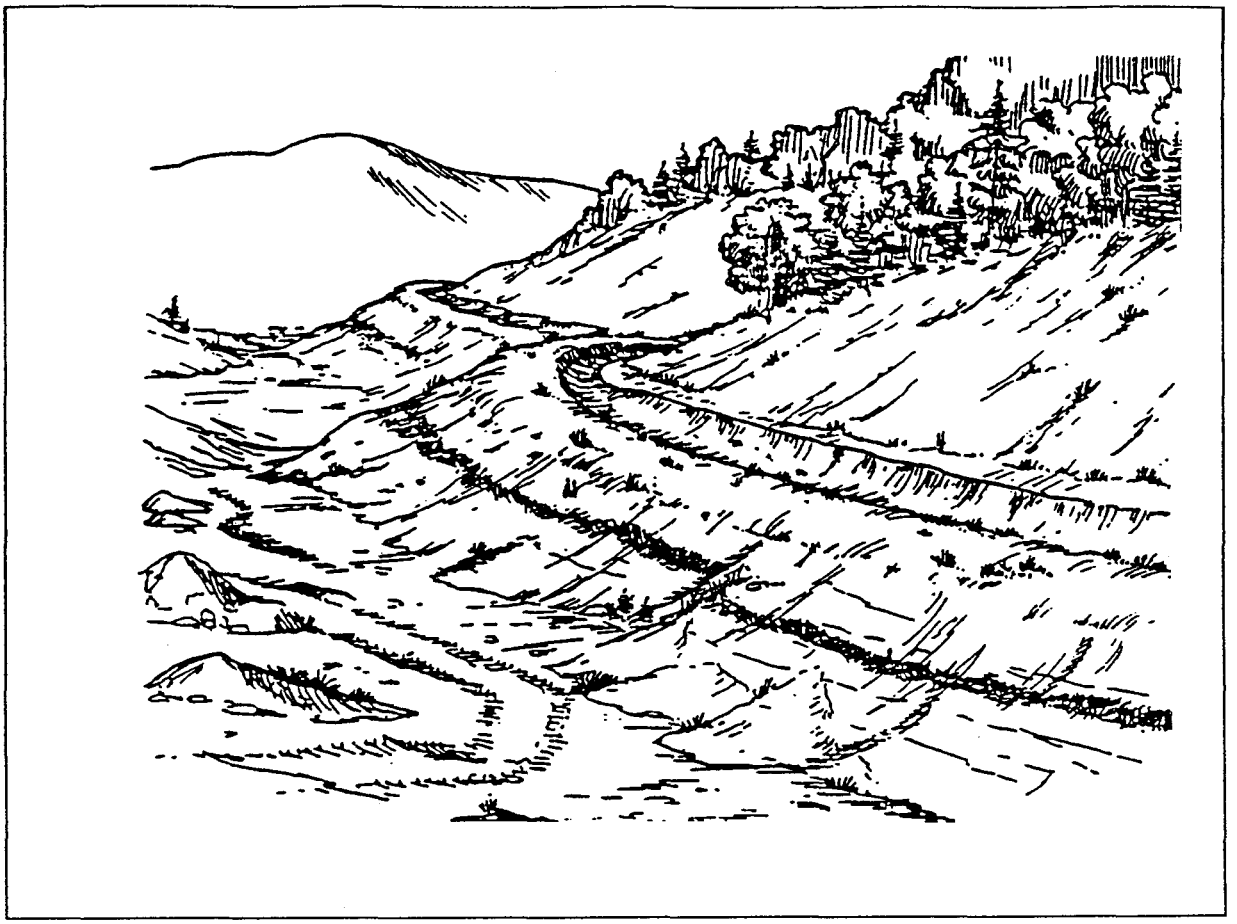


Figure 5. Upslope diversion ditches route runoff from undisturbed surfaces around disturbed areas.

REGULATORY REQUIREMENTS

State coal mining regulations (405 KAR 16:080 and 18:080) set forth standards for the design, construction, and maintenance of diversions for overland flow and ephemeral streams. Diversions are also subject to water quality regulations 401 KAR 5:031 and 5:066.

Diversion of perennial and intermittent streams that flow year-round may be done only with prior approval by the Cabinet. Permanent diversions or restored channel ways must establish or restore:

- the natural stream bank vegetation.
- an environmentally acceptable alignment.
- a longitudinal profile and cross-section, including aquatic habitats (using a pattern of riffles, pools, and drops rather than uniform depth) that approximates the pre-mining stream channel characteristics.

Should the Cabinet approve the placement of a coal refuse pile, coal waste impoundment, or an excess spoil fill in an intermittent or perennial stream, then the diversion of the stream channel must comply with the

requirements for diversions set forth in the performance standards for those structures (405 KAR 16:080, Section 2, and 18:080, Section 2).

Should the permitted activity require issuance of a U.S. COE permit, 401 Water Quality Certification by the state would be required to ensure stream protection.

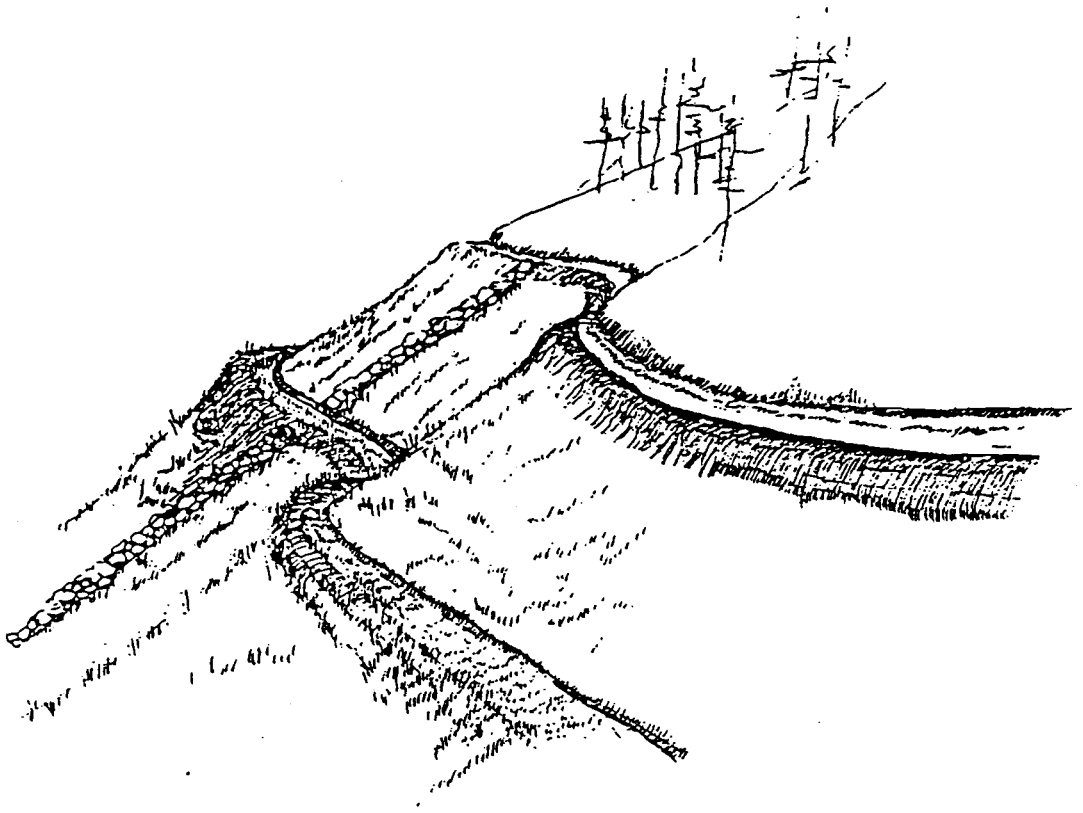


Figure 6. Diversions within the disturbed area reduce slope length and minimize velocity of runoff.

IMPLEMENTATION

Diversion channels that redirect overland flow and ephemeral streams must be adequate to pass the peak discharge of a 2-year, 24-hour storm in the case of temporary ditches, and a 10-year, 24-hour storm for permanent ditches. Under special conditions, diversions may be required to accommodate the hydraulic capacity of water control structures they circumvent (405 KAR 16:080 and 18:080).

Diversions should not be built where landslides could occur. This consideration is especially important on the upslope side of a head-of-hollow or valley fill.

Construction

To prepare for construction, the diversion should be laid with stakes. From a key point, such as an outlet, the diversion area should be divided into reaches of similar slope. Where the slope is uniform, stakes should be

placed approximately 100 feet apart. Stakes may need to be set closer than 100 feet when abrupt changes in slope are encountered.

Land on which the diversion is to be built should be cleared and grubbed. If possible, outlets should be constructed prior to channel construction. The channel outlets should be constructed to the prescribed grade, width, height, and shape as specified in the permit package.

When constructed on a slope, diversions have a berm on the downslope side to contain the flow of water. Diversions on flat land have berms on either side of the channel. The height of the ditch sides must be 0.3 feet in excess of the water level during peak storm events. This excess height is referred to as the freeboard.

Three cross-sectional geometrys are commonly used in the construction of diversions: v-shaped, trapezoidal, or parabolic (Figure 7). The v-shaped and trapezoidal are the simplest to construct. However, parabolic diversions can carry large volumes of water with the least erosive damage. Side slope steepness is limited in the regulations according to the channel lining as follows:

- no steeper than 1h:4v for solid rock
- no steeper than 1h:1v for riprap
- no steeper than 2h:1v for grass-protected.

where h is horizontal run and v is vertical rise.

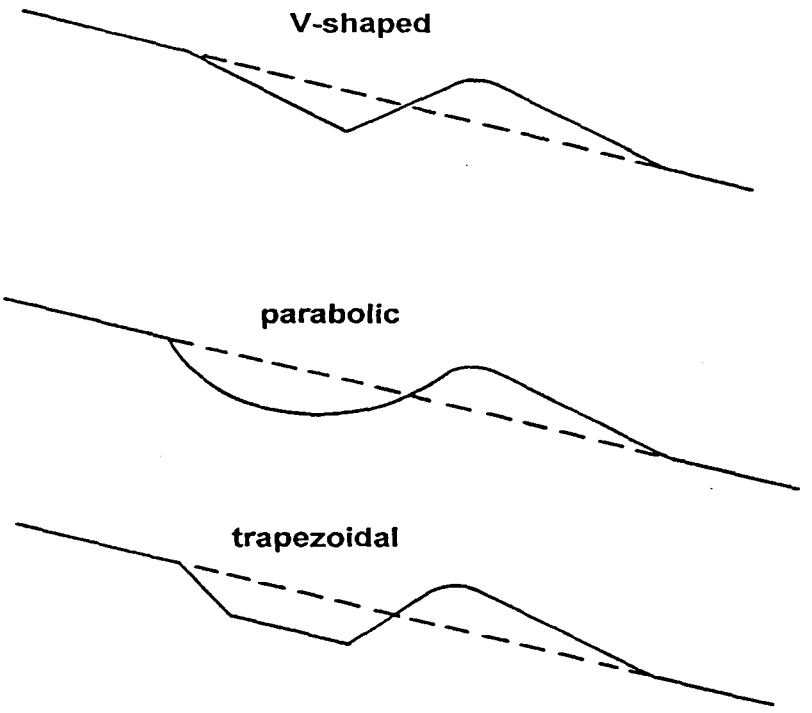


Figure 7. Cross-sectional geometry of diversion ditches.

In the excavation of diversions, disposal of excess material should be in compliance with 405 KAR 16:130 and 405 KAR 16:190. Topsoil should be handled in accordance with 405 KAR 16:050.

Erosion Control

Channel protection is essential in order to prevent erosion of diversions. Linings are the primary means of protection. Unless a channel is located on solid rock or lined with riprap or other non-erodible, non-degradable materials, diversions should be fertilized, seeded in grass, and mulched (see Revegetation, pg. 61-82). Native species are recommended as first choice for erosion protection and reclamation in general.

When channel linings are not sufficient to curb the erosive velocity of the runoff, the use of additional BMPs may be necessary (see Channel Protection, pg. 21-26).

Removal

Temporary diversions should be removed immediately upon completion of mining. Upon removal affected land should be , regraded and revegetated in accordance with 405 KAR 16:050, Sections 4 and 5; 405 KAR 16:190; and 405 KAR 16:200. If required, ephemeral stream channels shall be restored to approximate pre-mining characteristics.

MAINTENANCE

After each storm, diversions should be inspected for erosion damage to channels, linings, and/or check dams. Necessary repairs should be made promptly.

SEDIMENTATION PONDS

DEFINITION

Sedimentation ponds are water detention storage structures designed to detain storm flow. Ponds may be permanent (approved for post-mining land use) or temporary (removed and reclaimed prior to bond release).

PURPOSE

The purpose of sediment ponds is twofold:

- to create opportunity for the removal of settleable solids from non-point source (NPS) storm water.
- to collect NPS flow and transform it into point source discharge.

REGULATORY REQUIREMENTS

Sedimentation ponds must be established individually or in series prior to mining and must be designed and certified by a registered professional engineer. The design must provide for water retention time adequate to meet the requirements of 405 KAR 16:070. Ponds should be located in close proximity to the disturbance and out of perennial streams unless otherwise approved. They must meet the requirements specified under 405 KAR 16:090 and 16:100 and are subject to approval by the Cabinet on a case-by-case basis. Permanent impoundments are subject to the requirements specified under 405 KAR 16:060.

IMPLEMENTATION

Sedimentation ponds should be located immediately below the disturbance in low-lying areas. Materials from proposed pond locations should be tested for the absence or presence of toxic-forming or acid-forming materials. The type of pond selected is dependent on the topography. Embankment ponds are built on steeper slopes; dugout ponds are used on sites that range from level to shallow slopes.

The sediment storage volume of the pond is the anticipated volume of sediment that will be collected by a pond between scheduled clean-out operations. The amount of sediment that accumulates in any given period of time is dependent on the particle size distribution of the incoming suspension. For example, larger, heavier particles tend to settle faster than smaller, lighter particles.

Ponds must be designed so that water detention time is sufficient during a 10-year, 24-hour precipitation event to ensure that pond discharge will meet KPDES effluent limitations (405 KAR 16:070 and 401 KAR 5:065 and 40CFR434) regardless of rainfall amount, unless alternate precipitation-based limits are granted by the Kentucky Division of Water on a case-by-case or event-by-event basis.

In the case of fine, clay-sized particles, the use of special chemicals called flocculants may be necessary to enable settling. Flocculants bind smaller particles into clumps or "flocs," which then settle.

Site Preparation

The intended pond site should be cleared of vegetation. Trees should be removed and the remaining vegetation should be scalped, and stumps and roots should be grub out. Topsoil should be removed and stored or redistributed as appropriate (see Topsoil Removal and Storage).

In the case of an embankment pond, all surfaces should be sloped to no steeper than 1v:1h and the entire foundation surface should be scarified. If acid-forming or toxic-forming materials are present, crushed lime should be incorporated by disking into pond substrate and the pond lined with clay or geotextile membranes.

Embankments

Embankment construction specifications are addressed in SEDCAD$^+$ (Warner and Schwab, 1992). Excavation of a cutoff trench (to bedrock, if possible) is advised upstream of the proposed embankment centerline. Fill material used in the construction of embankments must be free of vegetative material, frozen soil, or coal processing waste. If quantities of suitable materials are insufficient, fill may be borrowed from stockpiles. Borrow pits should be excavated in a manner that prevents steep or unstable side slopes. Surfaces should be further stabilized with vegetation (see Revegetation).

Using the cleanest available fill material first, placement should begin at the lowest point of the foundation. The fill should be spread in horizontal layers six to eight inches deep and then compacted.

The entire embankment including the surrounding areas disturbed by construction should be immediately stabilized with a vegetative cover (see Revegetation). The active upstream face of the embankment where water will be impounded should be rip-rapped one foot higher than the level of the emergency or open spillway. Riprap should also be placed to a depth of 1.5 feet over the emergency spillway such that 25 percent of the rock is at least 18 inches in diameter.

Pond Removal

Temporary sedimentation ponds may be removed with approval by the Cabinet once all disturbed areas in the drainage area above the structure have been backfilled, graded, and revegetated. Such vegetation must have successfully survived two years from the last augmented seeding and have met the ground cover requirements of 405 KAR 16:200. Water discharged from the reclaimed area must be in compliance with

effluent limitation guidelines for coal mining under 40 CRF 434 or the KPDES permit from the operation. The Division of Water should be notified at the time of pond removal of the determination of the point source discharge.

MAINTENANCE

A proposed sediment clean-out schedule is to be included with every pond design submitted to the Cabinet. Regulatory requirements do not require sediment removal until the pond has reached the maximum sediment storage level. However, it is often advisable to remove sediment at the 60-percent level in order to ease the meeting of effluent limitations. In most cases, sediment accumulation levels can be determined via visual inspection.

Depending on pond size and location, clean out is often best accomplished using a clamshell or dragline. If neither is available or well-suited, a long-arm backhoe can be used. For operators who rent equipment, it may be less costly to build larger ponds requiring fewer clean outs.

Dredged material should be dried before it is backfilled and regraded. Often "drying beds" are planned alongside the ponds (away from drainage ways) within the context of the permit. Once materials are dried, they may be disposed of in accordance with 405 KAR 16:090.

The pond embankments should be regularly inspected for signs of erosion and be repaired and revegetated in accordance with 405 KAR 16:090, Section 6. Embankments should be kept free of woody vegetation which could cause weakening of the structure by root channels and subsequent failure. Vegetative covers should be maintained through mowing, fertilizing, and reseeding as needed.

CHANNEL PROTECTION

DEFINITION

Channel protection refers to those measures used for stabilizing channels to protect against the erosive forces of water. Channel linings and check dams are two means by which to protect channels. Channels can be lined with grass, rock, riprap, or concrete. Check dams can be constructed with straw bales, lumber, or rock.

PURPOSE

The primary purpose of channel protection practices is to reduce the velocity of storm water flow. Small amounts of sediment may be trapped in the process. However, channel linings and check dams are not sediment trapping practices per se and should not be regarded as such.

REGULATORY REQUIREMENTS

Kentucky coal surface mining regulations (405 KAR 16:080 and 16:220) and water quality regulations (401 KAR 5:031 and 5:065) require that the design, construction, and maintenance of diversion ditches and road drainage systems prevent additional contribution of suspended solids to stream flow or runoff outside the permit area. Channel protection in the form of channel linings is mandated to prevent ditch erosion.

There are no regulatory requirements for the use of check dams. However, use of check dams can be effective for short-term erosion and sedimentation control, especially during the construction phase of water containment structures, stream crossings and encroachments, or haul roads, or during revegetation.

IMPLEMENTATION

Channel Linings

For channels with a peak discharge design velocity less than five feet per second, grass linings are allowable. In those cases where velocities are five feet per second or greater, riprap or other non-erodible, non-degradable materials must be used in lining unless the ditch is located on solid rock. Lining restrictions are also based on channel configuration as follows:

- side slopes can be no steeper than 1h:4v f or channels lined with solid rock;
- side slopes cannot exceed 1h:1v if the use of riprap is planned; and
- grass-protected ditches may have side slopes no steeper than 2h:1v.

Grass Linings

As appropriate, diversion ditches (Figure 8) should be limed and fertilized, seeded, mulched, and maintained in compliance with 405 KAR 16:200 (see Revegetation). Grass species especially effective in protecting against erosion include Tall Fescue, Reed Canarygrass, Bermudagrass, and Kentucky Bluegrass.

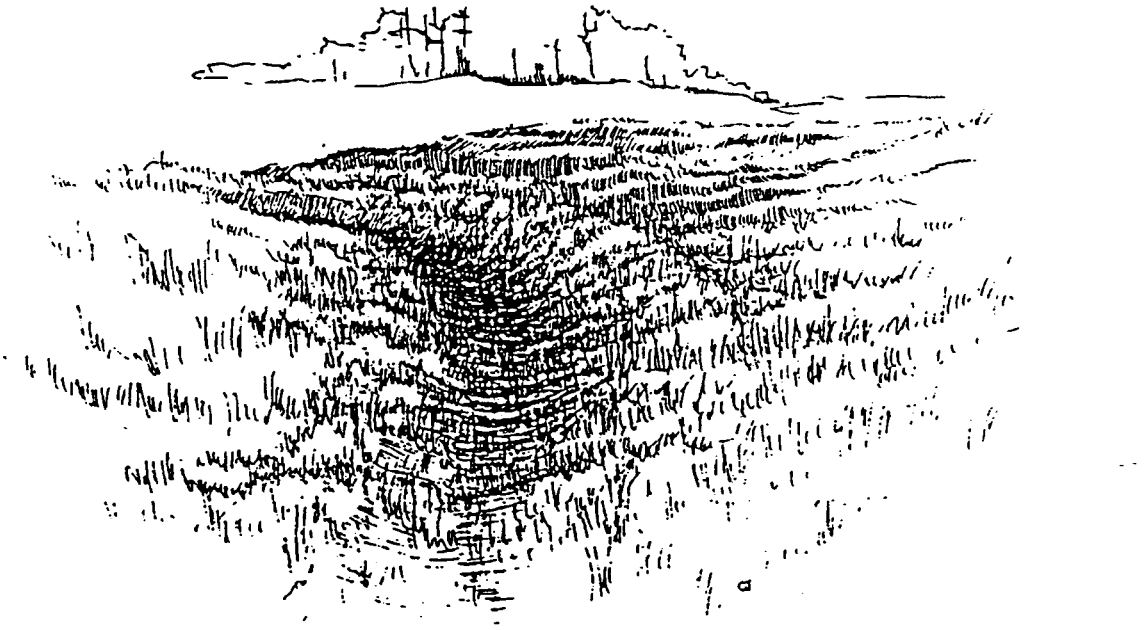


Figure 8. Grass Linings

Riprap Linings

Riprap linings (Figure 9) must be free of acid-forming and toxic-forming material and comply with the durability requirements of 405 KAR 16:130. That is, the Cabinet considers rock to be durable if the rock has a Slake Durability Index value of 9 or greater as determined via the Kentucky Method 64-513-79. Sand and gravel may not be used for channel lining.

The size of stones comprising riprap can be either uniform or graded. Generally graded riprap, that is, stones of varying size, is preferred because it forms a self-sealing cover. Consequently, installation of graded riprap is less expensive because stones can be dumped and be expected to remain in a well-graded mass. Uniform riprap requires individual placement of stones.

Riprap size can be specified by stone diameter or weight. Composition of a well-graded mixture down to the one-inch particle size such that 50 percent of the mixture by weight is no larger than the median stone size is preferred.

Riprap layers should have a minimum thickness of 1.5 times the maximum stone diameter, and not less than six inches. Rectangularly shaped stone is preferred for its durability, and the specific gravity of individual stones should be equal to or greater than 2.5. Channel banks should be protected to a height equal to the maximum depth of flow.

Check Dams -- General Construction

Check dams can be constructed where needed to reduce the velocity of concentrated storm water flow. Large rocks that might interfere with the functioning of the structure should be cleared, grubbed and removed. Building materials for check dam construction should be selected on the basis of expected flow rate and economics. Check dams should stretch from bank to bank. Water should cross only through a weir outlet and never over or around the sides of the check dam. The weir outlet itself should be at least six inches below the top of the embankment. The height of the dam should not exceed two feet. The maximum drainage area of the ditch or swale protected should not exceed 10 acres. For check dams built in series, the toe of the upper dam should be no lower than the crest or height of the lower check dam.

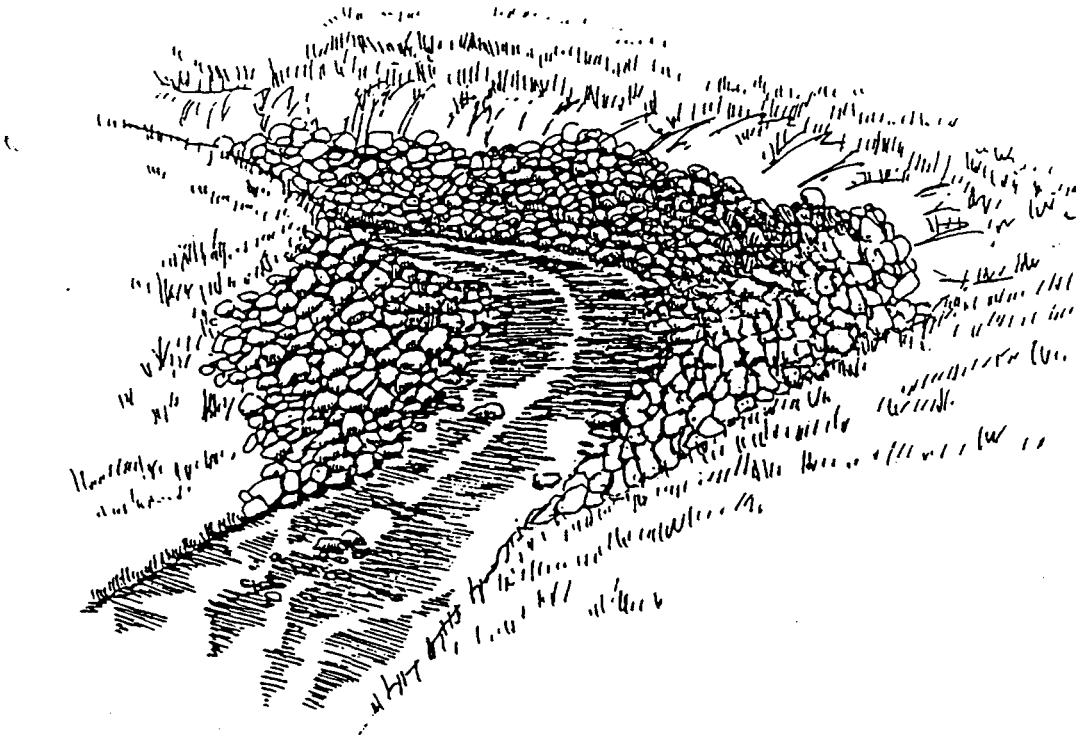


Figure 9. Riprap linings

Straw Bale Check Dams and Barriers

Straw bales are appropriate for use in erosion and sedimentation control on slopes and minor channels where concentrated flow will not develop.

The straw bale barrier should be built on a zero percent grade and parallel to topographic contours. Effectiveness of such barriers is limited by slope length and gradient. Limits on slope length are presented in Table 3.

Straw should be tied with plastic or hemp string (not wire) to form bales. Straw bales should be entrenched to a depth of four inches and staked to a depth of 18 inches (Figure 10).

Table 3. Maximum Slope Lengths for Straw Bale Check Dam (Smith, Jr., J.W., 1991)

Percent Slope	Maximum Slope Length (ft) Above Barrier	Percent Slope	Maximum Slope Length (ft) Above Barrier
2 or less	250	30	15
5	100	35	15
10	50	40	15
15	35	45	10
20	25	50	10
25	20		

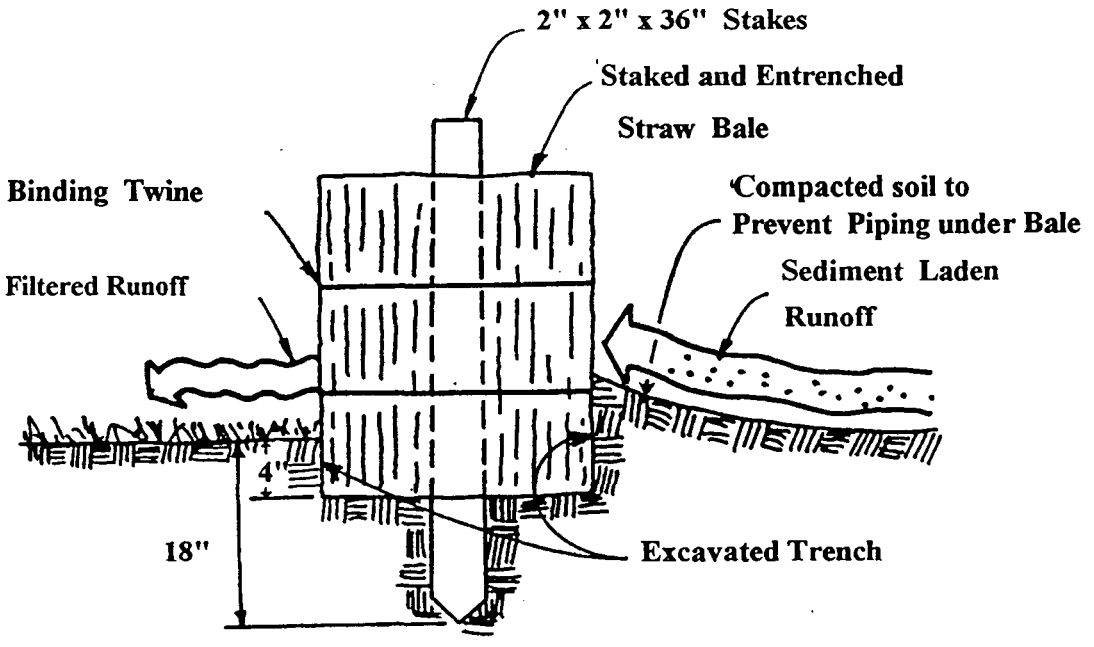


Figure 10. Cross-section of straw bale barrier

Log Check Dams

Because log check dams are more effective and stable than straw bale barriers, they can be used in channels. Typically, from a materials standpoint it may be less expensive to construct a check dam from logs rather than from rock. In terms of labor requirements, log dams require more time and hand work to build. Logs should be four to six inches in diameter and be driven 18 inches beneath the channel floor. Logs should stand perpendicular to the plane of the channel cross section, with no space between logs (Figure 11). Center logs should be driven deeper into the ground to provide a six-inch weir. Place riprap or shorter, wider logs on the downstream side of the weir to stabilize the outlet.

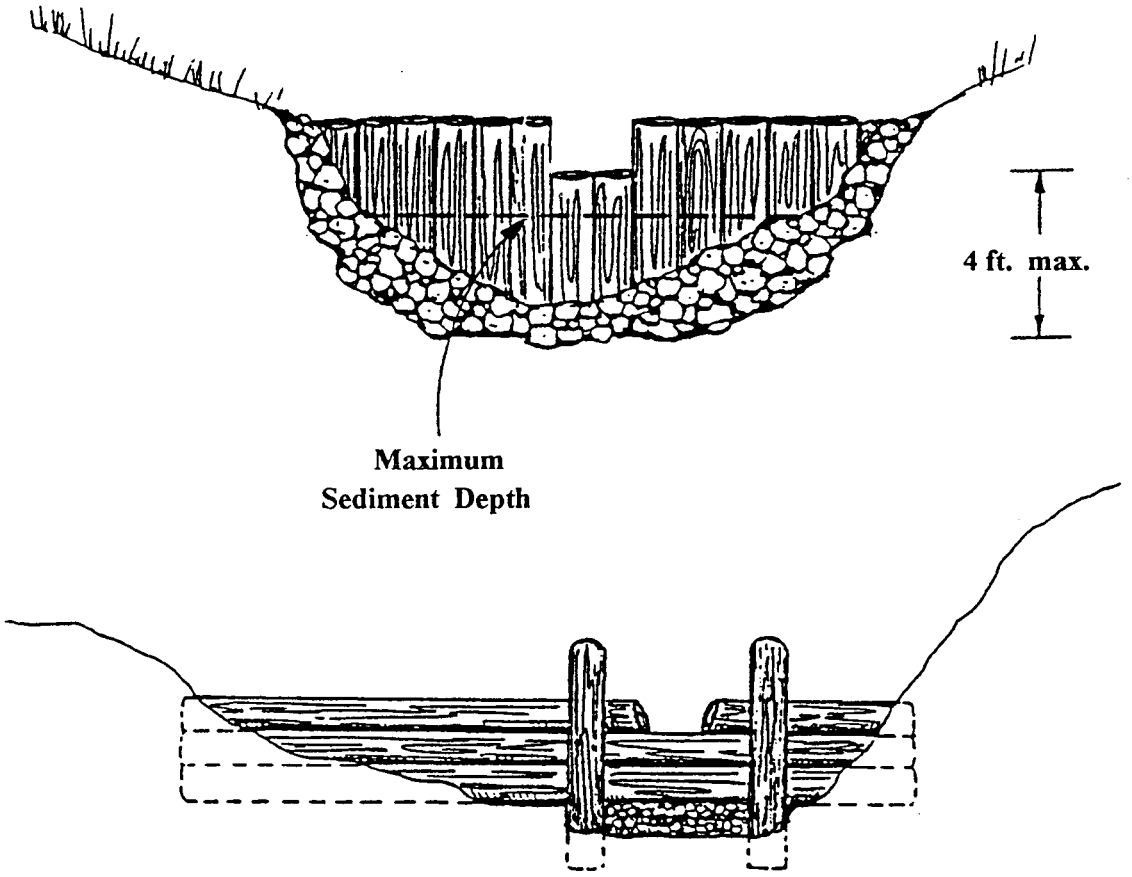


Figure 11. Log check dams

Rock Check Dams

Water passes over and through rock check dams (Figure 12). In small channels, loose rock may be dumped to form a check dam. In such cases, stone two to three inches in diameter can be used.

Larger channels may require the use of gabions (cages made from heavy wire fence and filled with rock). These check dams (Figure 13) are most effective if anchored three feet into the ground. Nine-inch diameter stone is sufficient for use when water velocities do not exceed eight feet per second.

Both the upstream and downstream faces should be no steeper than 1v:3h for loose rock and 1v:2h for gabions.

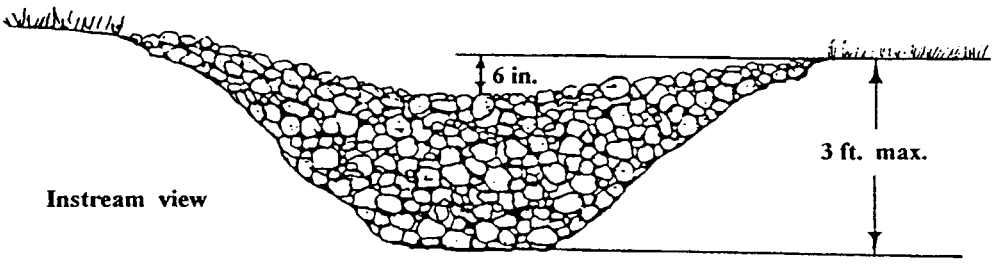


Figure 12. Rock Check Dam

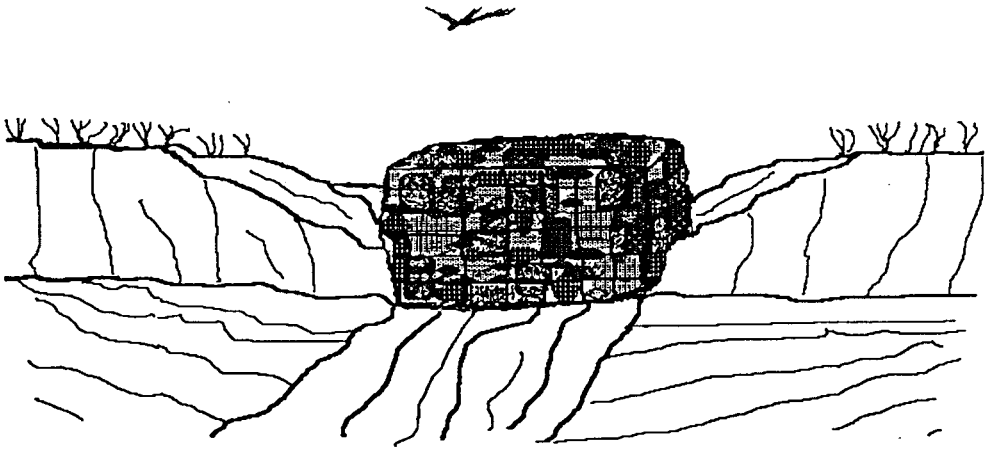


Figure 13. Gabion

Check Dam Removal

Check dams should be removed when temporary diversion ditches are regraded and revegetated. Stones in permanent grassed waterways should be removed to prevent damage to mowers.

For permanent channels, check dams should be removed once permanent linings are installed or grass has adequately matured to protect the ditch or swale.

MAINTENANCE

After each significant rain storm, check dams should be inspected for damage and sediment accumulation. Sediment should be removed when it accumulates to one-half the height of the dam or sooner. Sediment that has been removed should be backfilled, graded, and revegetated in accordance with 405 KAR 16:190 and 16:200.

Vegetative covers should be maintained through mowing, fertilizing, and reseeding as needed.

Riprap stone that has moved should be replaced by hand, and additional stone should be placed where undercutting has occurred.

SILT FENCES

DEFINITION

A silt fence is a temporary sediment barrier constructed of a semi-permeable fabric (burlap or synthetic) stretched between and attached to supporting posts.

PURPOSE

Silt fences trap sediment while allowing runoff water to pass through the fence.

REGULATORY REQUIREMENTS

There are no regulatory requirements for the use of silt fences on active mine sites. Nevertheless, silt fences can be effective in short-term erosion and sediment control, especially during the construction phase of other control structures, haul roads, and as a control for use in small drainage basins.

IMPLEMENTATION

Failure rates of silt fences are generally lower than those of straw barriers if fences are properly installed. Fences constructed of synthetic materials generally have a much lower permeability than those constructed of burlap. Screen sizes will vary according to the manufacturer. For that reason, synthetic barriers are usually limited to control of overland runoff flow. Usually these fabrics do not have the structural strength to support the weight of water impounded behind the fence line. The life expectancy of a silt fence under these conditions is generally expected to be about six months.

Silt barriers can sometimes be employed in minor channels (flow less than one cfs) when the area drained does not exceed two acres.

Planning/Installation

The following guidelines are offered to encourage the effective use of silt fences in erosion and sediment control:

1. The filter cloth should be able to filter 20 gallons of water per hour per square foot of fencing and retain at least 75 percent of the sediment.

2. Fence posts must be strong and durable. Suitable materials include 2x2 lumber, reinforcing rod (rebar), stamped steel posts, or hog fence T-posts. Do not attach filter cloth to trees.

3. The fence should preferably be constructed parallel to topographic contours, at a zero percent grade (Smith, 1991). A fence post spacing not to exceed six feet is recommended.

4. The size of the drainage area should be no more than ¼ acre per 100 feet of fence.

5. Maximum slope length should be 100 feet. When slope length exceeds 100 feet, a second installation of fence should not be installed behind the first.

6. Fences should be installed in undisturbed ground. Drive fence posts one foot deep along the fence line. Dig a six-inch by six-inch trench on the upslope side (Figure 14). Attach self-supporting filter cloth or a combination of wire fencing and filter cloth to the poles with durable large head nails.

7. The bottom six to eight inches of the filter fabric should be buried in the trench. The trench is then backfilled and compacted to aid in anchoring and minimize piping. The trench line should be revegetated immediately with a temporary seed mixture.

8. Considerations should be given to increasing the stability of the fence posts by using staked rope or wire tie-backs. Tie-backs are especially important when silt barriers are constructed in minor channels. In such instances, it is advisable to cut a v-notch weir outlet (Figure 15) in the filter cloth's upper edge at the lowest edge at the lowest point in the fence line. Beneath the v-notch, place riprap in the channel below the outlet.

Removal

Silt fences are intended as temporary erosion and sediment control devices and should be removed when no longer needed. Filter fabric can sometimes be recycled for use at a new location. The disturbed area should be regraded and revegetated in accordance with the revegetation plan.

MAINTENANCE

Silt fences should be inspected, especially following significant rain or windstorm events. Fence reanchoring or patching may be necessary.

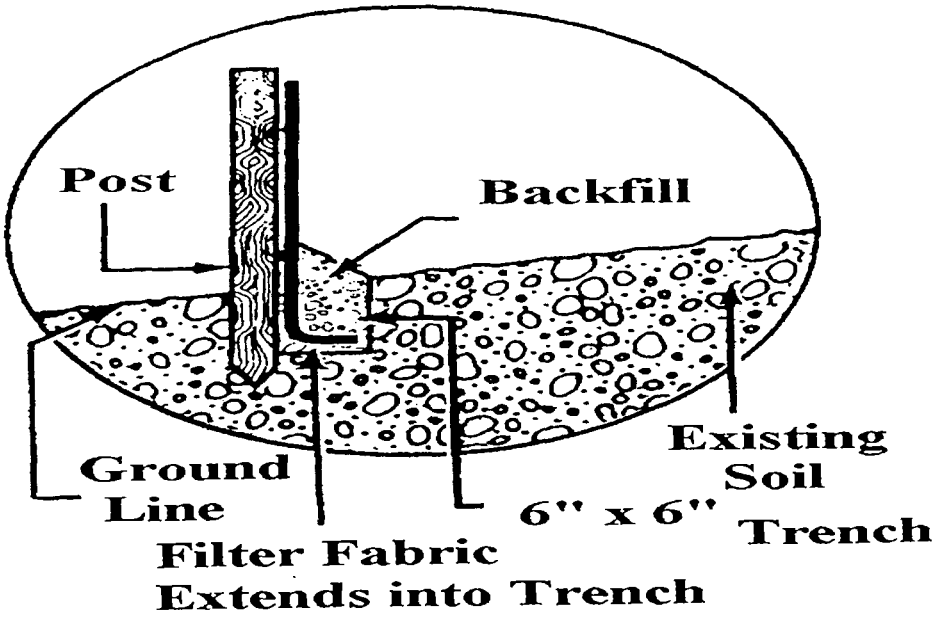


Figure 14. Silt fence installation

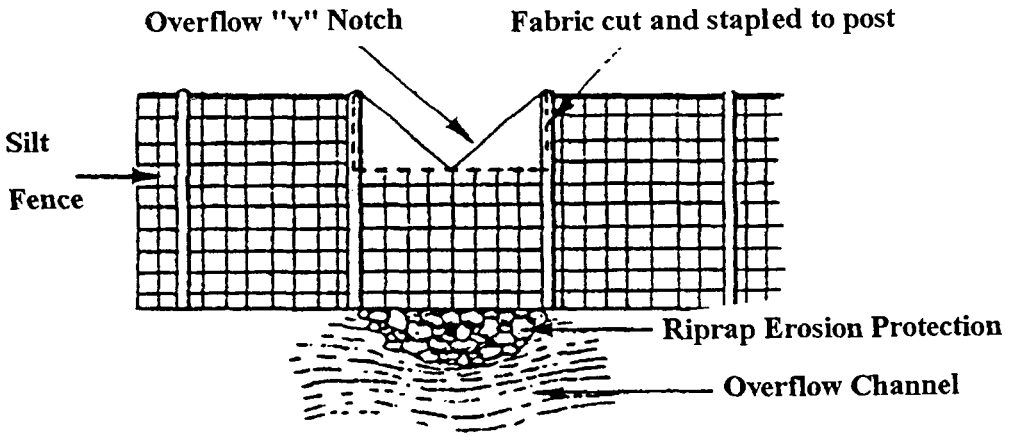


Figure 15. Silt fence weir

VEGETATIVE FILTERS

DEFINITION

Vegetative filters are temporary or permanent sediment traps composed of cultivated or naturally occurring vegetation. Synonyms for vegetative filters include riparian zones, grass filter strips, and stream buffer zones. Riparian zones are vegetative buffers along the banks of a natural drainage way or stream.

PURPOSE

The purpose of vegetative filters is to provide areas for the deposition of runoff-transported materials before they reach drainage ways. These zones are especially useful in the protection of streams paralleling land disturbances.

REGULATORY REQUIREMENTS

405 KAR 16:060 and 18:060, Section II, require a 100-foot stream buffer zone unless a variance is granted by the Cabinet. Approval for such a variance is based upon the assurance that the water quality and quantity and the environmental resources of the stream will not be adversely affected. In addition, 405 KAR 16:180 and 18:180 require the protection and/or restoration of riparian areas.

IMPLEMENTATION

Vegetative filters are best employed in areas of moderate slope that receive sheet flow following storm events. Naturally occurring vegetative buffers with thick vegetation can be effective and economical sediment traps to buffer the effects of disturbances associated with haul roads and regraded spoil slopes. Application of fertilizer can help increase plant growth and density. See the section titled Revegetation (pg. 61-82) for further discussion.

Stream buffer zones can also be established with grass or woody plants, when ground cover is absent. Researchers associated with the University of Kentucky have developed a Kentucky Grass Filter Model. This model addresses the factors that influence the effectiveness of cultivated grass filters, namely:

- Length of the filter
- Filter slope
- Grass characteristics
- Size distribution of incoming sediment
- Quantity and depth of flow

Vegetative filters can be constructed with grading equipment commonly available on active mine sites. The filter is commonly at least 15 feet above diversions and 100 feet above naturally occurring streams. These figures are approximate and should be adjusted to accommodate unique features of the site and the filter itself.

Grasses used for filters should be selected on the basis of their root system and above-ground density. Deep root systems resist scouring, and dense, well-branched top growth is generally flood and drought resistant. Tall Fescue and Reed Canarygrass are effective grasses for use in filter strips. See the section titled Revegetation for information on seedbed preparation, seeding, and mulching considerations.

Computer software (e.g., SEDCAD$^+$ Version 3) is available for the purpose of evaluating site-specific characteristics, e.g., soil type, flow, grass stiffness, and filter length, width, and slope and projecting the sediment-trapping efficiency of the filter (Warner and Schwab, 1992).

MAINTENANCE

Sediment reduction effectiveness of cultivated filters diminishes over time as the vegetative filter becomes clogged with sediment. Until a permanent cover is established on adjacent disturbed areas, it may be necessary to reseed and establish a new filter strip periodically.

ROADS

ROADS

DEFINITIONS

For the purpose of coal mining operations, the term roads applies to surface right-of-ways intended for use by land vehicles used in coal exploration or surface coal mining and reclamation operations as well as activities associated with abandoned mine reclamation. A road consists of the entire area within the right-of-way, including the roadbed, shoulders, parking and side area, approaches, structures, ditches, surface, and contiguous appendages necessary for the total structure. The term includes access and haul roads constructed, used, reconstructed, improved, or maintained, including those used by coal-hauling vehicles leading to transfer, process, and storage areas. The term also excludes any roadway within the immediate mining pit (405 KAR 7:001).

PURPOSE

Roads are used within the context of surface coal mining operations in order to minimize the disturbance created by mining equipment and other transport vehicles.

REGULATORY REQUIREMENTS

Environmental regulations designed to minimize the amount of erosion and sedimentation incurred from roadways are addressed in 405 KAR 16:220. This regulation sets forth requirements for the location, design, construction, maintenance, and removal or permanent retention of roads and associated drainage structures.

IMPLEMENTATION

Roads should be located, insofar as is reasonably possible, on ridges or on the most stable slopes available. Roads on or near ridges are desirable because typically they require the fewest stream crossings. Flatter slopes not only reduce the erosive effects of runoff water, but also improve truck performance and driver safety. Slope stability is determined by both percent slope and an analysis of the overburden.

Unless otherwise authorized by the Cabinet, under no circumstances may roads be located in stream channels. Approved stream fords may not adversely affect stream sedimentation or fish and wildlife. Streams or natural drainage ways may not be relocated to accommodate road construction.

Roadbed Construction

Design specifications for road construction should be present in the MRP. Practices follow that are intended to limit hydrologic disturbance (405 KAR 16:220):

- **Roadway width** -- should be appropriate for traffic volume and the anticipated size, weight, and speed of vehicles. As a rule of thumb, straight-aways should be at least 23 feet wide for a single-land road and 40 feet wide for a two-lane highway. The roadbed should be up to 20 percent wider at curves depending on the sharpness of the curve. Dead-end roads should allow sufficient room for easy turn around.

- **Vertical Alignment** -- Maximum road grade should not exceed 15 percent (1v:6.5h), and within any 1000-foot stretch of road, no more than 300 feet may have a slope in excess of 10 percent.

- **Horizontal Alignment** -- should be consistent with existing topography.

- **Clearing and Grubbing** -- Vegetation should be limited to the width necessary to accommodate road drainage construction.

- **Road Cuts** -- Cut slopes should not be steeper than 1v:1.5h in unconsolidated materials or 1v:0.25 h in rock, unless a minimum safety factor of 1.5 can be demonstrated (and Cabinet approval is obtained).

- **Road Embankments** -- No organic material or soil should be placed beneath or within any embankment. This includes materials such as coal, coal blossom, peat, or frozen or excessively wet materials. Acid-producing materials may be used in the construction of embankments only for those roads constructed on coal processing waste banks.

  When slopes are planned to exceed 20 percent, ground should be plowed, stepped, or if on bedrock, keyed. The keyway should have a minimum width of 10 feet and should extend a minimum of two feet below the toe of the fill.

  The embankment should be constructed in horizontal layers, and compacted. The fill should be placed in layers 6 to 12 inches thick. Each layer should be compacted using tampers, sheepsfoot, or pneumatic tired rollers, or vibratory compactors. Compaction should be sufficient to support the anticipated traffic volume, weight, and speed. Slopes should not be steeper than 1v:2h, except where fill material is comprised of at least 85 percent rock. In those instances, slopes should not be steeper than 1v:1.35h.

- **Minimum Safety Factor** -- A minimum safety factor for all embankments is 1.25.

- **Toe Berm** -- Considerations should be given to constructing a toe berm at the base of fill slope. A toe berm should be pitched at 1 to 3 percent toward the slope. The outslope of the berm should not exceed 33 percent.

- **Slopes and Curves** -- The road surface should be sloped to prevent the ponding of water. The banking of curves allows for safer truck handling and less load spillage. A banking slope should be specified in the plans developed by an engineer and should be at least 0.5 inches per foot. The crossfall should run from the outside of the curve to the inside. Crossfalls and banking should be smooth and gradual to minimize ponding. Berms must be at least as high as the axles of the equipment scheduled for use on the roadway.

- **Sub-base and Surfacing** -- Good quality sub-base reduces road and equipment costs and minimizes the effects of erosive forces. Acceptable sub-base materials include crushed gravel, clean sand, and sand-clay mixture. Acid- or toxic-forming materials are unacceptable for use in road surfacing. The depth of sub-base depends on the material used (Table 4).

Table 4. Depth of Sub-Base Materials

Sub-Base Material	Depth (in)
Crushed Rock	6-8
Gravel	8-12
Clean Sand	12-24
Sand-Clay Mixture	10-30

Source: Derived from California Bearing Ratios

When selecting a sub-base depth, consideration should be given to both weight load and particle size. If the loaded equipment is heavier than 40 tons, the thicker depths in the ranges above should be used. If loads are lighter and the sub-base contains mixed-sized particles, the thinner depths should be used. In general, however, the thicker the sub-base the better in terms of hauling efficiency, especially under wet conditions.

The practice of laying rolls of plastic filter cloth between the road surface and sub-base promotes the drying of road surfaces. Rutting and erosion are reduced because the plastic filter cloth tends to increase traction and encourage the even spreading of the road surface.

Surface paving materials include rock, crushed gravel, and asphalt. Asphalt is costly and tends to be slick when wet or covered with mud. Crushed gravel is more cost efficient in terms of application and provides better traction for heavy equipment. Gravel or rock used for the sub-base should be crushed finer for use on the road surface. Neither the sub-base nor the surface should contain more than 10 percent fines.

Removing gravel from streambeds can be harmful to aquatic life and should be avoided. If coal is trucked to a power plant, the Cabinet may approve the hauling of cinders back for surfacing as long as acidic conditions do not exist. The surfacing material should have a compacted thickness not less than six inches. Compaction can be achieved with rubber-tired or steel rollers.

Drainage

Roads and associated structures should be designed to allow adequate drainage to accommodate a 10-year, 24-hour precipitation event as a minimum (see the MRP). Water-control systems may include ditches, cross drains, and ditch relief drains. Natural water drainage channels should not be altered or relocated for the sake of road construction. If the area above the road is disturbed, all runoff from the road should be collected by using roadside diversions. Roadbeds constructed on hilly terrain should have a drainage ditch running alongside (usually cut into the cut slope) and a berm or mound on top of the fill slope. On flat or gently sloping land, a diversion ditch is needed along each side of the road.

- **Crossfall** -- Roadbeds should be sloped toward roadside ditches. Roads cut into hilly terrain should have a side crown and one full-width crossfall (Figure 16). Roads on flat or gently sloping land should have a center crown and two crossfalls.

  The crossfall or cross-slope of the bed should be ¼ to ½ inch per foot. For example, on a single-lane, side-crown road, the fill slope side of the road would be about 6 to 12 inches higher than the cut slope side. In comparison, the crossfall on a road of the same width built on level land would be half of that or about three to six inches. Runoff would flow from the center of the road to ditches on either side. For information on ditch construction, see Diversions.

- **Drainage ditches** -- Drainage ditches should be placed at the toe of all cut slopes. Ditches should be constructed on both sides of a throughcut and on the inside shoulder of a cut-and-fill section. Ditch-relief cross drains should be spaced according to the grade. Water should be intercepted before reaching a switchback or large fill and drained away. Water accumulated in a fill or switchback should be released below the fill, through conduits or in riprapped channels, and should not be discharged onto the fill. Trash racks and debris basins should be installed in drainage ditches to keep the drainage system free from clogging. The use of settling basins and risers are practices that can further help to control siltation stemming from road drainage.

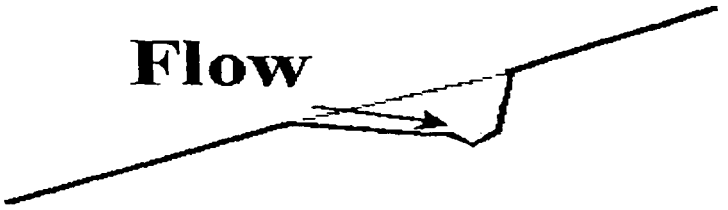


Figure 16. Roadbed crossfall on hilly terrain

- **Culverts** -- Drainage structures are required for stream channel crossings. Depending on the stream channel width and bank height, two or more culvert pipes side-by-side, may be required (Figure 17). Oval-shaped pipe is often more cost-effective than rounded pipe. Culverts should be long enough to run beneath the total width of the roadbed and both side slopes. Pipe diameter should be at least two feet. Culverts should be placed flush with the stream substrate, so as not to act as a barrier to aquatic organisms. Permanent bridges are recommended over culvert crossings (less damaging to stream substrate).

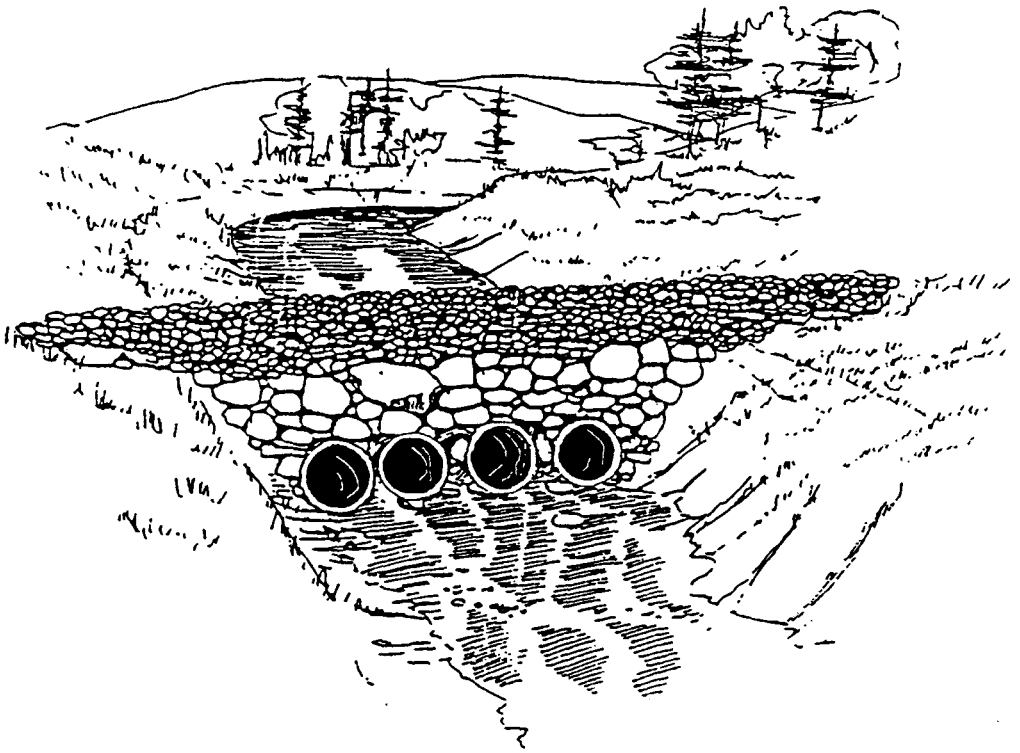


Figure 17. Constructing stream crossings by providing a culvert or bridge.

The stream bed should not be disturbed beyond that extent necessary. Culvert pipes should be laid on a slope of at least one-forth inch per foot (at least 2 to 4 percent slope) to ensure drainage. There should be no more than a one-foot gap between the outside edges of each pipe. After the pipes are placed in the stream, clean, fist-sized should be backfilled rock. Soil may not be used as a fill. All culverts should be covered with compacted fill to a minimum depth of one foot. A depth of one-half the pipe diameter is preferable (Figure 18.) Inlets should be protected from erosion by means of rock headwall. Culverts should be spaced more frequently as grade increases (Table 5).

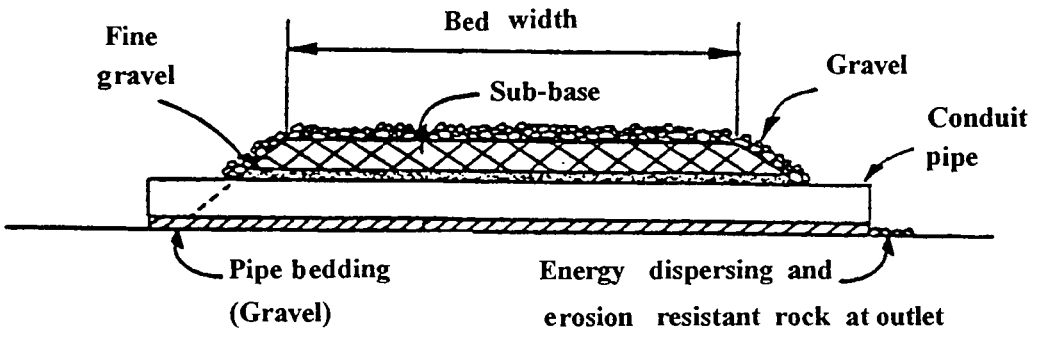


Figure 18. Cross-drain culvert construction

Table 5. Culvert Spacing with Grade

Culvert Spacing not to exceed	Percent Slope
1000 ft	0 to 3
800 ft	3 to 6
500 ft	6 to 10
300 ft	10 or greater

Source: Weigle, USDA Forest Service

On temporary crossings to be used no longer than six months, the upstream and downstream faces should be ripraped. Surface approaches for a distance of 25 feet with six inches of rough gravel. A four-inch concrete apron on both the upstream and downstream faces is recommended, together with an eight-inch reinforced concrete running surface (including 25 feet of both approaches).

Restoration

All roads within the permit area should be removed unless approved as part of the post-mining land use. Restoration should begin as soon as practical after the road is no longer needed for mining activities. To accomplish restoration:

- The road should be closed to all vehicular traffic. This can be accomplished using large boulders or logs.
- Roadbeds should be plowed, ripped, and scarified, starting at the top of the slope and working downward.
- Fill slopes should be returned to AOC by rounding or reducing slopes to conform to those of adjacent terrain.
- Cut slopes should be shaped to blend with natural terrain.
- Terraces should be constructed if necessary to prevent excessive erosion and to provide long-term stability in cut-and-fill slopes.
- Natural patterns should be restored.
- All bridges and culverts should be removed.
- Culverts should be replaced with cross drains, dikes, and water bars (Table 6).
- Roadbank surfaces should be topsoiled and revegetate. See Topsoil Redistribution and Revegetation.
- All road surfacing materials should be disposed of appropriately (see Noncoal Mine Waste).

Table 6. Water Bar Spacing

Road Grade	Spacing (ft)
2	250
5	135
10	80
15	60
20	45

MAINTENANCE

Road maintenance is essential for reducing operating costs and keeping roads safe and passable. Culverts and drainage systems should be checked on a regular basis to ensure that there are no obstructions that could lead to flooding or washouts. Inspections on a weekly basis are recommended. All systems should be checked following a rainfall event. Drainage ways should be cleared, as necessary. As ruts develop, the roadbed should be regraded and smoothed. Restoration should be completed, as appropriate.

TOPSOIL AND OVERBURDEN HANDLING

- Topsoil Removal and Storage
- Temporary Spoil Storage
- Backfilling and Grading
- Scarification
- Topsoil Redistribution
- Acid/Toxic Spoil
- Noncoal Mine Waste
- Excess Spoil Disposal

TOPSOIL REMOVAL AND STORAGE

DEFINITIONS

All topsoil, topsoil substitutes, and supplements for non-prime farmland uses and topsoil, and subsoil for prime farmland uses must be removed as separate layers from areas to be disturbed, segregated from other materials, and immediately redistributed or stockpiled pending redistribution.

PURPOSE

The purposes of removing and storing topsoil are these:

- To preserve media sufficient to sustain the approved postmining land use and to sustain vegetation that is adequate to meet the revegetation requirements of 405 KAR 16:200.
- To ensure stability in the foundations of structures built on surface mined lands such as excess spoil or coal mine waste piles and embankments constructed to impound water.

REGULATORY REQUIREMENTS

General requirements for topsoil removal and storage are outlined under 405 KAR 16:050. Soils from lands designated as prime farmland under 405 KAR 8:050, Section 3 must be removed and stored in compliance with 405 KAR 20:040.

IMPLEMENTATION

Removal of Woody Vegetation

Once erosion and sediment control structures are in place, trees, shrubs, and other woody vegetation must be removed before mine development can progress. Methods for tree removal are dependent on the slope of the terrain and the availability of equipment. Often it is convenient for the surface owner or operator to contract with a logging company to cut marketable timber. Unmarketable logs can be used for the construction of erosion control structures such as check dams (see Drainage). Information on logging companies and markets can be obtained from District Foresters (see Appendix D).

Remaining woody vegetation should be scalped. Slash can be chipped for use as mulch on reseeded areas. Windrowing or piling slash around the site is generally not a good practice. State regulation 405 KAR 16:060 prohibits disturbance within 100 feet of streams or other bodies of water to provide a buffer zone to filter sediment (see Vegetative Filters). Signs should be used to mark the boundary between buffer zones and disturbed areas.

Finally, tree stumps and roots must be grubbed out or provisions made to ensure their removal from the soil following soil replacement. The material should be disposed of in a designated location within the permit area. In heavily forested areas characterized by shallow soils, the problem of soil loss during grubbing may be significant. Care should be exercised to retain as much soil as possible.

Soil Removal

Following the removal of woody vegetation, the topsoil must be removed. In the case of lands that have herbaceous vegetation, these materials may be removed along with the topsoil. Topsoil is the richest, uppermost layer of soil, referred to as the A and E horizons (Figure 19). In some areas, especially the mountainous regions of Appalachia, the actual topsoil may be less than six inches thick. In these areas, the term "topsoil" is extended to include both the topsoil and the unconsolidated materials immediately below to

a total depth of six inches. Additionally, on a site-specific basis it may be necessary to remove the B horizon and portions of the C horizon if these are required to meet the revegetation requirements of 405 KAR 16:200 and to ensure soil productivity consistent with the approved post-mining land use. Bedrock or the D horizon lies below the subsoil and is also referred to as consolidated material. This may be weathered and removed without blasting.

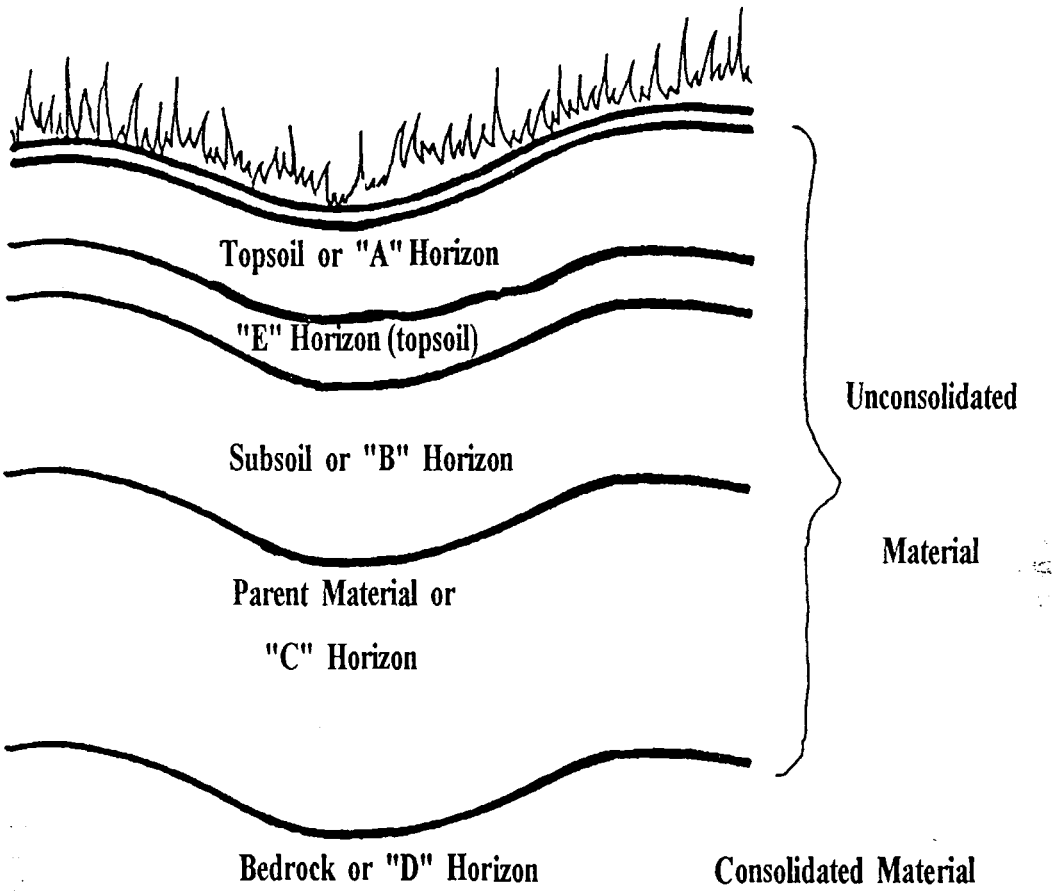


Figure 19. Schematic soil profile

Selected materials may be substituted for or used as a supplement to topsoil if it can be demonstrated that the resultant soil medium is equal to or more suitable for sustaining vegetation than the available topsoil and that it is the best available material to support vegetation. Considerations for selecting a topsoil substitute or supplement include:

- Volume.
- Physical and chemical characteristics:
  pH, net acidity or alkalinity, P, K, texture, and percent coarse fragments.
- Supplemental studies, if available.

In the case of lands designated as prime farmland, the removal of topsoil can be a somewhat more complex task. In such instances, it is necessary to remove and segregate the A, E, B, and C horizons to a restored depth of 48 inches. In order to achieve this goal, consider:

- Soil losses that may occur during handling when determining soil quantity to meet depth requirements.
- Information available through most recently published soil surveys, including maps and representative soil profiles.
- Flagging prime farmland soil boundaries on the site.
- Substitution of approved subsoil materials for fragipan horizons (horizon symbols containing "x") in order to improve chances for restoring productivity. These may be derived from appropriate associated non-prime subsoil horizons such as from soils designated by rule as being non-prime.
- The following types of equipment for use in soil removal to minimize compaction:
  - end-dump trucks
  - scrapers
  - wheel/conveyor.
- That soil removal should be performed under dry conditions, if possible, to minimize compaction.
- That combining B and C horizons with comparable horizons from scattered areas of prime farmland of the same soil type within the permit area is permissible as long as they are within the same ownership boundaries.
- The mixing of B and C horizons from the same or different soil types, although subject to regulatory approval, is a common practice.

Soil Storage

Soil should be stockpiled only when prompt redistribution is impractical (Figure 20). Otherwise, stockpiles should be constructed stable sites within the permit area. Stockpiles should be constructed using equipment that will minimize compaction (i.e., end-dump trucks, wheel/conveyors). If these sites occur on non-mined land, they should be prepared by removing all woody vegetation that may interfere with subsequent soil removal. Shallow slopes (not to exceed 1v:2h) minimize the effects of forces that cause erosion. Sloping the top of the stockpile upstream from the natural drainage may aid in providing adequate drainage in order to eliminate ponding. In the case of prime farmland soils, horizons A and E, B and C should be stockpiled separately. For stockpiles left in place more than 30 days, erosion control through the establishment of non-noxious, quick-growing annual and perennial plants (see Revegetation) is necessary.

In the case of long-term surface disturbances, soil may be distributed elsewhere within the permit area to enhance its use and condition as an alternative to stockpiling, if so approved. In all cases, topsoil should be redistributed as soon as possible.

MAINTENANCE

Soil stockpiles should be inspected on a regular basis, especially following significant rainstorms. Rill and gully erosion should be repaired and reseeding and mulching. Silt fences should be installed if necessary (see Silt Fences).

Figure 20. Soil storage

TEMPORARY SPOIL STORAGE

DEFINITIONS

This practice concerns the temporary stockpiling of spoil. Spoil is defined as overburden and other materials, excluding topsoil and subsoil, coal mine waste, and mined coal, that are excavated during coal surface mining and reclamation operations (405 KAR 7:001). Overburden (Figure 21) refers to material of any nature, consolidated or unconsolidated, excluding topsoil and subsoil, which lies above a natural deposit of coal (KRS 350.010).

PURPOSE

Temporary spoil storage offers an interim solution when displaced overburden cannot be immediately backfilled and regraded or otherwise permanently disposed. While temporary storage provides working space in the mine pit, it can necessitate the double handling of spoil.

REGULATORY REQUIREMENTS

As part of the mining and reclamation plan (405 KAR 8:030, Section 24) submitted with the permit application, the following must be included pertaining to the temporary storage of spoil:

- A narrative explaining the construction, modification, use, maintenance, and removal of overburden handling, transportation, and storage areas and structures.
- Locations of storage areas (to be marked on the MRP map).

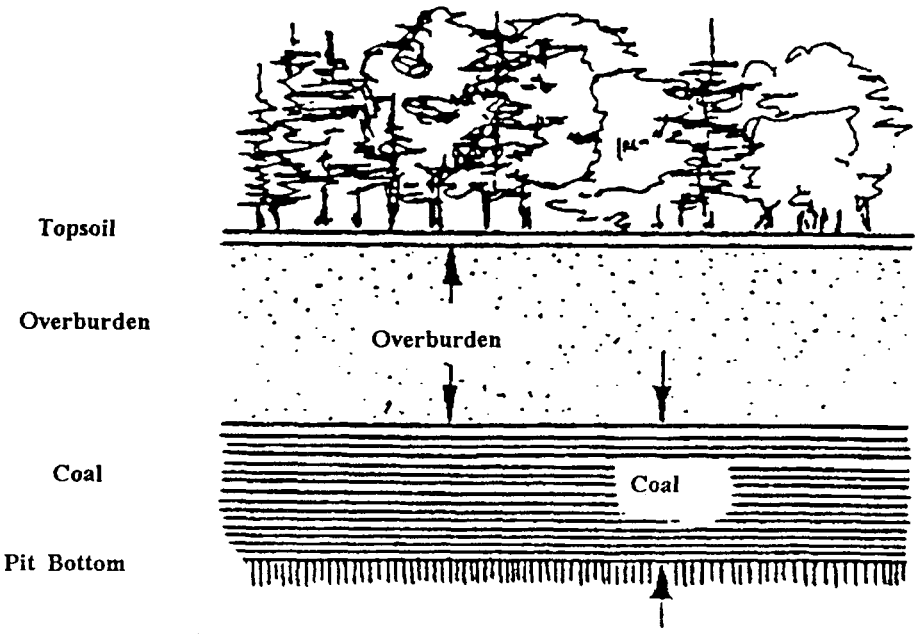


Figure 21. Typical surface mine cross-section before mining

IMPLEMENTATION

Site Selection

Sites for temporary spoil piles that are stable, with little or no slope should be selected . Areas containing seeps and springs or which are otherwise poorly drained should be avoided. Spoil piles should be located to minimize handling costs -- typically close to the final cut.

Topsoil Removal

Stable spoil pile construction depends on a firm foundation. For this reason, topsoil shouls be removed from intended spoil storage sites that occur on non-mined sites, and stored or redistributed (see Topsoil Removal and Storage).

Drainage Control

Diversions should be constructed around the base of the spoil storage site (see Diversions). Drainage should be tested for pH. All storage areas must drain to a sediment pond. Other temporary sediment barriers should be installed as necessary (see Silt Fence).

Construction

Temporary spoil storage piles must be designed by a qualified professional engineer. The specifications for pile construction will be outlined within the MRP. In general, spoil should be spread in horizontal layers and then compacted. Adequate compaction helps reduce the risk of acid drainage via percolation. Spoil placement should be avoided under wet conditions. Piles with relatively steep slopes should be terraced. The fill surface should be promptly seeded (see Revegetation). If parts of the pile have a good vegetative cover and others do not, new lifts should be laid on the bare surfaces, if engineering plans allow.

MAINTENANCE

Temporary spoil piles often have exposed areas from recent additions or subtractions of spoil. These exposed areas are susceptible to erosion and require close attention. Erosion damage to the grass cover, diversions, and silt fences should be repaired quickly. Refer to the appropriate Maintenance sections throughout the manual.

BACKFILLING AND GRADING

DEFINITION

Backfilling and grading (Figure 22) include those procedures used in replacing spoil into the pit or onto the bench and grading to approximate original contour (AOC) contemporaneously with coal extraction.

PURPOSE

Backfilling and grading is necessary to restore disturbed areas to their approximate original contour, to ensure stability and safety of regraded areas, to minimize soil erosion and water pollution, to promote revegetation, and to otherwise restore the hydrologic character of the site to pre-mining conditions compatible with the post-mining land use.

REGULATORY REQUIREMENTS

Requirements for backfilling and grading are set forth under 405 KAR 16:020, 16:190, and 20:060 and address highwall elimination, return to approximate original contour, timing of operations, use of terraces, thick and thin overburden conditions, burial of acid and toxic materials, and the regrading or stabilization of rills and gullies.

IMPLEMENTATION

Surface mining regulations require that all disturbed areas be backfilled and graded to the approximate original contour (AOC) unless a variance is approved by the Cabinet. This includes transporting and grading spoil and eliminating highwalls and spoil piles.

Unless otherwise approved, such activity must be performed contemporaneously with mining. Careful planning can limit double handling of spoil and thereby reduce operator costs. Regulatory time constraints on backfilling and final grading operations are presented in Table 7, by mining method.

Fig. 22. Backfilling and Grading

Table 7. Timing of Backfilling and Grading Operations

Mining Method	Starting at (day of)	Time (days)	Distance (linear feet) from First Cut
Area	Coal removal	180	4 spoil ridges (including current ridge)
Auger	Initial surface disturbance	60	1500
Contour	Initial surface disturbance	60	1500
Mountaintop Removal	Coal removal	180	N/A

Source: 401 KAR 16:020 Contemporaneous Reclamation

Before heavy earth-moving equipment can be removed from the site, backfilling and final grading of spoil must be complete. Within 30 days immediately following backfilling and rough grading, the area must be final graded, scarified, topsoil redistributed, and seeding completed. Time extensions may be granted if this schedule cannot be met for reasons outside the operator's control.

Furthermore, state regulations require that acid or toxic materials be buried by at least four feet of non-toxic material within 30 days of exposure. If such burial is not feasible within 30 days, the Cabinet may allow temporary storage if water pollution will not result.

Pit Dewatering

Water impounded in the pit must be removed before backfilling begins. Temporary topsoil, spoil piles, and/or natural barriers may not be removed or altered to aid in dewatering.

Water may be pumped or siphoned out in a controlled manner. Water that meets KPDES effluent quality standards can be discharged directly into natural waterways. Otherwise, the water will need to be routed to sedimentation ponds and treated.

Backfilling

In area mining, overburden should be removed with a dragline or other suitable equipment, and spoil material should be deposited directly behind the advance cut on the previously mined pit or bench. Spoil must be placed on solid ground. This system:

- Eliminates double handling, except in the case of that spoil removed from the first box cut or bench.
- Ensures that spoil is placed on solid ground.

Spoil from the first box cut may need to be temporarily stored and later transported to the final box cut, (see Temporary Spoil Disposal).

Contour mining in eastern Kentucky requires that spoil be hauled to a mined portion of the bench. Typical hauling distances for single-seam contour mines average 500 feet. The haul back method provides opportunity for the selective placement of spoil, e.g. in instances where acid spoil must be covered by at least four feet of fill,. (see Acid/Toxic Spoil).

Spoil must be transported, placed, backfilled, compacted (as necessary), and graded to eliminate highwalls, ensure a long-term static safety factor of at least 1.3, and achieve a post-mining slope that does not exceed the angle of repose and that does prevent slides. Excess spoil from contour mining is disposed of in head-of-hollow fills, (see Excess Spoil Disposal). The operator must not place the following materials on the downslope: spoil, waste, or vegetation or other debris.

If compatible with the postmining land use, cut-and-fill terraces may be allowed. Terraces must meet the following requirements:

- Highwall must be eliminated.
- Terrace bench must not exceed 20 feet in width.
- Terrace outslopes must not exceed a slope of 50 percent (1v:2h), unless otherwise approved.

Small depressions and/or impoundments, if approved, may be constructed on backfilled areas if they are suited to the approved postmining land use, do not adversely affect the stability of the fill, and are not located on steep-slope outslopes. Steep-slope mining is further regulated under 405 KAR 20:060 Steep Slopes. Steep slopes are those in excess of 20 degrees (Appendix G).

The postmining slope may vary from AOC if approval is obtained from the Cabinet for provisions for thin overburden, thick overburden, mountaintop removal mining, previously mined areas, steep slope mining, etc.

Grading

After spoil is dumped by truck or dragline, it must be graded to AOC. Grading to AOC requires that highwalls, temporary spoil piles, and depressions be eliminated unless otherwise approved by the Cabinet. The finished slope need not be constant from top to bottom nor precisely replicate the original terrain prior to mining. The goal is to leave as little slope as possible, yet still cover the highwall. Rough grading is most often accomplished using dozers. All final grading, including preparation of overburden before replacement of topsoil, topsoil substitutes, and topsoil supplements, and the subsequent placement of these materials shall be done along the contour to minimize erosion and instability later.

MAINTENANCE

See Scarification, Topsoil Redistribution, and Revegetation for information on maintenance. In general, where slopes permit, working along the contour will reduce erosion and slippage. Rills nine inches or deeper must be filled, regraded, and revegetated.

SCARIFICATION

DEFINITION

Scarification refers to those procedures or techniques used to prepare the regraded spoil surface for eventual topsoil redistribution and revegetation by gouging, ripping, disking, or other surface roughening.

PURPOSE

The purpose of scarification is to minimize surface water runoff and erosion. This is achieved by:

- Improving the bonding potential between the subsoil and the topsoil;
- Reducing compaction and increasing the ability of plant roots to penetrate the subsoil; and
- Increasing the movement of water from the topsoil to the materials below that in turn increase groundwater recharge.

REGULATORY REQUIREMENTS

Under 405 KAR 16:050, Section 4, the state mandates that prior to final placement of topsoil the land shall be scarified or otherwise treated to eliminate slippage surfaces and promote root penetration. Scarification may follow topsoil redistribution if the permittee can demonstrate no harm would result to materials and vegetation and approval by the Cabinet is granted.

IMPLEMENTATION

Excessive compaction of mine spoil often results from the movement of heavy earth-moving equipment such as scrapers and dozers used to backfill and grade sites to AOC. Surface roughening is a critical step to ensure adequate water infiltration and root penetration on the reclaimed land.

Liming

Lime should be applied to regraded spoil surfaces prior to roughening at rates consistent with lime recommendations for subsoils based on spoil test results (see Soil Amendments). Liming is important because it adjusts spoil pH to a range conducive to root development.

Surface Roughening

There are four common methods of surface roughening: ripping, scarification, dozer basins, and tracking. These methods differ in limitations, effectiveness, and equipment requirements. Most equipment can be used safely on slopes up to 30 percent. On slopes in excess of 30 percent, tracked vehicles are needed. If possible, roughening should be done along the contour to minimize erosion and slippage. On steep slopes where operating equipment along the contour is dangerous, a dozer should be driven up and down the slope; cleat or track marks will be created along the contour, thereby trapping some runoff and sediment.

Ripping

A single or multiple shank ripper will be necessary in severely compacted areas. Rippers are also used where grooves deeper than 17 inches are desired. Some single ripper shanks mounted on a ripper bar and attached to a crawler tractor may cut to a depth of three to four feet. Multiple shank rippers may also be used but will not cut as deep. Triple shank rippers mounted on four-foot centers yield two- to three-foot deep cuts, although channel density increases.

Scarification

Some lightly compacted soils may require only scarification. Special scarifying equipment is available, but chisel or disk plows can be used.

Dozer Basins

Dozer basins are created by mounting a V-shaped blade onto a bulldozer and dragging it across the ground intermittently. Dozer basins are seven to eight feet long and two to three feet deep on 15 to 20 foot centers. A driver can roughen approximately 2 to 2.5 acres per hour on gently sloping land. The 220 to 280 basins per acre store 1.5 to 2 acre-inches of runoff water. Application of this method requires Cabinet approval.

Tracking

Tracking is the simple operation of running a tracked dozer up and down a steep slope. Cleat marks left from the dozer are along the contour and aid in reducing runoff, soil erosion, and seed loss.

MAINTENANCE

Topsoiling and seeding should be done as soon as possible to minimize the amount of erosion damage that may require repair (see Topsoil Redistribution and Revegetation).

TOPSOIL REDISTRIBUTION

DEFINITION

This practice refers to the redistribution of topsoil and topsoil substitutes/supplements from a designated temporary storage area and/or coincidentally with topsoil removal. In the case of prime farmland land uses, it also refers to the redistribution of subsoil in addition to the topsoil.

PURPOSE

Soil and soil substitutes/supplements are redistributed to provide a medium adequate to comply with the revegetation requirements of 405 KAR 16:200 or to ensure soil productivity consistent with the approved post-mining land use.

REGULATORY REQUIREMENTS

Required topsoil redistribution practices are addressed in 405 KAR 16:050 Section 4. For lands designated as prime farmland, soil replacement requirements are detailed in 405 KAR 20:040, Section 5.

IMPLEMENTATION

Following scarification, prior to bond release, topsoil and/or topsoil substitute and supplemental materials must be placed on all surfaces that have been disturbed by mining, including access roads, stream diversions, and excess spoil disposal sites.

Land mined, backfilled, graded, and scarified should be topsoiled and revegetated as soon as possible. To avoid double handling of topsoil, the reclamation operation should be planned so that topsoil redistribution is accomplished in tandem with topsoil removal to the extent possible. That is, topsoil removed from the area of the advance cut is immediately distributed on land already mined, backfilled, graded, scarified, and limed (if necessary).

Heavy equipment used to redistribute topsoil materials can cause excessive compaction. Compaction impairs the ability of plant roots and water to penetrate the soil, which in turn causes increased levels of runoff and erosion. Topsoil redistribution is best accomplished by using trucks (base level dumping) and spreading with low-ground-pressure dozers. Returning the soil in parallel windrows with trucks or scraper pans and spreading between the windrows with wide-blade or low-pressure dozers may also be a satisfactory alternative (SCS, 1986).

Redistributing topsoil during wet periods should be avoided because this may result in greater soil compaction or otherwise diminish soil quality. Heavy equipment traffic should be kept to a minimum on reconstructed soils. All traffic areas should be ripped or chiseled.

Topsoil should be spread evenly to achieve a uniform thickness for each horizon segregated (see Topsoil Removal). Low spots or depressions should not be left.

Topsoil must be reconstructed to a minimum depth of six inches. On lands designated as prime farmland, the combination of topsoil and subsoil must be reconstructed to a minimum depth of 48 inches unless otherwise approved (405 KAR 20:040). B and/or C horizons or other approved substitute soil material must be redistributed to a thickness not less than the combined average thickness of the original unmined B and/or C horizons or to a depth of 42 inches, which assumes the replacement of six inches of topsoil (or less if a qualifying restrictive layer existed).

MAINTENANCE

Reclaimed areas should be checked periodically for signs of erosion. Tracking with a dozer or application of mulch will provide temporary protection. Rills and gullies should be regraded, if formed, and reseeding should be done as soon as possible.

ACID/TOXIC SPOIL

DEFINITIONS

Acid-forming materials are those for which the potential acidity of the material exceeds its neutralization potential. Toxic-forming materials are defined as those for which the potential acidity exceeds the neutralization potential of a spoil mixture by at least 5.0 tons $CaCO_3$/1000 tons of material. Also toxic-forming are those materials that could potentially release chemicals in toxic quantities to surface or ground water supplies.

PURPOSE

The identification, selective handling, and/or burial of potentially acid- and/or toxic-forming spoil is a crucial preventive measure for protecting surface and ground water quality.

REGULATORY REQUIREMENTS

Requirements for the identification of acid- and toxic-forming materials are addressed under 405 KAR 8:030, Section 13, Baseline Geologic Information. Should toxic materials be present, a Toxic Materials Handling Plan is required as part of the MRP. Prescribed remedial actions are outlined in 405 KAR 16:060 and 16:190. Acid- or toxic-forming spoil must be covered within 30 days of first exposure unless otherwise approved.

IMPLEMENTATIONS

The following BMPs are designed to prevent or minimize the formation of acid mine drainage (AMD). Acid mine drainage contains iron and sulfate pollutants (pg. 6). The chemical reaction that produces this drainage occurs much faster in the presence of the iron-oxidizing bacteria Thiobacillus ferrooxidans and Thiobacillus sulfooxidans. The resulting low pH environment can cause metals such as aluminum and manganese to leach into water supplies. Preventive BMPs are outlined below.

An acid-base account employing volume-weighted averages of the neutralization potential and potential acidity of overburden strata may be used to determine if overburden materials may become "toxic." If not toxic, yet acid-forming, selective blending of the disturbed strata would be prescribed before all the material is replaced in order to neutralize any potentially acid-forming effects.

If the overburden is found to be "toxic," the Toxic Materials Handing Plan from the MRP should be followed. Such a plan would require the toxic-forming materials be possibly treated and covered with a minimum of four feet of non-acid, non toxic-forming material. Such burial should not be in proximity of a drainage way because it could cause or pose a water pollution threat.

If specified in the permit, additional measures to reduce the oxidation potential of disturbed strata may be required:

- Application of limestone to neutralize acid spoil.
- Compaction.
- Selective placement to minimize contact with surface and ground water.
- Encasement in low-permeability substances.
- Installation of finger drains, French drains, or relief wells.

Cover with more than four feet may be necessary as determined on a case-by-case basis to protect against the upward migration of salts, exposure via erosion, or other local conditions.

Pit Dewatering

Some water will enter the pit as precipitation and/or ground water. Surface mining activities should be planned and conducted to prevent the accumulation of such water. Any water that does not accumulate must be removed by pumping, siphoning, or an otherwise controlled manner to a natural or constructed drainage way. Sedimentation ponds provide a means for treating pit water, which has come into contact with coal or acid spoil near the coal seam. Other acid drainage treatment methods are discussed earlier in this manual (p. 10-15). Dewatering the pit is a critical opportunity for point source treatment of non-point source water pollutants.

In no event should water from pit dewatering be discharged directly to a stream without being determined in compliance with KPDES permit effluent limitations (401 KAR 5:065). Pumping and siphoning water from pits are point source discharges that are subject to KPDES self-monitoring and reporting requirements unless they pass through a sediment structure prior to discharge to surface water.

Selective Handling

Selective handling of overburden strata is best achieved with scrapers, front-end loaders, and trucks. Stripping shovels and draglines are generally inadequate for separating strata on a small-scale basis. The MRP could call for placing alkaline spoil beneath, above, and/or mixed with acid spoil.

Burial

Burial and consolidation of acid spoil is the most cost-effective method for preventing AMD. If the disposal site is above the water table, the MRP will require that acid spoil be buried in some combination with alkaline spoil. The acid spoil should be dumped into the disposal site in one-foot thick layers. If required by the MRP, mix crushed agricultural limestone in with each layer. Each layer should be compacted , if required.

The disposal site should be covered with four feet of non acid-forming, non-toxic forming, non-combustible materials within 30 days of exposure. These materials are best applied in one-foot thick layers and compacted, if required. Installing a layer of clay over the entire disposal area should be considered. The final surface should be graded so no depressions or low spots remain. Otherwise, puddling could occur that might promote seepage and infiltration of water into the toxic material. The installation of finger drains, French drains, or relief wells may be useful to direct water away from areas where toxic/acid spoil is buried.

MAINTENANCE

Monitor water quality as necessary. Treat mine drainage for excess solids, metals, and lowered pH, if indicated. See Mine Drainage Treatment. Suspect overburden materials should be routinely analyzed in order to isolate toxic/acid strata. Preventive measures can then be taken to prevent AMD seeps.

NON-COAL MINE WASTE

DEFINITIONS

Non-coal mine wastes include, but are not limited to, grease, lubricants, paints, flammable liquids, garbage, abandoned mining machinery, lumber, and other combustibles generated during surface mining activities.

PURPOSE

Environmentally sound storage and disposal practices for wastes other than coal mine waste, soil, or rock are necessary to adequately protect surface and ground water supply.

REGULATORY REQUIREMENTS

The storage and disposal of non-coal mine waste are regulated under 405 KAR 16:150. Disposal of hazardous and solid waste other than "coal mining solid waste" (as defined by regulations of the Kentucky Division of Waste Management) shall not be conducted on the permit area unless a permit is obtained from the Kentucky Division of Waste Management.

IMPLEMENTATION

At no time may non-coal mine waste be deposited in a refuse pile or impounding structure. Nor may any excavation of non-coal mine waste be performed within eight feet of any coal outcrop or coal storage area.

Storage

Storage of these materials must be in a controlled manner in a designated portion of the permit area such that leachate and runoff do not degrade surface and ground water quality. The area must be designed to prevent the chance of fires from developing via selective layering, sealing, and compacting as necessary. The area must be built to remain stable and suitable for reclamation and revegetation compatible with the natural surroundings.

Disposal

Final disposal of non-coal mine wastes shall be designated for a disposal site within the permit area or a state-approved solid waste disposal site. Disposal sites within the permit area shall be designed and constructed to ensure that leachate and surface runoff from the site does not degrade the surface or ground water supplies. Wastes shall be routinely compacted and covered to prevent combustion and wind-borne waste. When the disposal is completed, a minimum of two feet of soil cover must be placed over the site, slopes stabilized, and revegetation accomplished (405 KAR 16:150).

MAINTENANCE

Rills nine inches or deeper must be filled, regraded, and revegetated. Diversions should be inspected following significant rainfall events and properly maintained (see Diversions).

EXCESS SPOIL DISPOSAL

DEFINITIONS

Excess spoil is mined overburden left over after the mine site is otherwise graded and restored to AOC. Durable rock spoil has a Slake Durability Index of 90 or greater as determined by the Kentucky Department of Transportation's Method for Determination of Slake Durability Index (Kentucky Method 64-513-79).

PURPOSE

Drainage control and construction practices that ensure stability of excess spoil disposal sites are essential for achieving the restoration and reclamation of all surface areas affected by mining activities.

REGULATIONS

Practices related to the disposal of excess spoil are regulated under 405 KAR 16:130. This regulation pertains to the general considerations of design certification, stability, spoil placement, drainage, and inspections. The design and construction of valley fills, head-of-hollow fills (Figure 23), rock-core chimney drains, end-dump fills, and disposal on unreclaimed pre-existing benches are addressed.

IMPLEMENTATION

Excess spoil should be disposed of in a controlled manner in order to:

- Minimize the adverse effects of leaching and surface water runoff.
- Ensure mass stability.
- Ensure final fill is suitable for reclamation to the approved post-mining land use.

In order to minimize the handling/transport costs, excess spoil is usually backfilled directly onto or trucked to disposal areas. Valley fills and head-of-hollow fills are frequently used methods for disposal in eastern Kentucky in order to address the difficulty of disposing of excess spoil on mountainous terrain. End-dumped fills of durable rock spoil may be approved by the Cabinet as an alternative method of disposal. Where they exist, and if approved by the Cabinet, it may be possible to use pre-existing benches for disposal of spoil.

Major steps and considerations in the planning and construction of excess spoil disposal areas include:

- Site Selection/Preparation
- Drainage Control
- Fill Construction
- Inspection

Site Selection/Preparation

Regulations dictate that disposal areas be located on the most moderately sloping and naturally stable areas available within the permit area and, if possible, on natural terraces or pre-existing benches if such placement provides additional stability and prevents mass movement. Vegetative and organic material should be removed from the site via scalping and grubbing. Topsoil should be removed, segregated, and stored and/or redistributed prior to excess spoil placement. (Vegetative material may be used for mulch and/or incorporated with topsoil materials if approved by the Cabinet.)

If the fill will rest on an area that has a natural slope in excess of 2.8h:1v (36 percent), keyway cuts (excavations to stable bedrock) and/or rock toe buttresses should be constructed to anchor the fill and ensure its stability. Dimensions of cuts and buttresses should be specified in the MRP as designed by a professional engineer.

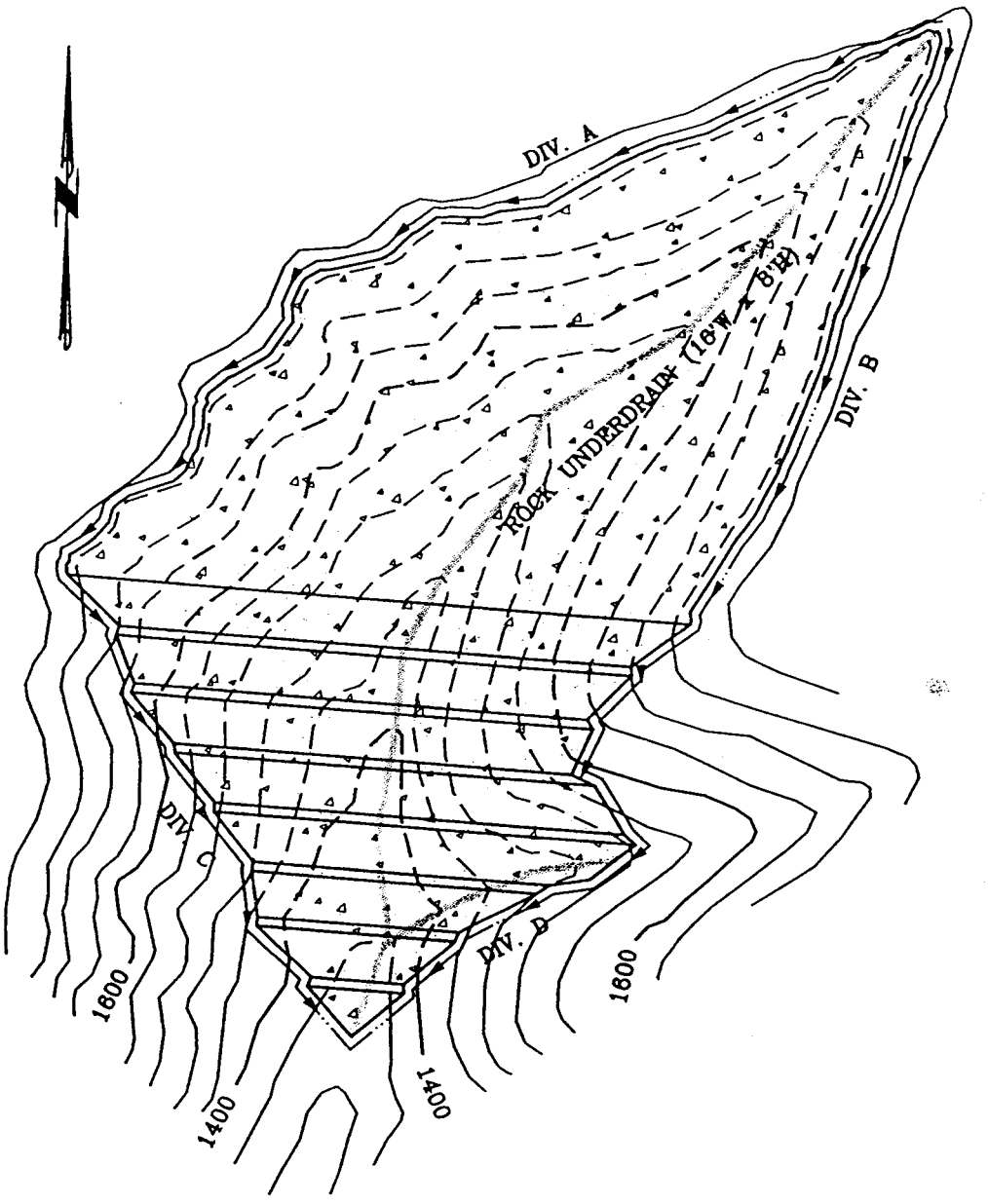


Figure 23. Head-of-hollow fill

Drainage Control

Diversions. Prior to any disturbance of the disposal site, drainage from above and adjacent to the site must be diverted to a sedimentation pond in order to control erosion. Diversions should safely drain runoff from above a nearby fill to accommodate a 100-year, 24-hour storm event. Only in cases when spoil is to be disposed of on pre-existing benches may this design requirement be altered to 10-year, 24-hour storm event. All diversions should be designed to minimize the infiltration of water into the fill and ensure fill stability. Bench diversions are built along the toe of each outslope and direct runoff to lateral drains along the sides of the fill. Lateral drains are constructed before filling operations begin. Surface diversions continue to be built as filling operations continue.

Rock Underdrains. Underdrains are constructed in advance of fill construction and must be composed of durable (SDI $\geq$ 95), nonacid-forming, nontoxic-forming rock. Materials must be adequately sampled and analyzed under the direction of a professional engineer to certify these requirements have been met. Underdrains are used to drain water from the fill that originates from springs, man-made or natural drainage ways, wet-weather seeps, and seeps due to precipitation. Surface runoff uphill from the fill may not be diverted under or through the fill, except in the case of rock-core chimney drains. Underdrains should be constructed along the natural drainage paths of valley or hollow fills.

The design specifications of underdrains should be contained within the MRP. These specifications should be sufficient to carry away from the fill the maximum anticipated water seepage and discharge in the foundation area. The minimum cross-sectional dimensions of the underdrain are specified in Table 8, unless otherwise approved. Construction requirements demand that no more than 10 percent of the rock be less than 12 inches in diameter and no single rock be larger than 25 percent of the width of that segment of the underdrain in which the rock is located. Underdrain design should contain a filter system to protect the system from piping and contamination and ensure long-term functioning.

Table 8. Minimum Drain Segment Cross-sectional Dimensions

Total cumulative volume of fill material to be drained by segment	Predominant type of fill material	Minimum size of drain segment in feet	
		Width	Height
Less than 1,000,000 yd^3	Sandstone	10	4
	Shale	16	8
More than 1,000,000 yd^3	Sandstone	16	8
	Shale	16	16

The underdrain may be divided into segments for purposes of determining required dimensions of the individual drain segments. Each segment will drain the volume of fill overlying the segment plus carry the water drained to the segment from areas of the fill located upstream of the segment. Where the cumulative volume of the fill material to be drained by a segment is less than 1,000,000 yd^3, the smaller dimension may be used.

Source: 405 KAR 16:130 Appendix A.

Work should begin by digging trenches where runoff naturally flows. They may be dug in the same configuration as a trapezoidal diversion (see Diversions). The underdrain may then be constructed into the trench in either of two ways:

1) Wrapped Drain. The trench bottom and sides should be lined with filter cloth, (see Silt Fences). Enough extra material should be left on the sides to be folded and stapled shut. For example, if the main underdrain is 10 feet wide and four feet high, the filter cloth should be 30 feet wide.

Width of Filter Cloth = top + bottom + sides + stapling strip

= 10 + 10 + (4 + 4) + 2
= 30 feet

Six inches of rock should be dumped into the trench, then it should be filled with riprap. The exposed cloth should be folded over the rock and stapled shut every six inches.

2) Layered Drain. Only the trench bottom should be lined with filter cloth. Six inches of sand or gravel should be dumped into the trench. Then three layers of rock should be dumped into the trench. Each layer should be a different size, as determined by the mining engineer. The largest stone should be dumped first, the smallest last. The riprap should be covered with another layer of sand and gravel, until the top of the underdrain is level with the ground. The drain should be covered with a sheet of filter cloth. The cloth should be staked into solid ground on one-foot centers.

Smaller, lateral drains should be built from every seep or spring. Depending of the flow, these may be constructed using the same methods used for a main underdrain or with a plastic, perforated pipe wrapped in filter cloth. Holes should be cut in the filter cloth and lateral drains connected to the main underdrain. The cloth should be stapled at the points of connection.

Pipe Underdrains. For fills less than 250,000 cubic yards in volume, perforated pipe underdrains may be approved on individual basis, if fill failure would not result in stream blockage or create a public health or safety hazard. Pipe underdrains must be made of corrosion-resistant material and protected from clogging and contamination by a filter system.

Rock-Core Chimney Drains. A rock-core chimney drain (Figure 24) may be used in a head-of-hollow fill in place of the subdrain and surface water diversion system as long as the fill is not located in an area containing an intermittent or perennial stream. Rock-core chimney drains are permissible for use in valley fills that do not exceed 250,000 cubic yards in volume.

In constructing a chimney drain, a durable rock vertical core with a minimum thickness of 16 feet must be built to extend from the toe of the fill to the head of the fill and from the base of the fill to the surface of the fill. A system of lateral rock underdrains should connect this rock core to each area of potential drainage or seepage within the disposal area (405 KAR 16:130, Section 3). A filter system should be designed to ensure long-term functioning of the rock core.

The grading of the rock core may drain water away from the outslopes of the fill and toward the rock core. In no case may intermittent or perennial streams be diverted into the rock core.

The maximum slope of the graded fill surface may be 33h:1v (3 percent). Terraces on the fill shall be graded with a three- to five-percent slope toward the fill or a 1 percent slope toward the rock core.

A depression may be graded into the head of the fill during and after construction for the purpose of intercepting and collecting surface water runoff. This water would then be discharged through or over the rock drain, if approved by the Cabinet. In no case should such an impoundment exceed a volume in excess

of 10,000 cubic feet of water. The rock chimney drainage must be capable of accommodating a 100-year, 24-hour precipitation event.

Fill Construction

In general, three methods of fill construction exist:

- Horizontal, layered placement and compaction.
- Gravity placement -- end-dumped fills.
- Disposal on existing benches.

Selection of the appropriate method is site dependent, and should be specified in the MRP.

Horizontal, Layered Placement and Compaction. The primary method used to construct permanent disposal sites for excess spoil is the process of horizontal, layered placement and compaction. In this method, horizontal lifts should not exceed four feet in thickness. Exceptions to the four-foot rule may be made with Cabinet approval when fill consists of hard rock spoil. To construct the fill, work should start at the toe of the fill, and the fill should be built in an uphill direction. Each layer should be compacted. The fill should be inspected and evaluated for stability under the supervision of a professional engineer throughout the construction process. The long-term static safety factor of the fill must be at least 1.5.

Grading of the top of the fill should result in a slope steeper than 20h:1v (5 percent) toward drainage. Surface runoff from the top surface of the fill must not flow over the outslope of the fill (405 KAR 16:130, Section 1). The fill outslope may not exceed 2h:1v (50 percent) or that slope necessary to ensure stability of the fill.

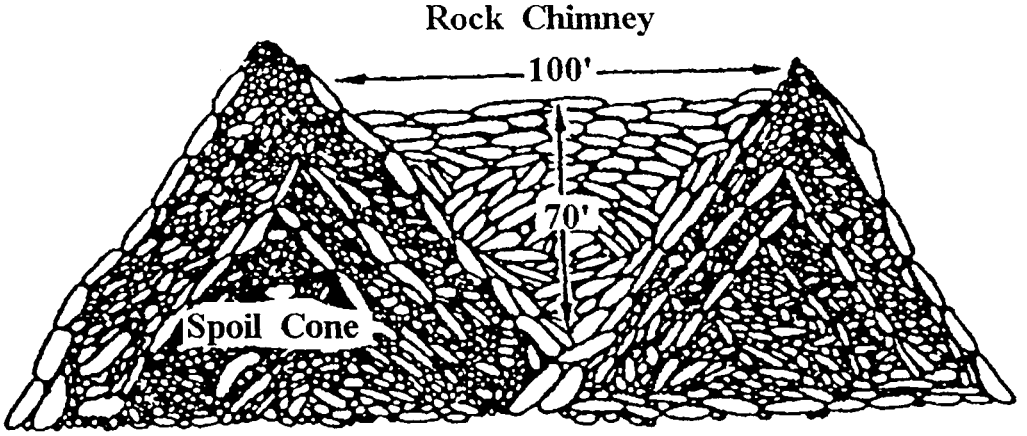


Figure 24. Schematic cross section of 70-foot-deep, V-shaped rock chimney for infiltration basin.

Terrace benches may be constructed on the outslope for the purpose of erosion control, enhanced stability, to preserve soil moisture, or to meet the post-mining land use. The benches should be graded with a 3- to 10-percent slope toward the fill. The outslope between terraces should not exceed 2h:1v (50 percent).

Gravity Placement -- End-Dumped Fills. Durable rock spoil may be disposed of in single or multiple lifts via gravity placement if the excess spoil is nonacid- and non-toxic-forming and is at least 80

percent (by volume) free of non-durable material (e.g., coal, clay, poorly cemented shale). The fill must meet a static safety factor of 1.5 and a minimum earthquake safety factor of 1.1. It may be possible to construct the underdrain system at the time of spoil placement through the natural gravity segregation of materials. If this method of drainage construction is not adequate to meet the 100-year, 24-hour precipitation event requirement, the underdrain may need to be constructed separately.

Disposal on Existing Benches. When the MRP specifies that spoil is to be disposed of on existing mined benches, only the solid portion of the bench should be used. Excess spoil should be transported and placed in horizontal lifts and concurrently compacted to ensure a long-term static safety of 1.3. Grading should be performed in a manner that encourages surface and subsurface drainage compatible with the existing terrain. The pre-existing bench should be backfilled and graded to achieve the most moderate slope possible. Highwalls should be eliminated to that extent practicable. Disposal from an upper bench to a pre-existing lower bench via gravity placement may be performed with Cabinet approval only. If approved, a safety berm must be constructed on the lower bench of sufficient dimension to prevent the gravity transport to the downslope.

MAINTENANCE

The fill and associated structures must be inspected under the supervision of a professional engineer. During all stages of construction, the disposal site must yield a static safety factor of 1.5 (1.3 in cases where disposal occurs on existing benches). Fills should be inspected after each rainfall. Ponding, or erosion in the form of rills exceeding nine inches, should be corrected through regrading. Any indications of slumping or sliding should be reported immediately to the mining engineer.

REVEGETATION

- Soil Amendments
- Non-Woody Plants
- Woody Plants
- Mulch

SOIL AMENDMENTS

DEFINITION

Soil amendments are substances that indirectly aid plant growth by improving the quality of the soil. Amendments include lime, fertilizers (including organic manures), and approved special wastes such as sewage sludge and power plant fly ash.

PURPOSE

Soil amendments are used to increase the speed and success of revegetation. Plant nutrients can be provided, such as nitrogen, phosphorus, potassium, etc.; soil pH or acidity can be corrected; and changes in soil texture can be made in order to improve water-holding capacity and decrease soil compaction.

REGULATORY REQUIREMENTS

Soil amendments must be applied to regraded areas in accordance with 405 KAR 16:050 and 18:050, Section 5; that is, in a manner sufficient to sustain the approved post-mining land use and to sustain a vegetative cover that meets the requirements of 405 KAR 16:200 and 18:200.

The application of special wastes must be in compliance with land-farming regulations 401 KAR 45:030; 050, 070, and 100. All land-farming sites in which repeated applications of organic wastes are planned must also be permitted through the Kentucky Division of Waste Management and operated by a certified land-farming operator.

IMPLEMENTATION

All soil, water, and special waste analyses referenced in the sections that follow should be performed by a qualified laboratory using standard methods approved by the Cabinet. (Soil and special waste laboratories are not certified in Kentucky.)

Lime

Lime is used to neutralize acidic mine soils. The rate of lime application should be sufficient to raise soil pH to a value no lower than 6.4 for all land uses. Liming rates for mine soils as determined on the basis of buffer pH values appear in Table 9.

Table 9. Limestone Rates for Soil-buffer pH Readings

Buffer pH readings	Agricultural limestone (tons/acre) required to adjust soil to pH 6.4
6.7 - 6.3	2-4
6.3 - 5.9	4-6
5.9 - 5.3	6-8
5.3 - 5.0	8-11
5.0 - 4.5	11-15
4.5 - 4.0	15-25
below 4.0	25*

* When lime rates are 25 or more tons/acre, refer to section on Lime Requirement for Highly Acidic Spoils in Agr. 40.

Quality agricultural limestone is the liming agent of choice. By definition, such limestone contains sufficient calcium and magnesium carbonates to be equivalent to not less than 80 percent calcium carbonate. It must be fine enough so that not less than 90 percent passes through a U.S. Standard No. 10 sieve, and not less than 35 percent passes through a U.S. Standard No. 50 sieve. Lower quality lime may have a lower cost; however, larger quantities will be required to achieve the target pH. Consequently, lower purchase costs may be offset by higher transportation costs.

Suppliers will often apply lime. Broadcast spinners mounted onto a haul track can be used to spread the lime at an even rate. Disking is the primary method used to incorporate lime into the soil. Lime should be incorporated into the topsoil to a depth of at least six inches. Incorporation not only increases the affected zone to allow better rooting of plants, but it also minimizes lime loss via rainfall runoff. Lime should not be applied under wet soil conditions because it is difficult to incorporate uniformly into the soil.

Fertilizer

The three primary plant nutrients are nitrogen (N), available phosphorus (P_2O_5), and water-soluble potash (K_2O). Mixtures of fertilizer materials are commercially available; their grade or content is expressed in weight percent as N:P:K.

Nitrogen should be applied at the rate of 60 lb of N/acre for fall or spring seedings, with a topdressing of 30 lb/acre six months later. Additions should be applied as pounds of N and not pounds of fertilizer. For example, 100 lbs of 46-0-0 contains only 45 pounds of nitrogen. An additional 30 lb/acre should be applied during the spring of the second growing season when ground cover is the only revegetation objective.

The rates at which available phosphate and potassium (potash) are applied are determined on the basis of soil tests and intended land use. Fertilizer recommendations for vegetative covers to achieve either erosion control or hay and pasture land use are listed in Table 10.

Table 10. Fertilizer Requirements for New Seedlings[a]

	lbs P_2O_5 and K_2O to apply per acre[b]			
	Surface Cover		Hay and Pasture	
Test level (lbs/acre)	P_2O_5	K_2O	P_2O_5	K_2O
Very Low (below 10P; 75K)	120-140	30-60	150-200	60-90
Low (10-30P; 165K)	100-120	0-30	100-150	30-60
Medium (31-60P; 165-250K)	50-100	0	50-100	0-30
High (above 60P; 250K)	0-50	0	0-50	0

a) If soil tests are very low, retesting is recommended prior to planting trees since additional P_2O_5 may be needed to maintain surface cover.

b) For alfalfa production, rates should be increased to 20-40 lbs P_2O_5 and 20-40 lbs of K_2O/acre.

Fertilizer is most simply spread in the dry, granular form. Modest incorporation is desirable but not required. It should not be applied when soils are wet. A salt solution forms when water and fertilizer are mixed that can significantly reduce the percentage of seed germination, especially those of grasses. The effectiveness of bacteria inoculated on legumes is also reduced.

If hydroseeders are used to broadcast seed, the slurry pH should be kept above 5. For a tank holding 1000 gallons of water, the pH should be above pH 5 if 100 pounds of calcium hydroxide (hydrated lime) were added to the tank mix and mix for at least 15 minutes prior to adding the bacteria inoculant, use two 6.7 ounce packages of inoculant, and spread within three hours. If delays exceed this time limit, both seed and inoculant should be added again as the germination would likely be significantly reduced and poor stands will likely result. It is not recommended to apply fertilizers and seed in the same tank mix when hydroseeders are used.

Special Wastes

Special wastes, especially sewage sludge and fly ash, are sometimes used to improve mine soils and topsoil substitutes. The suitability of wastes for land-farming is determined through a series of chemical and physical analyses as specified in the land-farming regulations. Heavy metal concentrations in waste materials are of particular concern because of their potential to cause toxicity in plants as well as the potential to pollute ground and surface waters. Information on waste material composition and soil test results are then used to calculate land-farming application rates.

The advantage of sewage sludge is that it generally behaves as a slow-release fertilizer with 15 percent of the total nutrients released the first year, 15 percent of the remaining the second year, 10 percent of the remaining the third year, and 5 percent of the remaining in the fourth and fifth years. Sludge can be applied with a manure or lime spreader and disked or chisel plowed to ensure incorporation.

Although fly ash has been found to offer little nutrient benefit in terms of N, P, or K, it has been used successfully as a neutralizing agent in acidic spoil. It should not be assumed that all fly ash has liming properties. The material should be tested prior to its use. Fly ash may be used to change the texture of the soil because it is largely comprised of silt-sized particles.

MAINTENANCE

Booster applications of lime and fertilizer may be beneficial as determined on the basis of soil test results. Requirements for land-farming management as specified in 401 KAR 45:100, Section 6 and 401 KAR 48:200 Section 8 must be met, if applicable.

NON-WOODY PLANTS

DEFINITIONS

Non-woody plants refer to low-lying herbaceous grasses, cereals, and legumes. Legumes differ from other plants in that they fix nitrogen from the air into the soil, thereby providing a valuable nutrient. Non-woody plants can be classified as either annual or perennial. Annuals live only one growing season, and for that reason are used for temporary vegetative cover unless they are capable of reseeding themselves, such as Korean or Kobe lespedeza. Perennials live multiple growing seasons, and some may produce seed that helps to keep an adequate stand.

PURPOSE

Non-woody plants can be used for both temporary and permanent revegetation of mined lands. Temporary ground cover is used to meet the revegetation timetable as specified in the MRP for the purpose of binding soil and reducing or preventing soil erosion and the sedimentation of drainage ways. Permanent ground

cover is designed not only to prevent erosion, but also to meet the objectives of the post-mining land use plan as specified in the MRP.

REGULATORY REQUIREMENTS

Revegetation of land affected by coal mining must meet the criteria set forth under 405 KAR 16:200, including requirements for temporary and permanent vegetative cover, species selection, establishment schedules, and success standards TRMs #19 and #21. A diverse, permanent vegetative cover must additionally meet the requirements delineated under 405 KAR 16:180 Protection of Fish, Wildlife, and Related Environmental Values. Certain areas on mines may have to meet additional requirements mandated by the Kentucky Division of Water under CWA Section 401 certification conditions for restored/replaced wetlands and riparian zones.

IMPLEMENTATION

Revegetation is required on all disturbed surface of soils and/or spoils. Seeding must be done as soon as weather permits and after soil amendments have been applied. Deadlines for these activities should be listed in a timetable within the MRP. In most cases, especially more steeply sloping sites, a fast-growing cover crop is sown along with the permanent species in order to protect the soil from erosion until the permanent crop is established. Such a practice could increase available moisture for the permanent grasses and legumes. The local agricultural extension agent (Appendix F) can recommend products and application rates for this purpose.

Revegetation activities include:

- Species Selection
- Seedbed Preparation
- Legume Inoculation
- Sowing

Species Selection

Seeding mixtures, rates, and timetables should be specified in the MRP. Mixtures will be tailored to meet seasonal variations in temperature and precipitation. Cool weather plant species can be sown in the fall or spring; warm-season species should be sown during the early summer months. Other site-specific factors considered in species selection in addition to the post-mining land use are tolerances and needs for soil pH and water-holding capacity, availability of nutrients, sunlight, and potential for grazing. Tables 11 and 12 summarize some suggestions for seeding mixtures and rates for eastern and western Kentucky coal fields by season, including both temporary and permanent species. In addition, TRM #21 is the guidance document (1995) published by the Kentucky Division of Forestry, Department for Surface Mining Reclamation and Enforcement, and Department of Fish and Wildlife Resources that also suggests plant species, distribution patterns, seeding rates, and planting arrangements. Caution should be exercised in the purchase of seed mixes marketed as "strip mine" mixes. Some companies may use this outlet to dispose of seed varieties with poor germination and performance.

Seedbed Preparation

Disk, harrow, or chisel plow topsoil to freshly prepared seedbed. Shallow ripping may be needed for compacted topsoils when scraper pans were used, (see Scarification).

Legume Inoculation

Legumes are an important component to any seeding mixture because they "fix" nitrogen from the air into the soil. This is accomplished by means of nodules on plant roots that are formed by soil bacteria called Rhizobia. Topsoil that has been stripped and stockpiled generally lacks enough living bacteria necessary to support this cycle. Therefore, it is critical that legume seed be inoculated immediately before sowing (and no more than 24 hours prior).

Different types of Rhizobia are required for the different legume species. The correct one should be used. Inoculants for birdsfoot trefoil, crown vetch, locust, and lespedeza may need to be specially ordered a few weeks in advance of seeding because they may not be available from the seed dealers. Check the date on the package to be sure it has not expired. Keep packages out of heat or direct sunlight (e.g., truck windshield, car trunk). Refrigeration is recommended.

Legume growth is improved when a "sticker" is used to bind the inoculant to the seed. Stickers may be purchased or made by the operator by mixing one part granulated white sugar, molasses, or syrup to nine parts water.

All seed should be sufficiently wet with the sticker in a wheelbarrow or other large container. Do not use too much sticker so that the seeds will stick together. Next, mix the inoculant (six ounces per 25 pounds of seed). Plant as soon as possible.

Hydroseeding inoculated seed has had limited success. Because of the dilution necessary to hydroseed, quantities of inoculant should be increased by two to five times in order to be effective. Seed should not be mixed with fertilizers because the salts will kill the bacteria within a few minutes. The inoculant just prior to starting the seeding operation, (see Fertilizers for method of pH adjustment).

Sowing

Seed should be planted at the rate and time specified in the MRP. Seeding can be accomplished using hand-operated broadcast or drill seeders, or tractor-mounted fertilizer or lime spreaders. Grasses and legumes should not be covered deeper than one-fourth inch.

If a source of clean water is available, a hydroseeder is easier and safer for use on steep slopes. Through the use of hydroseeding, seeding and other treatments can be accomplished in one application. Inoculated legumes or grasses should not be mixed with fertilizers or pesticides. Grains should be sown to a depth not to exceed one inch. Excess use of mulch with seed will often result in poor stands due to poor soil/seed contact.

MAINTENANCE

Revegetation success can be measured using procedures provided by the Kentucky Department for Surface Mining Reclamation and Enforcement's TRM #19 (1991). Poor stands should be resown following re-evaluation of soils and/or spoils in terms of acidity and fertility. As noted above, certain areas may need to meet requirements mandated by the Kentucky Division of Water.

Table 11. Useful Grasses and Legumes for Kentucky

The following is a brief description of several grasses and legumes considered useful in surface-mine revegetation. The reader should be aware that new varieties of species continue to be released on a periodic basis.

Cool Season Grasses for Permanent Cover

Species: Tall Fescue *Festuca arundinacea* L.
Varieties: KY 31, Kenhy, Festal, Johnstone
Characteristics: Long-lived grass species that is somewhat drought and acid tolerant (pH 4.5-8.5). May be established in fall or spring. Gives good ground cover; however, should be used only when hay cropland or pastureland is the approved post-mining land use or for incidental erosion-prone areas when soil stabilization is the principal concern. In such cases, only endophyte-free fescue should be used (Burchick, 1993). Seeding rates 20-40 lbs/A, for late spring or fall, higher end of range should be used, and a reduced rate should be used when seeded within mixtures of grasses or legumes.

Species: Red Fescue *Festuca rubra* L.
Varieties: Fortress, Creeping red fescue, Common
Characteristics: Long-lived grass species with fine stems. Acid tolerant (pH 4.5-8.5) and moderate drought tolerant. Does not produce high yields but gives good ground cover and may be less competitive than tall fescue when trees are to be established in these plantings. Seeding rate 20-30 lbs/A. Rates should be increased for late planting; rates should be reduced when planted in mixtures.

Species: Redtop *Agrostis alba* L.
Varieties: Common
Characteristics: Moderately long-lived grass species, which is little more acid tolerant than tall fescue (pH 4.0-8.5). It is a fine stemmed grass that does well in wet or poorly drained sites once established. However, it is also moderately drought tolerant. It gives good ground cover, moderate forage yields. Seeding rate 4-8 lbs/A.

Species: Perennial Ryegrass *Lolium perenne* L.
Varieties: Omega, Revielle, Common: Penta is a turf type variety.
Characteristics: None of the varieties are true perennials although some remain longer than others under ideal management conditions. The tall types are rapidly established and effective in controlling erosion. Less acid tolerant than tall fescue (5.5-7.5), and seeding rates are similar to tall fescue (30-35 lbs/A). When seeded in mixtures, perennial ryegrass is dominant and may reduce or eliminate other species from the stand. Turf types of perennial ryegrass may be less competitive for areas where trees are to be established after 1 year. May also be used for temporary seedings if cover needed only for 1 to 2 years.

Species: Timothy *Phleum pratense* L.
Varieties: Clair (only one tested although others are available).
Characteristics: Moderately long-lived (5 years) grass that had moderate acid (pH 5.0-6.5) and drought tolerance. It is a bunch grass and may be used to partially substitute for tall fescue in reclamation mixtures. It produced moderate ground cover and forage yields. It may be substituted for tall fescue in wildlife mixtures.

Species: Kentucky Bluegrass *Poa pratensis* L.
Varieties: Troy, Kenblue, Parade, etc.
Characteristics: Long-lived grass that has a moderate drought and acid resistance (pH 5.5-8.5). It does best on well to moderately drained area, however it is slow to be established. Moderate forage yields were obtained on mined land, especially the second and third years. Seeding rate is 15-25 lbs/A and should be established in periods where drought stress is not expected.

Species Orchardgrass *Dactylis glomerate* L.
Varieties: Boone, Hallmark, Benchmark
Characteristics: Long-lived grass species that is acid tolerant (pH 4.5-7) but not exceptionally drought tolerant, especially for newly established stands. It may be substituted for part of tall fescue in grass mixtures, but pure stands have not been too successful. Seeding rates of 15-20 lbs/A for spring, 15-30 lbs/A for fall seedings, but seeding rates reduced when in mixtures.

Species: Reed Canarygrass *Phalaris arundinacea* L.
Varieties: Common
Characteristics: Long-lived sod-forming grass species that spreads by rhizomes but usually initially established from seed. **It is well suited for wet areas**, but it also is adapted to droughty sites. It is slow to be established as seed germination is low. It has a moderate acid tolerance (pH 5.8-8.5). Seeding rate 10-15 lbs/A, but rates should be increased by 5 lbs/A for fall seedings. May be planted in mixtures but usually results are poorer.

Cool-Season Grasses (Marginal for Kentucky)

Species: Canada Bluegrass *Poa compressa* L.
Variety: Reubens
Characteristics: Moderately to long-lived grass species that is both acid (pH 4.5-8.5) and drought tolerant. It does fairly well on soils or spoils that are low in fertility in which little production is needed. It gives reasonable ground cover and spreads because it produces good seed quantities. It is shallow rooted and may be suited for areas in which trees are to be established later. Seeding rate 10-15 lbs/A and should be reduced when planted in mixtures. Better success in establishment was achieved in early fall plantings.

Species: Smooth Brome Grass *Bromus inermis* Leyss.
Varieties: Common
Characteristics: Moderately long-lived seasoned grass with moderate acid tolerance (pH 5-7). When established is a good sod-former grass species that is moderately drought tolerant. Kentucky is the lower limit of its use and may be more successful in eastern Kentucky, although not aware of its being planted in research plots. Seeding rates are similar to those of tall fescue in wildlife plantings or forage mixtures. In pure stands, moderate forage yields were obtained.

Species: Hard Fescue *Festuca ovina* L. (var. *duriuscula* L. Koch.)
Varieties: Scaldis, Dura
Characteristics: Seeding rate 15-30 lb/A (See Fine fescue)

Species; Meadow Fescue *Festuca elatior* L.
Variety: Bundy
Characteristics: Seeding rate 20-30 lb/A (See Fine fescue)

Species: Fine Fescue *Festuca ovina* L.
Variety: (Experimental F-1377)
Characteristics: The above species appear to be drought tolerant as well as moderately tolerant to acidity (pH 5.0-8.0). However, these are all turf type cool-season grasses that have low forage production when harvested as hay. They do give good ground cover but are slow to be established. Competition may be less than tall fescue when trees are planted into these species. Seeding rate: Fine fescue: 5-10 lbs/A.

Species: Crested wheatgrass *Agropyron desertorum* Schult.
Variety: Norden
Characteristics: This is a cool-season, cold-tolerant grass commonly used in reclamation in the western U.S. It provides good ground cover and production for hay or grazing. It shows some promise for western Kentucky reclamation with limited testing. Although it will grow on acidic spoils (pH 4.5-5.5), it is one of

the better grasses for dry alkaline soils (pH 7.8-9.0). Seeding rates 12-15 lbs/A and may be seeded in early fall and spring. The species was introduced from Russia.

Species: Western Wheatgrass *Agropyron smithii* Rydh.
Variety: Common
Characteristics: (See below)

Species: Intermediate wheatgrass *Agropyron intermedium* Beauv.
Variety: Cahe, Tegmar
Characteristics: Both of the above species are long-lived, cold-tolerant grass species that are similar to crested wheatgrass in their use. They are not as tolerant to alkalinity but a little more tolerant to acidity than crested wheatgrass. The seeding rates range from 12-15 lbs/A. Yields are generally a little lower than crested wheatgrass because stands are not as thick, at least under Kentucky conditions. Both species would appear to be less palatable to livestock than crested wheatgrass.

Warm-Season Grasses for Permanent Cover

Species: Bermudagrass *Cynodon daclylis* L.
Variety: Common (Some new varieties of seed types of bermudagrass may be available but not tested. Sprigs of Midland and Coastal were planted but little survival was obtained.
Characteristics: This is a moderately short-lived grass species. It is relatively drought tolerant and acid tolerant (pH 3.5-7.5). It is subject to winter killing, especially where potassium fertility levels are low. For good forage yields, high nitrogen rates are needed. Has a special use in reclamation of acidic sandy spoils as a "nurse" crop for other long-lived cool-season grasses such as tall fescue. Although stands thin when tall, fescue is overseeded the fall of the 1st or 2nd growing seasons, some plants have been found after 5 years. Seeding rate, de-hulled seed - 10 lbs/A; unhulled seed - 25 lbs/A. Seeding should be done only in late April to late May.

Species: Weeping Lovegrass *Eragrostis curvula* Schrad.
Variety: Common (commercial varieties may be available)
Characteristics: This is a moderately to short-lived grass species that is drought and acid tolerant (pH 4-8). It established fairly rapidly but can reduce stands of other longer-lived cool-season grasses when it is seeded in mixtures. This grass has the tendency to convert to bunch grass growth habit. Good yields may be obtained with good management, but it is hard to manage so that animals will not normally graze it. Seeding rates 3-5 lbs/A and seeded only between March 1-June 30.

Species: Switchgrass *Panicum virgatum* L.
Variety: Blackwell, KY - 1625-77
Characteristics: This is a long-lived grass species that is moderately drought and acid tolerant (pH 4.5-8.0). It does best where adequate moisture is available. It is very slow to be established especially when seeded in mixtures with cool season grasses. Once established, high production is obtained, but forage quality for hay is unknown. It is one of the original tall prairie grasses of Kentucky and the western U.S. Seeding rates of 10-15 lbs/A and should be planted in the spring.

Species: Big Bluestem *Andropogon gerarda* Vitman.
Variety: Experimental KY-30-70, Kaw-75
Characteristics: (See below)

Species: Little Bluestem *Andropogon scoparius* Michx.
Variety: Common
Characteristics: Both of the above are grasses that are slow to be established and were originally part of tall prairie grass mixture. Production is good when established, forage quality good if grazed at short to medium growth stages. Growth is good even at pH levels as low as pH 4.5. Seeding rates used 15-20 lbs/A and seeded only in the spring months.

Species: Indian Grass *Sorghastrum nutans* L.
Variety: Experimental KY 591-76, Cheyenne
Characteristics: A grass species that is drought tolerant but slow to be established. This is a prairie grass and produces high yields once established. Similar to switchgrass with respect to characteristics and seeding rates (10-20 lbs/A).

Species: Deertongue *Panicum clandestinum* L.
Variety: Tioga
Characteristics: This is an acid-tolerant (pH 3.8-6.5) forage grass that is good for grazing. However, because seed is not plentiful, it has a limited use in reclamation. Seeding rates are unknown and it is assumed to be a warm-season grass.

Species: Buffalograss *Buchloe dactyloides* Englem.
Variety: (unknown)
Characteristics: A short growing grass - a part of short prairie grasses of the western U.S. It is drought tolerant, but because seed is expensive, it doesn't appear to be of importance in reclamation in Kentucky or western U.S. for large plantings. It has survived 5 years in experimental planting in western Kentucky Seed rates used are 5-10 lbs/A.

Species: Sideoats Grama *Bouteloua curtipendula* Torr.
Variety: (unknown)
Characteristics: A long-lived grass that is drought tolerant. A part of the prairie grass mixture. Has little use in Kentucky reclamation, although has survived in a short prairie grass mixture for 5 years. Seeding rate used 5-10 lbs/A. **This species is (or has been) on the endangered species list in Kentucky**

Species: Blue Grama *Bouteloua gracilis* Lag Steud.
Variety (unknown)
Characteristics: Similar to sideoats grama, drought tolerant, long-lived grass. Not likely to have a place in KY reclamation. A part of a prairie grass mixture. Seeding rates 5-10 lbs/A.

Species for Temporary Cover

Species: Annual Ryegrass *Lolium* L.
Variety: Common
Characteristics: A cool-season annual that is planted in the fall, harvested as hay in early late spring or summer. Used as a temporary quick cover for one winter as it usually does not reseed itself. Because it will dominate the stand, it may cause failure of the establishment of permanent grasses. It may be killed under severe winters. Seeding rate 18-25 lbs/A.

Species: Wheat *Triticum aestivum* L.
Varieties: Wakefield, Madison, Clark, Verne, Coker 9803, etc.
Characteristics: A winter annual grain group that may serve as a companion crop in establishment of permanent grasses but could cause reduction of these species. May be used to provide standing mulch or harvested for grain or mulch for other areas. May be used for grain production for prime land production requirements. Seeding rates 40-60 lbs/A companion crops, 90-120 lbs/A grain crop, and 120-160 lbs/A temporary erosion control.

Species: Rye *Secale cereale* L.
Varieties: Abruzzi, Wheeler, Aroostook, etc.
Characteristics: Use as a quick-cover winter annual companion crop or green manure crop. Because it is taller, it may reduce survival of interseeded grasses and legumes when high seeding rates are used. Seeding rates 40-60 lbs/A for companion crop, 90-120 lbs/A grain or mulch crop to be harvested for straw, and 120-180 lbs/A for temporary erosion control. Aroostook especially noted for erosion-control capacity.

Species: Millet
Varieties: Japanese, German
Characteristics: Summer annual grasses used as quick-cover crop for summer seedings. Good feed for birds.

Species: Grain Sorghum
Variety: Yellow, Atlas, Sudangrass Hybrid
Characteristics: Summer annual grasses used as quick-cover crop for summer seedings.

Species: Austrian Peas

Species: Sunflower
Variety: Peredovik

Species: Buckwheat

Cool-Season Legumes

Species: Birdsfoot Trefoil *Lotus cornicalatus* L.
Variety: Fergus, Viking, Dawn, Empire
Characteristics: Birdsfoot Trefoil is a species that is long-lived species once established, and varieties listed above are in order of best to least with respect to this characteristic. This species cannot compete very well in early stages of establishment when the grasses (or weeds) are actively growing due to high nitrogen levels. Birdsfoot trefoil is both drought and acid tolerant (pH 4.0-8.2). Although relatively low growing, good forage yields may be obtained, especially when grazed. Once established, it is good for erosion control. May be seeded with tall fescue, orchardgrass, or timothy, but grass seeding rates should be reduced. Seeding rate 10-15 lbs/A; better success has been achieved in spring seedings than fall. Once established, it is one of the best legumes for reclamation.

Species: Alfalfa *Medicago sativa* L.
Variety: Vernal, Apollo, Arc, Vanguard, Williamsburg, Tempus, Trident, etc. (Those listed have been tested on mined land.)
Characteristics: A long-lived (5-7 years) legume that is traditionally grown on soils or spoils that have a near neutral pH (6.0-8.0). It will survive on more acid areas if adequate moisture and/or on spoils in which at least the upper 4-6 inches has been limed to pH 6.5. Alfalfa requires high fertility if high production is to be achieved, however, it will survive under low fertility conditions. Although some varieties are insect resistant, production may be reduced for the first (and second) harvest if insecticides are not used. Compatible with grasses and other legumes. Seeding rates of 10-20 lbs/A are used in mixtures or pure stands. One of the better legumes for reclamation.

Species: Red Clover *Trifolium pratense* L.
Variety: Kenstar, Kenland, Redland, Redman, Cinnamon. (Those listed here have been tested on mined land.)
Characteristics: A short-lived (usually 2-3 years) legume that under proper management may stay in a stand for longer periods. Good production if used for forage under good fertility. It is not nearly as drought or acid tolerant as Birdsfoot Trefoil and grows best when pH is near neutrality (pH 6-7.5). With proper seedbed preparation and conditions, it is easily established with best results for spring seeding at 15-25 lbs/A.

Species: White Clover *Trifolium repens* L.
Variety: White Dutch (Ladino)
Characteristics: A legume that may be short-lived species as it requires some seed production to maintain a good stand. Because of its low growing habit, it will produce low forage yields. Should always be planted with a grass. Adapted to neutral pH levels (pH 5.8-7.5). Seeding rate 5-10 lbs/A.

Species: Alsike Clover *Trifolium hybridum* L.
Variety: Common
Characteristics: Similar to red clover and dies out after two years. It is a legume that does well in wet areas. May be seeded with tall fescue. It is more acid tolerant than red clover. Establishes best in the spring using 12-18 lbs/A. Even when it is allowed to go to seed, it does not remain as long as red clover even under good fertility and management.

Species: Crownvetch *Cornoilla varia* L.
Variety: Common (May be some commercial varieties available but to date none have been tested on mined land in Kentucky)
Characteristics: A long-lived legume if not grazed heavily. Should be used only on incidental erosion-prone areas where soil stabilization is the principal concern. This species should not be used for the purpose of wildlife habitat. Slow to be established from either seed or space planted seedlings, especially when seeded with tall fescue. Well adapted to steep areas and where pH's are above 6.0 Once it is established, it is effective in erosion control and aggressive with respect to domination of the stand. Fall plantings are less successful than spring seedlings. The seeding rate 10-15 lbs for fall, 5-10 lbs for spring; seed is very expensive, but well worth it, if only a few well-spaced plants occur because this legume has a good spreading habit.

Species: Sweet Clover (yellow) *Melilotus officianalis* L.
Variety: Common yellow blossom
Characteristics: A short-lived or biannual legume, but a good reseeder will usually remain in a stand. Not useful for hay or grazing but will serve to increase nitrogen(a green manure crop) in spoils. Established rapidly when under good conditions and may suppress other plants in which it is seeded. Although has survived on acid spoils (pH 5-6), it grows best at neutral pH's. It is drought resistant. Plant only the yellow blossom types at 15-25 lbs/A. May be used as a green manure crop and to reduce bulk densities of subsoil horizons of reconstructed prime farmland sites.

Warm-Season Legumes

Species: Sericea Lespedeza *Lespedeza cuneata* G. Don.
Variety: Common, Interstate, Cericea, Serala
Characteristics: A long-lived legume that has a moderate acid (pH 4.5-7.0) and good drought tolerance. Widespread use of this species is discouraged. Should only be used on incidental erosion-prone areas where soil stabilization is the principal concern. This species should not be used for the purpose of wildlife habitat. It is slow to be established when adequate nitrogen is applied for the grass, but once it becomes established, it will dominate the stand primarily used for hay/pasture land use. Therefore, it would need to be maintained. Does not perform well when cut regularly. Stands are more successfully obtained in the spring and fall seedings. Hulled seeds should be used in fall planting, and unhulled seeds should be used in spring planting. The seedlings that germinate in the fall usually do not survive. Seeding rate 15-25 lbs/A. Low food value for wildlife but provides good cover.

Species: Korean-Kobe Lespedeza *Lespedeza stipulacea* Maxim.
Variety: Usually sold as Korean or Kobe
Characteristics: An annual season legume that is a good reseeder if properly managed and not grazed intensively. It is acid tolerant (pH 4.5-7) but if production is needed as a hay, pH should be in 6-7 range. If harvested as hay, it must be reseeded. Good success is achieved when seeded with a grass mixture. Kobe is a little more manganese tolerant than Korean. Provides good wildlife food for birds such as quail. Seeding rates 25-30 lbs/A for Korean, 30-35 lbs/A for Kobe.

Species: Flat Pea Vine *Lathyrus sylvestris* L.
Variety: Limited seed available (USDA)
Characteristics: Long-lived legume that is drought resistant and acid tolerant. Some related species are poisonous, but not the above, which may be grazed. Little value other than conservation plantings due to limited seed sources and difficulty of establishing when planted with tall fescue. It may require some re-seeding to be able to maintain a long-lived stand. Seeding rate 5-10 lbs/A, drilled in rows or space planted.

Winter Annual Legumes

Species: Hairy Vetch *Vicia villosa* Roth.
Variety: Common
Characteristics: A legume that provides short-range ground cover. Serves as a green manure or source of nitrogen and erosion control when seeded with a cereal grain such as wheat or rye. Useful in wildlife plantings, but it should be seeded each fall as little carry over of seed from one year to the next occurs. Plant only in the fall (Aug-Oct) at 40-50 lbs/A (pure stand) or with grass, 20-30 lbs/A in mixtures with other legumes.

Species: Big Flower Vetch *Vicia grandiflora* Scop.
Variety: Unknown or common - some new varieties may be available.
Characteristics: A legume similar to hairy vetch that appears to have limited use in reclamation of non-topsoiled mined land. On non-mined land, it out yielded Hairy Vetch, but it did not reseed itself in two trials on mined land spoils, probably due to birds eating the seed. Seeding rate 25-35 lbs/A.

Table 12. Suggestions for Seed Mixes and Rates for Kentucky

Cool-Season Grasses for Permanent Cover	Seeding Rate lb/acre
Tall Fescue	20-40
Red Fescue	20-30
Redtop	4-8
Perennial Ryegrass	30-35
Timothy	4-9
Kentucky Bluegrass	15-25
Orchardgrass	15-20
Reed Canarygrass	10-15 (5 lb/Amore for fall seedings)
Cool-Season Grasses (Marginal for Kentucky)	
Canada Bluegrass	10-15
Smooth Brome Grass	20-40
Hard Fescue	15-30
Meadow Fescue	20-30
Fine Fescue	5-10
Crested Wheatgrass	12-15
Western Wheatgrass	12-15
Intermediate Wheatgrass	12-15
Warm-Season Grasses for Permanent Cover	
Bermudagrass	
hulled	10
unhulled	25
Weeping Lovegrass	3-5
Switchgrass	10-15
Big Bluestem	15-20
Little Bluestem	15-20
Indian Grass	10-20
Deertongue	unknown
Buffalograss	5-10
Sideoats Grama	5-10
Blue Grama	5-10

Species for Temporary Cover		Seeding Rate lb/acre
Annual Ryegrass		18-25
Wheat	companion crop	40-60
	grain crop	90-120
	temporary erosion control	120-160
Rye	companion crop	40-60
	grain or mulch crop	90-120
	temporary erosion control	120-180
Millet		10
Grain Sorghum		20

Cool-Season Legumes	Seeding Rate lb/acre
Birdsfoot Trefoil	10-15
Alfalfa	10-20
Red Clover	15-25
White Clover	5-10
Alsike Clover	12-18
Crownvetch	10-15 Fall 5-10 Spring
Sweet Clover	15-25
Narrowleaf Trefoil	5-10
Warm-Season Legumes	
Sericea Lespedeza	15-25
Korean-Kobe Lespedeza	25-30
Flat Pea Vine	5-10
Winter Annual Legumes	
Hairy Vetch	40-50 Fall 20-30 with other legumes
Big Flower Vetch	25-35

WOODY PLANTS

DEFINITIONS

Woody plants used in the revegetation of coal mines comprise both shrubs and trees. Deciduous shrubs and trees shed their leaves in the fall as part of their life cycle. Coniferous shrubs and trees are typically characterized as softwood and retain their leaves year-around.

PURPOSE

The use of trees and shrubs in the revegetation of mined lands not only plays an important role in providing wildlife habitat, but also is an integral element in achieving the post-mining land use. Trees and shrubs are essential in the post-mining land uses of forest and provide food and cover for the fish and wildlife post-mining land use. Trees and shrubs may be used as greenbelts to provide food and shelter for wildlife and for other post-mining uses as well.

REGULATORY REQUIREMENTS

Revegetation of land affected by coal mining must meet the criteria set forth under 405 KAR 16:200, including tree and shrub-stocking standards and criteria for measuring stocking success (TRM #19). A diverse, permanent vegetative cover must additionally meet the requirements delineated under 405 KAR 16:180 Protection of Fish, Wildlife, and Related Environmental Values and TRM #21. Certain areas on mines must meet additional requirements mandated by the Kentucky Division of Water under CWA Section 401 certification conditions for restored/replaced wetlands and riparian zones.

IMPLEMENTATION

Trees and shrubs are to be planted according to the locations and timetable specified in the MRP. Shrub and tree planting activities include:

- Species Selection
- Site preparation
- Planting

Species Selection

Trees and shrubs to be planted should be specified in the MRP. Species selection criteria for the purpose of achieving the post-mining land use include: benefits to wildlife, soil moisture, site drainage, slope and aspect, and soil and water quality. Ideally, marketable trees should be planted on more level ground to aid future logging for the forestry post-mining land use. Legume trees (alder, locust) and shrubs (autumn olive and shrub lespedeza) provide nitrogen to the soil. Mixing legumes with hardwood trees reduces the need for booster fertilizer. Pines tend to be drought resistant and acid tolerant. Willow, cottonwood, sycamore, and sweet gum are examples of trees that do well on wetter sites. Recommended trees and shrubs for the revegetation of coal-surface mined lands in eastern and western Kentucky are presented in Tables 13 and 14.

Table 13. Recommended Tree Seedlings for Kentucky

Hardwoods

Species: Cottonwood *Poplus deltoides*
Hybrid Poplar:
Characteristics: Cottonwood and hybrid poplars are pioneer deciduous species, well-suited to disturbed sites. Eastern cottonwood grows naturally along stream banks and on bottom lands. These trees are fast growing and are spread from seed or cuttings. Grow best near pH 7. They do not grow well at pH levels below 5 or in soils that are compacted and dense.
Uses: Crating, veneer baskets, pallets, pulpwood and Furniture frames.

Species: Sycamore *Platanus occidentalis*
Characteristics: A rapid-growing deciduous that may tolerate both wet or dry soils but does best on well-drained alluvial soils. They tolerate a pH range 4-8 but optimum pH 6.0-7.5. Tolerant of competition from other tree species except black locust. They may be established from both seed and cuttings, but direct seeding required constant moisture while germinating.
Uses: Furniture parts, boxes, millwork, flooring, particle board, and paper.

Species: Green Ash *Fraxinus pennsylvanica* var. lanceolata
Characteristics: A small to medium-size deciduous tree that will tolerate pH levels 4.0-8.1. This species grows naturally in alluvial soils along rivers and brooks. Established from cuttings.Direct seeding is not recommended.
Uses: Tool handles, sporting goods, furniture pulpwood and fuel wood.

Species: White Ash *Fraxinus americana*
Characteristics: A moderate-size deciduous tree, less widespread than other ashes. Although it will grow at pH as low as 4, it does best at higher values. Established from one-year old-seedlings, direct seeding not recommended and older seedlings are too large to economically plant on spoils.
Uses: Tool handles, sporting goods, furniture and fuel wood.

Species: European Black Alder *Alnus glutinosa*
Characteristics: A medium-size deciduous tree that can tolerate extremely low pH levels - 4.0, but it does best near 7.0. It can tolerate both wet and dry soils. Although not a legume, alders fix nitrogen that is available to neighboring trees. Established from one-year-old seedlings or direct seeding.
Uses: Seed-wildlife food, wood charcoal, paper, particle board, and fuel wood.

Species: Gray Birch *Betula populiforia*
Species: Paper Birch *Betula papyrifera*
Species: European White Birch *Betula pendula*
Characteristics: Small deciduous trees, native to northern U.S. and high elevations of Appalachian states. Grows best on well-drained sandy loams having pH 4.0 or higher. Established from one year seedling.
Uses: Pulpwood and fuel wood.

Species: River Birch *Betula nigra*
Characteristics: The only native birch (river birch) to southern U.S. It is a medium deciduous tree that is comparatively short-lived tree species. It can tolerate pH as low as 4.0. Established from one-year-old seedlings on wet, poorly drained sites.
Uses: Limited due to its poor form.

Species: Silver Maple *Acer saccarinum* L.
Characteristics: A moderate to large deciduous tree that will tolerate wet or dry sites, but it does best on well-drained alluvial soils. May tolerate pH levels as low as 4, but does best at pH levels of 5-7.0. Established as one year old seedlings or direct seedings on moist sites.
Uses: Pulpwood, boxes, millwork, firewood, and pallets.

Species: Northern Red Oak *Quercus rubra*
Characteristics: A native deciduous tree that grows best on north or east slopes. Will tolerate pH as low as 4.0 but does best at 5-7.0. It will grow on heavy clays if moisture is available. Established from one-year-old seedlings.
Uses: Furniture, veneer, moldings, handles, and fuel wood.

Species: White Oak *Quercus alba*
Characteristics: Will grow on all but the driest or swampy sites if the pH is 5.0 or greater. Established from one year old seedings.
Uses: Cooperage, furniture, veneer, fuel wood, pallets, and flooring.

Species: Black Walnut *Juglans nigra*
Characteristics: A large deciduous tree that grows best in soils 6.0-7.5, that are deep, moist, well-drained. Poorly drained and droughty sites should be avoided. Established from one year old seedlings.
Uses: Veneer, furniture, gun stocks, and novelties.

Species: Black Locust *Robinia pseudoacacio*
Characteristics: A medium-size deciduous tree that requires a soil of pH 4.0 or greater but does better at pH levels of 6-8.0. Grows well on a large variety of sites except poorly drained, heavy textured. Established from one-year-old stock or treated seed from a local source. This species fixes nitrogen that benefits this and neighboring trees.
Uses: Fence posts and firewood and pasture for bees.

Species: Royal Paulownia *Paulownia tomentosa*
Characteristics: Native to China, but adapted to southeastern U.S. Grows best on moist, well-drained soils often on south-facing steep slopes. Established from seedlings one year old and in open areas as it cannot tolerate shade.
Uses: Export to make rice pots, bowls, wooden spoons, musical instruments, and religious furniture. Wood is light and strong and will not split even under rapid kiln drying.

Conifers

Species: White Pine *Pinus strobus*
Characteristics: Eastern white pine is the largest native conifer of the northeastern U.S. It grows on most soils, but it will do well on excessively drained or well-drained soils that are droughty. Growth poorest on clay or poorly drained soils. Its pH tolerance is 4.0-7.5. Established from two- or three-year old seedlings.
Uses: Building materials, furniture, doors, and window sashes, as well as a popular species for Christmas trees.

Species: Loblolly Pine *Pinus taeda*
Characteristics: A coniferous tree widely limited to states below the Ohio River due to its being damaged from ice and snow. Tolerant to other trees and/or grasses on soils from sandy loams to clays with pH levels 4-7.5. One-year-old seedlings are used for establishing.
Uses: Pulpwood, saw logs, veneer, posts, poles, and piling.

Species: Virginia Pine *Pinus virginiana*
Characteristics: An abundant conifer of Appalachian states that is fast growing. Can tolerate pH levels as low as 3.5 but natural stands found in soils pH 4.6-7.9. Grows best on clay loams or sandy loams that are moderately to well drained. One-year seedlings are preferred for planting.
Uses: Pulpwood and beneficial as wildlife species.

Table 14. Recommended Shrubs for Kentucky Wildlife Habitat

Species: Autumn Olive *Elaeagnus umbellata*
Characteristics: A shrub that is well adapted to a variety of spoil conditions. Grown on spoils with a pH as low as 3.2 but better in pH levels 4-7. It is a nitrogen fixer and assists in building the soil. Plant one-year-old seedlings and may be interplanted with oak, walnut, and ash to "train" or shade out lower branches.
Uses: Wildlife food and nitrogen fixer.

Species: Tatarian Honeysuckle; Amur Honeysuckle; Bi-color Lespedeza; Juponica Lespedeza, Shrub Lespedeza, and bristly locust.
Characteristics: All of the species listed above are tolerant to moderately acidic conditions (pH levels 4.5 - 7.0). They may be used to provide both food and wildlife cover. Established from cuttings and/or seed.

Site Preparation

Typically, trees and woody plants are established on areas where grasses had been planted the previous year. However, planting trees and grasses within the same time frame may help to reduce competition early on. Another approach that may be considered is to band apply a constant herbicide in strips one to two months prior to tree planting. This reduces competition for moisture, yet provides soil protection. The use of a tree setter, following a shallow subsoiler or ripping, may improve tree seeding survival. Ideally, minimum grading will result in a less compacted soil but approval will be needed from the Cabinet.

Planting

Planting rates and timetables for woody plants should be specified in the MRP. Forested lands should be planted to a density of at least 300 trees and shrubs per acre as counted with a statistical confidence of 90 percent with trees comprising at least 75 percent of the woody plant species (Kentucky DSMRE TRMs #19 and 21).

Seedlings may be bare rooted or in small, individual containers. Direct planting of seeds may be used, but they are slow to germinate, and may not compete with grasses. For this reason, seeds should be planted to supplement seedlings.

Bare-rooted seedlings come from suppliers in bundles. (Each spring the Kentucky Division of Forestry sells them at reasonable rates (Appendix D). The roots should not be allowed to dry out. If they cannot be planted soon after delivery, a trench should be dug and the seedlings placed into the trench without folding the roots. The roots should be covered with soil and tamped down with the foot.

Because the roots of containered seedlings are protected, their survival rate is greater, and they afford greater flexibility for planting schedules. Containered seedlings have a higher unit cost, but this expense is balanced by less need to replant, thereby expediting bond release.

Seedling containers are of three types: tube, block, and plug. Tubes and blocks can be planted by machine. Tubes are made of a biodegradable material; blocks are composed of growing media (e.g., peat moss, vermiculite). Plugs must be planted by hand and are composed of soil that has been formed in a mold. Molds can often be reused.

In the machine planting of seedlings, equipment should be run on the contour where slope permits. Otherwise, work at right angles to the contour, up and downhill. Seedlings that require hand planting can be set using a mattock, dibble, or spade (Figure 25). Punch a hole to a depth so that the roots will not bend. Set the seedling no deeper than it was at the nursery. Tamp down the soil. Further information about the planting of tree and shrub seeds and seedlings is available through a district forester (Appendix D).

MAINTENANCE

Revegetative success can be measured using procedures provided by the Kentucky Department for Surface Mining Reclamation and Enforcement's TRM #19 (1991). Poor stands should be resown, following re-evaluation of soils and/or spoils in terms of acidity and fertility. As noted above, certain areas may need to meet requirements mandated by the Kentucky Division of Water.

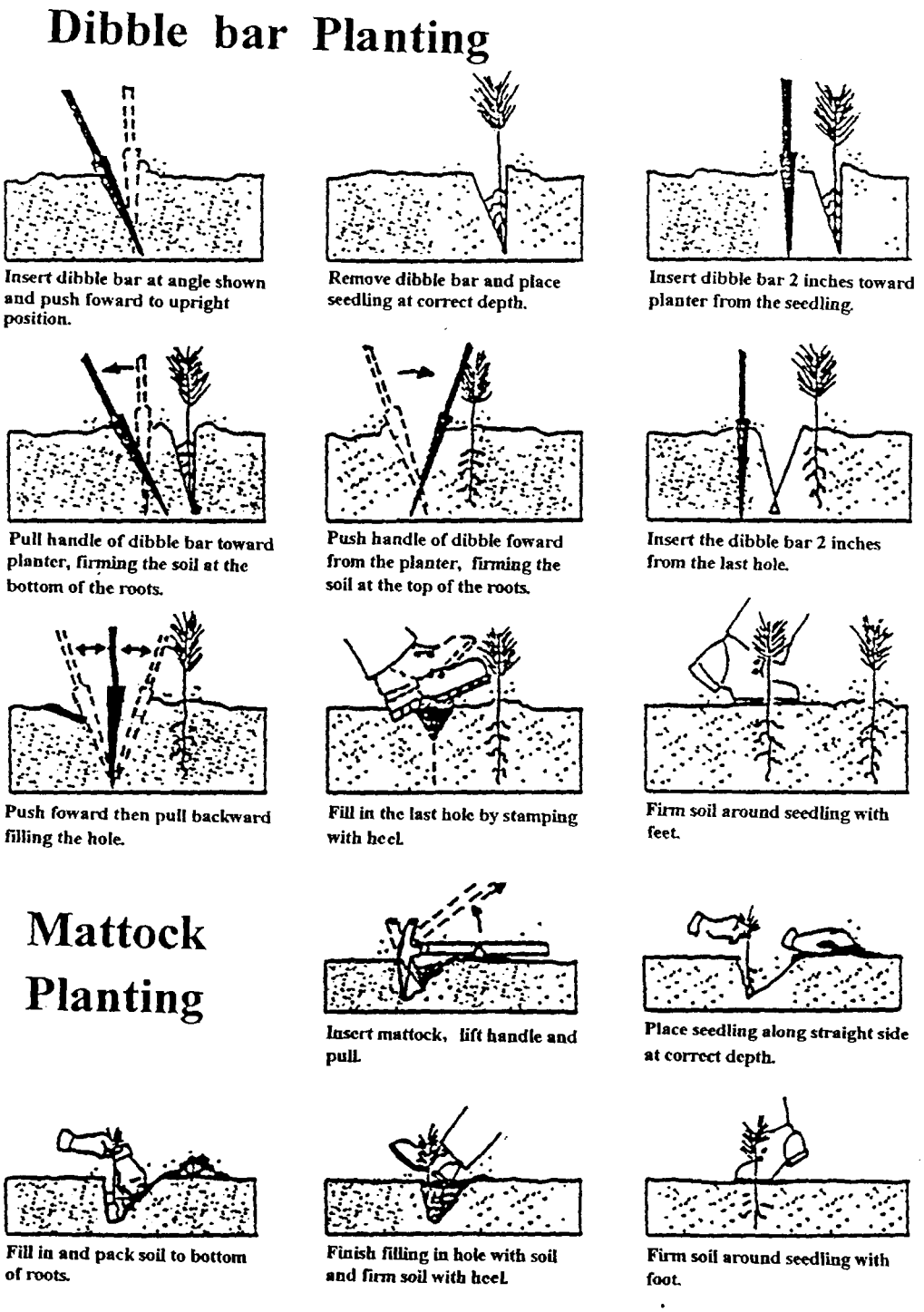
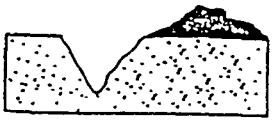
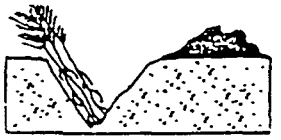


Figure 25. Seedling planting techniques

Heeling In

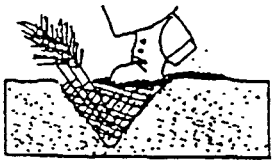


Dig a v-shaped trench in a moist shady place.



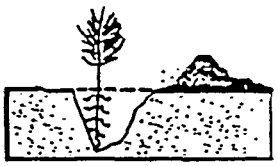
Break bundles and spread out evenly.

Fill in with loose soil and water.

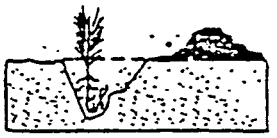


Complete filling in with soil and firm soil with foot.

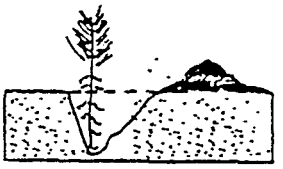
Correct and Incorrect Depths



Correct - At the same depth or 1/2 inch deeper than seedling grew in the nursery.

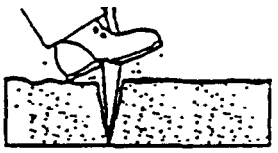


Incorrect - Too deep and with roots bent.

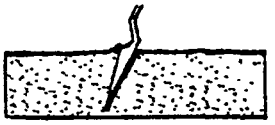


Incorrect - Too shallow and roots exposed.

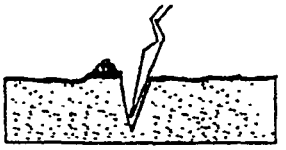
Spade Planting



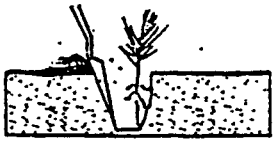
Shovel in position for starting planting hole. Blade reversed, perpendicular.



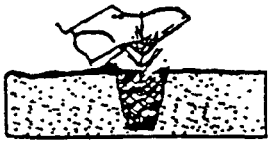
Shovel handle pushed forward. Bottom of hole opened up and out. Shovel pulled back and out of hole.



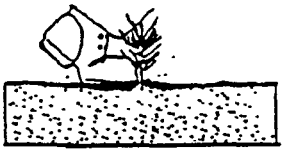
Beginning of second cut to straighten back wall of hole.



Shovel pulled back making clean hole. Tree placed in hole, roots in normal position. Plant tree 1/2 inch deeper than it formerly grew.



First packing, hole half filled with soil. If tree is in proper position, the shoe heel is used in tamping.



Second packing, hole completely filled. Cover packed soil with mulch or loose soil.

Figure 25. (cont.)

MULCH

DEFINITION

MULCH

DEFINITION

Mulch is a material that is spread over the surface of the soil. Examples of mulch materials include straw, hay, wood chips, bark, mushroom compost, excelsior, jute, and woven paper or plastic fibers.

PURPOSE

Mulch protects soil, seeds, and/or plant roots from the erosive effects of rain and minimizes fluctuations in soil moisture and temperature.

REGULATORY REQUIREMENTS

Section 4 of 405 KAR 16:200 requires the application of mulch in addition to a temporary vegetative cover on all regraded and topsoiled areas that have a slope in excess of 10 percent. The use of mulch may be waived on a case-by-case basis for those areas with slopes less than or equal to 10 percent if the Cabinet finds that based on seasonal, soil, and slope factors the temporary vegetative cover will achieve proper erosion control until a permanent cover is established.

IMPLEMENTATION

Establishment

Locally available, inexpensive materials are often preferred for use as mulch. Suggested mulching rates for selected materials are listed in Table 15. On steep slopes and sites with difficult accessibility consider the use of a blower or hydroseeder to apply mulch. This can sometimes be accomplished in conjunction with seed and/or fertilizer application. However, excessive use of mulch mixed with seed can result in poor stands.

Anchoring

Loose mulch should be anchored to prevent loss through erosion. Methods and materials used to anchor mulch include netting, disking, and asphalt spray.

MAINTENANCE

Mulched areas should be inspected, especially following wind and/or rain storm events. If necessary, mulch and seed should be replaced.

Table 15. MULCHING GUIDE

Mulching Material	Rates	Remarks
Small grain straw, tall fescue, or mixed hay	Apply uniformly with chopper-blower at the rate of 1.5 to 2 tons (60-80 bales) per acre.	One of the better mulching materials when tacked down with asphalt emulsion or other chemical binders or when pressed into the soil with a crimper. Can be applied by hand or power mulcher.
Corn Stalks	4-6 tons per acre	Air-dried; cut or shredded in 4"-6" lengths.
Shredded bark	Apply at rate of 45 cu. yds. per acre	Excellent mulching material that will stay in place without tacking down. Bark can be applied on leveled and sloping areas with the truck-mounted spreader. It can be applied with a manure spreader on leveled areas.
Wood fiber	Apply at rate of 1,400 to 1,600 lbs. per acre	Processed wood or cellulose fibers and some reprocessed paper materials are popular because they can be mixed with seed and fertilizer in a hydroseeder and applied all at one time. Most cellulose materials are colored for visibility.
Wood chips	10-20 tons per acre	Air dried; may contain bark.
Leaves	Apply at a rate of 2-3 tons per acre or 100 bales per acre	Use of deciduous tree leaves for mulching is limited to level areas because light disking is necessary to hold them in place. Leaves can be spread with a power mulcher or with a manure spreader.
Other waste products	Apply at a rate of 10 tons per acre	Waste products such as processed or compost garbage and dewatered sewage sludge can be used as mulches and organic amendments. Application can be made with truck-mounted spreader followed with a light disking.

APPENDICES

A. KENTUCKY DIVISION OF WATER

Central Office
14 Reilly Road
Frankfort, KY 40601-1189
502-564-3410

Eastern Coalfield

Columbia Regional Office
102 Burkesville Street
P.O. Box 335
Columbia, KY 42728
502-384-4734
Clinton
Pulaski
Wayne

Hazard Regional Office
233 Birch Street, Suite 1
P.O. Box 1179
Hazard, KY 41701
606-439-2391

Breathitt	Floyd
Johnson	Knott
Letcher	Magoffin
Martin	Perry
Pike	Wolfe
Lee	

London Regional Office
85 State Police Road
Regional State Office Building
London, KY 40741
606-878-0157

Bell	Clay
Harlan	Jackson
Knox	Leslie
Owsley	Rockcastle
Whitley	Laurel
	McCreary

Morehead Regional Office
Mabry Building, KY 32S
Morehead, KY 40531
606-784-6635

Boyd	Carter
Elliott	Greenup
Lawrence	Menifee
Morgan	Rowan
Lewis	Mason

Western Coalfield

Bowling Green Regional Office
1508 Western Avenue
Bowling Green, KY 42101
502-746-7475

Butler	Edmonson
Hart	Logan
Warren	

Madisonville Regional Office
Madisonville State Office Building
625 Hospital Drive
Madisonville, KY 42431
502-825-7529

Breckinridge	Caldwell
Christian	Crittenden
Daviess	Grayson
Hancock	Henderson
Hopkins	McLean
Muhlenberg	Ohio
Webster	

Frankfort Regional Office
South Annex Bldg.
1047 U.S. 127
Frankfort, KY 40601
502-564-3358

Estill	Madison
Powell	

B. KENTUCKY DEPARTMENT FOR SURFACE MINING RECLAMATION AND ENFORCEMENT

Central Office

#2 Hudson Hollow
Frankfort, KY 40601
502-564-2320

Field Offices

London Regional Office
Regional State Office Building
85 State Police Road
London, KY 40741-9008
606-878-0098

Middlesboro Regional Office
1804 E. Cumberland Avenue
Middlesboro, KY 40965-1229
606-248-6166

Prestonsburg Regional Office
1346 S. Lake Drive
Prestonsburg, KY 41653-1397
606-886-8536

Pikeville Regional Office
109 S. Mays Branch Road
Pikeville, KY 41501
606-432-7726

Madisonville Regional Office
Regional Office Building
625 Hospital Drive
Madisonville, KY 42431
502-825-6536

C. U.S. OFFICE OF SURFACE MINING

Lexington Field Office
2675 Regency Road
Lexington, KY 40503-2922
606-233-2494

London Area Office
P.O. Box 1048
London, KY 40741
606-878-6440

Madisonville Area Office
100 YMCA Drive
Madisonville, KY 42431
502-825-4500

Prestonburg Area Office
P.O. Box 306
W. Prestonburg, KY 41668
606-886-1391

D. KENTUCKY DIVISION OF FORESTRY

Eastern Coalfield

Northeastern District
749 W. First St.
Morehead, KY 40351
606-784-7504

Boyd	Greenup
Carter	Morgan
Elliott	Rowan

Southeastern District
P.O. Box 130
Pineville, KY 40977
606-337-3011

Bell	Laurel
Clay	Leslie
Harlan	McCreary
Jackson	Rockcastle
Knox	Whitley

Eastern District
P.O. Box 189
Betsy Lane, KY 41605
606-478-4495

Floyd	Magoffin
Johnson	Martin
Lawrence	Pike

Kentucky River District
P.O. Box 702
Hazard, KY 41702
606-439-1385

Breathitt	Letcher
Estill	Owsley
Knott	Perry
Lee	Wolfe

Western Coalfield

Central District
P.O. Box 663
Elizabethtown, KY 42702
502-769-1361

Edmonson	Hancock
Grayson	Hart
Breckinridge	Warren

South Central District
120 Gaines Drive
Campbellsville, KY 42718
502-465-5071
Pulaski

Green River District
P.O. Box 465
Madisonville, KY 42431
502-825-6527

Butler	McLean
Christian	Muhlenberg
Daviess	Ohio
Henderson	Todd
Hopkins	Union
Logan	Webster

Western District
P.O. Box 349
Mayfield, KY 42066
502-247-3913

Caldwell	Crittenden

E. KENTUCKY SOIL AND WATER CONSERVATION DISTRICTS

COUNTY & AREA	ADDRESS	TELEPHONE
BELL (7)	R. 1, Box 64, Pineville 40977	606-337-6320
BOYD (8)	17213 Bear Creek Rd., Catlettsburg 41129	606-928-1477
BREATHITT (9)	170 Howell Heights, Suite 2, Jackson 41339	606-666-5138
BRECKINRIDGE (3)	105 E. Fourth St., Hardinsburg 40143	502-756-2776
BUTLER (2)	213 W. Ohio St., P.O. Box 307, Morgantown 42261	502-526-3784
CALDWELL (1)	114B Edwards St., Princeton 42445	502-365-5533
CARTER (8)	301B Carol Malone Blvd., Grayson 41143	606-474-5184
CHRISTIAN (1)	530 Noel Avenue, Hopkinsville 42240	502-885-8688
CLAY (9)	R. 7, Box 1A, Manchester 40962	606-598-5132
CRITTENDEN	113 Morningside Drive, Marion 42064	502-965-3921
DAVIESS (2)	3032 Alvey Park Drive, Suite 2, Owensboro 42303	502-685-1707
EDMONSON (3)	100 Washington St., P.O. Box 248, Brownsville 42210	502-597-2761
ELLIOTT (8)	R. 1, Box 1690, Sandy Hook 41171	606-738-6222
FLOYD (8)	37 S. Lake Dr., Suite 100, Prestonsburg 41653	606-886-3128
GRAYSON (3)	115 Commerce Drive, Leitchfield 42754	502-259-3738
GREENUP (8)	HC 63, Box 952, Town Hill Plaza, Greenup 41144	606-473-7194
HANCOCK (2)	Monroe Street, P.O. Box 70, Hawesville 42348	502-927-6622
HARLAN (9)	209 N. Main St., Harlan, 40831	606-573-2838
HART (3)	805 N. Main St, Govt. Bldg., P.O. Box 186, Munfordville 42765	502-524-5482
HENDERSON (2)	706B N. Green St., Henderson 42420-2951	502-827-5157
HOPKINS (2)	1105 National Mine Dr., Madisonville 42431	502-821-4464
JACKSON (7	US 421, Demsil Bldg., P.O. Box 172, McKee 44047	606-287-8314
JOHNSON (8)	958 Broadway Plaza, Paintsville 41240	606-789-5263
KNOTT (9)	Court Street, Box 296, Hindman 41822	606-785-0113
KNOX (7)	106 Cumberland Ave., Barbourville 40906	606-546-3393
LAUREL (7)	85 South Laurel Rd., Suite B, London 40741-8300	606-864-2180
LAWRENCE (8)	US 23, 100 Business St., Suite 3, P.O. Box 29, Louisa 41230	606-638-4145
LEE (9)	Lee Co. Court House, Main St., P.O. Box 248, Beattyville 41311	606-464-8480
LESLIE (9)	Hertz Creek Shopping Ctr., P.O. Box 932, Hyden 41749	606-672-2357
LETCHER (9)	710C Jenkins Rd., Whitesburg 48158	606-633-4448
LOGAN, N.&S. (2)	253C Hopkinsville Road, Russellville 42276	502-726-2618
MCCREARY (7	Whitley City Plaza, Hwy. 27S., P.O. Box 293, Whitley City 42653	606-376-5017
MCLEAN (2)	Farm Bureau Bldg., P.O. Box 289, Calhoun 42327	502-273-3655
MAGOFFIN (8)	465 E. Mountain Parkway, Salyersville 41465	606-349-1919
MARTIN (8)	Main Street, P.O. Box 392, Inez 41224	606-298-3595
MENIFEE (8)	Elwood Motley Bldg., P.O. Box 86, US 460 West, Frenchburg 40322	606-768-2541
MORGAN (8)	1092 Highway 7, West Liberty 41472	606-743-3194
MUHLENBERG (2)	340 Dean Rd., Suite 3, Greenville 42345-1400	502-338-3743
OHIO (2)	492 St. R. 69, N.,Suite 1, Hartford 42347	502-298-3340
OWSLEY (9)	Presbyterian Manse Bldg., P.O. Box 31, Booneville 41314-0530	606-593-5183

COUNTY & AREA	ADDRESS	TELEPHONE
PERRY (9)	825 High St., Hazard 41701	606-436-3731
PIKE (8)	Post OFfice Bldg., Main St., P.O. Box 1481 Pikeville, 41502-4481	606-437-7879
PULASKI (7)	600 Clifty Rd., Somerset 42501	606-678-5416
ROCKCASTLE (7)	USDA Ag. Bldg., Richmond St., P.O. Box 156, Mt. Vernon 40456	606-256-2541
ROWAN (8)	120 Normal Ave., Morehead 40351	606-784-5375
TODD (2)	101 Elk Fork Road, Elkton 42220-7218	502-265-2268
UNION (2)	217 N. Court, Morganfield 42437	502-389-1981
WARREN (3)	925 Lovers Lane, Bowling Green 42103	502-843-1112
WEBSTER (2)	HWY 41A Davenport Duplex Bldg., P.O. Box 158, Dixon 42409	502-639-5763
WHITLEY (7)	109 S. Third St., Williamsburg 40769	606-549-3242
WOLFE (9)	Main Street, Box 235, Campton 41301	606-668-3113

F. KENTUCKY AGRICULTURE EXTENSION AGENTS*

COUNTY	ADDRESS	PHONE
BELL	101 Courthouse Sq, Pineville 40977-0430	606-337-2376
BOYD	P.O. Box 638, Cattletsburg 41129-0638	606-739-5184
BREATHITT	P.O. Box 612, Jackson 41339-1191	606-666-8812
BRECKINRIDGE	P.O. Box 459, Hardinsburg 40143-0459	502-756-2182
BUTLER	P.O. Box 306, Morgantown 42261-0306	502-526-3767
CALDWELL	100 E. Market St., Princeton 42445-1600	502-365-2787
CARTER	P.O. Box 605, Grayson 41143-0605	606-474-6686
CHRISTIAN	509½ W. Ninth St., Hopkinsville 42240-2133	502-886-6328
CLAY	P.O. Box 421, Manchester 40962-0421	606-598-2789
CRITTENDEN	107 S. Main St., Marion 42064-1500	503-965-5236
DAVIESS	Courthouse, Owensboro 42303-4148	502-685-8480
EDMONSON	227 Mammoth Cave Rd., Brownsville 42210	502-597-3628
ELLIOTT	P.O. Box 709, Sandy Hook 41171-0709	606-738-6440
FLOYD	Box 111, Prestonsburg 41653-0111	606-886-2668
GRAYSON	126 S. Clinton St., Leitchfield 42754-1115	502-259-3492
GREENUP	P.O. Box 646, Greenup 41144-0646	606-473-9881
HANCOCK	P.O. Box 10, Hawesville 42348-0010	502-927-6618
HARLAN	P.O. Box 329, Harlan 40831-0329	606-573-4464
HART	P.O. Box 367, Munfordville 42765-0367	502-524-2451
HENDERSON	9½ S. Main St., Henderson 42420-3121	502-826-8387
HOPKINS	P.O. Box 450, Madisonville 42431-0450	502-821-3650
JACKSON	P.O. Box 188, McKee 40447-0188	606-287-7693
JOHNSON	P.O. Box 806, Paintsville 41240-0806	606-789-8108
KNOTT	P.O. Box 462, Hindman 41822-0462	606-785-5329
KNOX	HC84, Box 518, Barbourville 40906-8910	606-546-3447
LAUREL	200 County Extension Rd., London 40741-9008	606-864-4167
LAWRENCE	P.O. Box 686, Louisa 41230-0686	606-638-9495
LEE	P.O. Box 546, Beattyville 41311-0546	606-464-2759
LESLIE	P.O. Box 788, Hyden 41749-0788	606-672-2154
LETCHER	P.O. Box 784, Whitesburg 41858-0784	606-633-2362
LOGAN	P.O. Box 660, Russellville 42276-0660	502-726-6323
McCREARY	P.O. Box 278, Whitley City 42653-0278	606-376-2524
McLEAN	P.O. Box 265, Calhoun 42327-0265	502-273-3690
MAGOFFIN	P.O. Box 349, Salyersville 41465-0349	606-349-3216
MARTIN	P.O. Box 325, Inez 41224-0325	606-298-7742
MENIFEE	P.O. Box 85, Frenchburg 40322-0085	606-768-3866
MORGAN	P.O. Box 35, West Liberty 41472-0035	606-743-3292
MUHLENBERG	P.O. Box 199, Greenville 42345-0199	502-338-3124
OHIO	P.O. Box 66, Hartford 42347-0066	502-298-7441
OWSLEY	Box 186, Booneville 41314-0186	606-593-5109

PERRY	P.O. Box 7070, Hazard 41701-7070	606-436-2044
PIKE	1110 Hambley Building, Pikeville 41501-1342	606-432-2534
PULASKI	P.O. Box 720, Somerset 42502-0720	606-679-6361
ROCKCASTLE	P.O. Box 900, Mt. Vernon 40456-0900	606-256-2403
ROWAN	P.O. Box 848, Morehead 40351-0848	606-784-5457
TODD	P.O. Box 97, Elkton 42220-0097	502-265-5659
UNION	P.O. Box 310, Morganfield 42437-0310	502-389-1400
WARREN	P.O. Box 1018, Bowling Green 42102-1018	502-842-1681
WEBSTER	P.O. Box 97, Dixon 42409-0097	502-639-9011
WHITLEY	P.O. Box 270, Williamsburg 40769-0270	606-549-1430
WOLFE	P.O. Box 146, Campton 41301-0146	606-668-3712

* These are the addresses of the county agents in coal-producing counties; agents in adjacent counties also may be of assistance. For further information, contact the Kentucky Cooperative Extension Service, University of Kentucky, College of Agriculture, Lexington, KY 40546 telephone 606-257-1846.

G. SLOPE MEASUREMENT

Slopes can be measured and expressed in any of three ways:

1. Ratio - Compares one unit (often a foot) of climb or vertical rise to a corresponding number of units of horizontal run. The ratio is written v:h, where v = vertical unit and h = horizontal units.

2. Percentage - Determined as (v / h)(100)

Table G-1. Slope Quick Reference Conversion Table

Ratio (v:h)	Percentage (%)	Degrees(°)
1v:0.25h	400	80
1v:1.35h	75	37
1v:1.5h	67	34
1v:2h	50	27
1v:2.8h	36	20
1v:3h	33	18
1v:4h	25	14
1v:5h	20	11
1v:6.5h	15	9
1v:10h	10	6
1v:20h	5	3
1v:33h	3	2

3. Degree - Angle θ measured and reported.

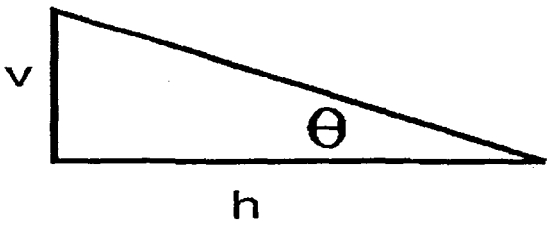


Figure G-1. Parameters for determination of slope defined.

H. DESIGN STORM DATA

The amount of rainfall from a storm is dependent on storm length (hr) and intensity (in/hr). Regulations require drainage systems be built large enough to handle certain design storms. Based on weather history, the definition of design storms vary throughout Kentucky. The engineer uses design storm data to determine specifications for mine site drainage systems.

The most used design storm is the 10-year, 24-hour storm. That is, a storm that is 24 hours in duration with an intensity that occurs one time in every 10 years. Ten-year and 100-year storms are defined for Kentucky by county below.

Table H-1. 24-Hour Design Storm Data in Inches of Rainfall for Kentucky Coal-Producing Counties

COUNTY	2-year	10-year	25-year	100-year
BELL	3.1	4.5	5.2	6.3
BOYD	2.7	4.0	4.6	5.5
BREATHITT	3.0	4.3	4.9	5.9
BRECKINRIDGE	3.3	4.6	5.4	6.4
BUTLER	3.4	4.8	5.5	6.6
CALDWELL	3.4	4.9	5.6	6.8
CARTER	2.8	4.0	4.7	5.6
CHRISTIAN	3.4	4.9	5.7	6.8
CLAY	3.0	4.4	5.1	6.2
CRITTENDEN	3.5	4.9	5.6	6.8
DAVIESS	3.3	4.7	5.5	6.5
EDMONSON	3.3	4.7	5.5	6.5
ELLIOTT	2.8	4.1	4.7	5.7
FLOYD	2.9	4.2	4.8	5.7
GRAYSON	3.3	4.7	5.5	6.5
GREENUP	2.8	4.0	4.6	5.5
HANCOCK	3.3	4.7	5.4	6.5
HARLAN	3.0	4.4	5.1	6.1
HART	3.3	4.6	5.4	6.4
HENDERSON	3.4	4.8	5.5	6.6
HOPKINS	3.4	4.8	5.5	6.7
JACKSON	3.1	4.4	5.1	6.2
JOHNSON	2.8	4.1	4.7	5.7
KNOTT	2.9	4.3	4.9	5.9
KNOX	3.1	4.5	5.2	6.3
LAUREL	3.1	4.5	5.2	6.3
LAWRENCE	2.8	4.0	4.7	5.6
LEE	3.0	4.3	5.0	6.1
LESLIE	3.0	4.4	5.0	6.1
LETCHER	2.9	4.3	4.9	5.9
LOGAN	3.4	4.8	5.6	6.7
MCCREARY	3.2	4.6	5.3	6.4
MCLEAN	3.4	4.8	5.5	6.6
MAGOFFIN	2.8	4.2	4.8	5.8

MARTIN	2.9	4.1	4.7	5.6
MENIFEE	2.9	4.2	4.9	5.9
MORGAN	2.9	4.1	4.8	5.8
MUHLENBERG	3.4	4.8	5.5	6.7
OHIO	3.3	4.7	5.5	6.5
OWSLEY	3.0	4.3	5.0	6.1
PERRY	3.0	4.3	5.0	6.0
PIKE	2.9	4.2	4.8	5.7
PULASKI	3.2	4.5	5.3	6.3
ROCKCASTLE	3.1	4.4	5.2	6.2
ROWAN	2.9	4.1	4.8	5.8
TODD	3.4	4.9	5.6	6.7
UNION	3.4	4.8	5.5	6.7
WARREN	3.4	4.8	5.5	6.6
WEBSTER	3.4	4.8	5.5	6.7
WHITLEY	3.2	4.5	5.3	6.4
WOLFE	2.9	4.2	4.9	5.9

I. SUPPORTING DOCUMENTS

Ackman, T.E. 1982. Sludge Disposal From Acid Mine Drainage Treatment. U.S. Bureau of Mines Report of Investigations No. 8672.

Albrecht, S.C. and B.J. Barfield. 1982. Use of a Vegetative Filter Zone to Control Fine-grained Sediments from Surface Mines. U.S. Environmental Protection Agency, Cincinnati, OH.

Amimoto, P.Y. 1978. Erosion and Sediment Control Handbook. U.S. Environmental Protection Agency EPA 440/3-78-003, Washington, D.C. 197 p.

Atthowe, H. 1993. Mycorrhizae and mined land restoration: current status and future directions. In Planning, Rehabilitation and Treatment of Disturbed Lands, Vol. 2, Sixth Billings Symposium, March 21-27, Montana State Univ. Reclamation Research Unit Publ. No. 9301, p. 60-71.

Barfield, B.J., R.C. Warner, and C.T. Haan. 1981. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press, Stillwater, OK.

Barnett, J.P. 1980. Containerized Pine Seedlings for Difficult Sites, Reprinted from Proceedings -- Reforestation of Disturbed Sites, Texas Agricultural Extension Service and Texas A & M University.

Barnett, J.P. and J.M. McGilvray. 1980. Container Planting Systems for the South. USDA Forest Service.

Barnhisel, R.I. 1976. Lime and fertilizer recommendations for reclamation of surface-mined spoils. AGR-40. University of Kentucky, Cooperative Extension, Lexington, KY.

Barnhisel, R.I. 1983. The environmental consequence of burial depth of toxic spoils and of excessive compaction of prime land on the growth of plants. University of Kentucky, Cooperative Extension, Lexington, KY.

Barnhisel, R.I. 1993. Variability of crop yields on reclaimed prime farmlands. In Planning, Rehabilitation, and Treatment of Disturbed Lands, Vol. 1, Sixth Billings Symposium, March 21-27, Montana State Univ. Reclamation Research Unit Publ. No. 9301, p. 253-262.

Beckett, Jackson, and Reader, Inc. 1981. Soil Erosion and Sedimentation Control. Environmental Design Press, Reston, VA.

Braden, J.B. and D.L. Uchtmann. 1985. Agricultural nonpoint pollution control: An assessment. J. Soil and Water Conservation, 40(1):23-26.

Brady, N.C. 1990. The Nature and Properties of Soils. 10th ed. MacMillan Publishing Co., N.Y. 621 p.

Brooks, R.P., R.F. Unz, L.K. Davis, W.F. Tarutis, Jr., and J. Yanchunas, Jr. 1990. Long-term removal and retention of iron and manganese from acidic mine drainage by wetlands. Vol. I and II, USBM OFR 24 (1 and 2)-90, 145 and 127 p.

Burchick, M. 1993. The problems with Tall Fescue in ecological restoration. Wetland Journal 5(2):16.

Byrnes. W.R., W.W. McFee, and J.G. Stockton. 1980. Properties and Plant Growth Potential of Mineland Overburden. U.S. Environmental Protection Agency EPA-600/7-80-054, Cincinnati, OH. 55 p.

Campbell, G.R. and S.L. Campbell. 1990. Feeding industrial wastes to microorganisms. The World & I. November, p. 280-286.

Caruccio, F.T. and G. Geidel. 1990. Acid-Mine Drainage/Quality: The problem, the chemistry, the field settings, the treatment and potential solutions.

Chesters, G. and L.J. Schierow. 1985. A primer on nonpoint pollution. J. of Soil and Water Conservation, 40(1):9-13.

Chironis, N.P. 1978. How to Build Better Roads. Coal Age, January.

Chironis, N.P. 1978. Coal age operating handbook of coal surface mining and reclamation. McGraw-Hill, New York, NY. 442 p.

Clark, E.H., II. 1985. The off-site costs of soil erosion. J. Soil and Water Conservation, 40(1):19-22

Clausen, J.C. and D.W. Meals. Jr. 1989. Water quality achievable with agricultural best management practices. J. of Soil and Water Conservation, Nov.-Dec., p. 593-596.

Davison, J. 1994. Brochure. Lambda Remediation Systems, Inc. Columbus, OH.

Ditsch, D.C. and L.W. Murdock. 1987. Soil Erodibility: How is it determined and used? AGR 125. University of Kentucky, Cooperative Extension, Lexington, KY.

Dollhopf, D.J. 1993. Deep lime incorporation methods for neutralization of acidic minesoils. In Planning, Rehabilitation, and Treatment of Disturbed Lands, Vol. 1, Sixth Billings Symposium, March 21-27, Montana State Univ. Reclamation Research Unit Publ. No. 9301, p. 216-225.

Edenborn, H.M. 1989. Man-made wetlands to control acid mine drainage. Land and Water, Oct.-1989, p. 4, 15.

Elliott, J.G. 1990. Geomorphic evaluation of erosional stability at reclaimed surface mines in northwestern Colorado. U.S. Geological Survey, Water-Resources Investigations Report 90-4132. Denver, CO. 67 p.

Ettinger, C.E. 1980. Development of Methods to Improve Performance of Surface Mine Sediment Basins: Phase I, EPA 600/7-80-072, U.S. Environmental Protection Agency, Office of Research and Development.

Evangelou, V.P. 1981. Preparation of surface-mined coal spoils and establishment of vegetative cover. AGR 89. University of Kentucky, Cooperative Extension, Lexington, KY.

Evangelou, V.P. and R.I. Barnhisel. 1982. Revegetation guide for surface-mined land in Kentucky. University of Kentucky, Cooperative Extension, Lexington, KY, AGR 95.

Evangelou, V.P. and W.O. Thom. 1985. A laboratory evaluation of abandoned pyritic mine spoils and reclamation approach. Reclamation News & Views 3(3), University of Kentucky, Cooperative Extension, Lexington, KY.

Evangelou, V.P. and R.I. Barnhisel. 1990. Sampling Surface Mine Lands Before and After Mining. University of Kentucky, Cooperative Extension Service, AGR-41.

Evans, J.K. and G. Lacefield. 1981. Inoculation of Forage Legumes. AGR 90. University of Kentucky, Cooperative Extension Service, Lexington, KY.

Federal Clean Water Act Amendment. 1987. Public Law 100-4.

Forster, D.L., C.P. Bardos, and D.D. Southgate. 1987. Soil erosion and water treatment costs. J. of Soil and Water Conservation, 46(5):349-352.

Foster, G.R. 1991. Advances in wind and water erosion prediction. J. Soil and Water Conservation, 46(1):27-29.

Goldman, S.J., K. Jackson, and T.A. Bursztynsky. 1986. Erosion and Sediment Control Handbook. McGraw Hill Book Co., NY.

Graves, D.H. and S.B. Carpenter. 1978. The Use of Sawmill Residue as a Soil Amendment on Eastern Kentucky Surface Mines. Proceedings: Third Annual Meeting of the Canadian Land Reclamation Association.

Grove, J.G. and R.I. Barnhisel. 1983. Managing Nitrogen Supply During Mineland Reclamation. Reclamation News and Views (1)9, University of Kentucky, Lexington, KY.

Haan, C.T. and B.J. Barfield. 1978. Hydrology and Sedimentology of Surface Mined Land. University of Kentucky, Lexington, KY. 286 p.

Harrington, W., A.J. Krupnick, and H.M. Peskin. 1985. Policies for nonpoint-source water pollution control. J. Soil and Water Conservation, 40(1):27-36.

Hasbach, A. 1992. Bioremediation/wetlands used to treat acid mine drainage. Pollution Engineering, June, 1992.

Haussman, R.F. and E.W. Pruett. 1973. Permanent Logging Roads for Better Woodlot Management. USDA Forest Service.

Hayes, J.C., B.J. Barfield, and R.I. Barnhisel. 1984. Performance of grass filters under laboratory and field conditions. Trans. ASAE, p. 1321-1331.

Hedin, R.S. 1989. Treatment of coal mine drainage with constructed wetlands. In Majundar, S.K., R.P. Brooks, F.J. Brenner, and R.W. Tiner, Jr., Wetlands Ecology and Conservation: Emphasis in Pennsylvania. Pa. Acad. Sci., Chap. 28, p. 349-362.

Hedin, R.S. and D.M. Hyman. 1989. Treatment of coal mine drainage with constructed wetlands. Ch. 15 in Biotechnology in Minerals and Metals Processing. Soc. Min. Eng. AIME, p. 113-120.

Hedin, R.S. and R.W. Nairn. 1990. Sizing and performance of constructed wetlands: case studies. Paper in Proceedings of the 1990 Mining and Reclamation Conference and Exhibition. WV Univ. Publ. Serv., v. 2, p. 385-392.

Henry, D.S. 1983. Forage Yield and Quality on Kentucky Surface Mine Spoils. J. of Soil and Water Conservation, 38(1):56-57.

Hill, R.D. 1978. Methods for controlling pollutants. Chap. 39 In Reclamation of Drastically Disturbed Lands, ASA, CSSA, SSSA, Madison, WI, p. 687-704.

Hittman Associates. 1976. Erosion and Sediment Control: Surface Mining in the Eastern U.S. - Volume 1, Planning and Volume 2, Design, EPA 625/3-76-006, U.S. Environmental Protection Agency.

James, D.M. 1982. Reclamation/Seeding Checklist. Nature Scape, May.

Johnson, L.C. 1987. Soil loss tolerance: Fact or myth? J. Soil and Water Conservation, 46(3):155-160.

Kanzinger, B. and J. Sparks. 1993. Wetland Compensation Mitigation and Monitoring Plan: Guidelines for Kentucky. Louisville COE, Region IV US Fish and Wildlife Service, Region IV US EPA, KY Division of Water, and KY Department of Fish and Wildlife Resources. ID No. 199300229.

Kentucky Department of Fish and Wildlife Resources, Department of Natural Resources, Division of Forestry, and Department for Surface Mining Reclamation and Enforcement. 1995. Plant Species, Distribution Patterns, Seeding Rates, and Planting Arrangements for Revegetation of Mined Lands. Technical Reclamation Memorandum #21.

Kentucky Department for Surface Mining Reclamation and Enforcement. 1983. Revegetation of Kentucky Surface Mined Lands.

Kentucky Department for Surface Mining Reclamation and Enforcement. 1991. Field sampling techniques for determining ground cover, productivity, and stocking success of reclaimed surface mined lands. Technical Reclamation Memorandum #19.

Kentucky Department of Natural Resources and Environmental Protection, Watkins and Associates, Inc., and C.T. Haan. 1977. Onsite Control of Sedimentation Utilizing the Modified Block-Cut Method of Surface Mining. EPA-600/7-77-068, U.S. Environmental Protection Agency, Office of Research and Development.

Kentucky Department for Surface Mining Reclamation and Enforcement and the U.S. Soil Conservation Service. 1985. Kentucky Prime Farmland Revegetation and Crop Production Restoration After Mining. Frankfort, KY. 4 p.

Kentucky Department for Surface Mining Reclamation and Enforcement. 1990. Kentucky Surface Mining Law KRS Chap. 350.

Kentucky Department for Surface Mining Reclamation and Enforcement. 1992. Permanent Program Regulations for Surface Coal Mining and Reclamation Operations and Coal Exploration Operations.

Kentucky Department of Transportation. 1979. Method for determination of Slake Durability Index. Kentucky Method 64-513-79. Frankfort, KY.

Kentucky Division of Conservation and Division of Water, Natural Resources and Environmental Protection Cabinet. 1985. Kentucky Best Management Practices for Agriculture, Commonwealth of Kentucky, Frankfort, KY, 99 p.

Kentucky Division of Forestry. 1992. Kentucky Forest Practice Guidelines for Water Quality Management. Frankfort, KY. 55 p.

Kentucky Division of Forestry. Kentucky Tree Planting Manual.

Kentucky Division of Water and the U.S. National Park Service. 1992. Kentucky Rivers Assessment. National Park Service, Atlanta, GA. 264 p.

Kentucky Division of Water. 1971. Rainfall Frequency Values for Kentucky. Frankfort, KY. 34 p.

Kentucky Division of Water. 1984. Best Management Practices for Surface Coal Mining. Frankfort, KY. 152 p.

Kentucky Division of Water. 1994. Kentucky Report to Congress on Water Quality.

Kentucky Division of Water. Guidelines for mitigating unavoidable impacts to streams. Frankfort, KY. 11 p.

Kentucky Environmental Quality Commission. 1992. State of Kentucky Environment: A Report of Progress and Problems. Commonwealth of Kentucky, Frankfort, KY. 332 p.

Kim, A.G., B.S. Heisey, R.L.P. Kleinmann, and M. Deul. 1982. Acid Mine Drainage: Control and Abatement Research. U.S. Bureau of Mines, Information Circular No. 8905.

Kleinmann, R.L.P. and P.M. Erickson. 1981. Field Evaluation of a Bactericidal Treatment of Control Acid Drainage. In D. Graves, Proceedings, Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, University of Kentucky, Lexington, KY, p. 325-330.

Kleinmann, R.L.P. 1980. Bactericidal Control of Acid Problems in Surface Mines and Coal Refuse. In D. Graves, Proceedings, Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, KY, p. 333-338.

Kleinmann, R.L.P. and P.M. Erickson. 1982. Full-scale Field Trials of a Bactericidal Treatment to Control Acid Mine Drainage. In D. Graves, Proceedings, Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, KY, p. 617-622.

Knezek B.D. and R.H. Miller (ed.) 1978. Application of Sludges and Wastewaters of Agricultural Lands: A Planning and Educational Guide. U.S. Environmental Protection Agency, Office of Water Program Operations, Pub. 235.

Laflen, J.M., L.J. Lane, and G.R. Foster. 1991. WEPP A new generation of erosion prediction technology. J. Soil and Water Conservation, 46(1):34-38.

Laflen, J.M., W.J. Elliot, J.R. Simanton, C.S. Holzhey, and K.D. Kohl. 1991. WEPP soil and erodibility experiments for rangeland and cropland soils. J. Soil and Water Conservation, 46(1):39-43.

Leedy, D.L. and W.T. Mason, Jr., and C.T. Cushwa. 1981. Coal surface mining reclamation and fish and wildlife relationships in the eastern United States. Vol. I and II. U.S. Fish and Wildlife Service, Washington, D.C.

Libicki, J. 1978. Effects of the Disposal of Coal Waste and Ashes in Open Pits. U.S. Environmental Protection Agency, Office of Research and Development.

Lovell, H. 1973. An appraisal of neutralization processes to treat coal mine drainage. EPA-670/2-73-093.

Madison, C.E. 1992. Tillage and Grass Filter Strip Effects on Sediment and Chemical Losses. M.S. Thesis, University of Kentucky, Lexington, KY, 155 p.

Mihok, E.A., M. Deul, C.E. Chamberlin, and J.G. Selmeczi. 1968. Mine Water Research: The Limestone Neutralization Process, USBM, Report of Investigations No. 7191.

Mining and Reclamation Council of America and Hess and Fisher Engineers, Inc. 1985. Handbook of Alternative Sediment Control Methodologies for Mined Lands. U.S. Department of the Interior, Washington, D.C. 173 p.

Moore, I.D. and J.P. Wilson. 1992. Length-slope factors for the Revised Universal Soil Loss Equation: simplified method of estimation. J. Soil and Water Conservation 47(5):423-428.

Murdock. L.W. and W.W. Frye. 1983. Erosion: Its Effect on Soil Properties, Productivity and Profit. University of Kentucky Extension Service AGR 102.

Myers, C.F., J. Meek, S. Tuller, and A. Weinberg. 1985. Nonpoint sources of water pollution. J. of Soil and Water Conservation, 40(1):14-18.

Nawrot, J.R., A. Woolf, and W.D. Klimstra. 1982. A guide for enhancement of fish and wildlife on abandoned mine lands in the eastern United States. U.S. Fish and Wildlife Service. FWS/OBS-80/67. Washington, D.C. 100 p.

Novotny, V. and G. Chesters. 1989. Delivery of sediment and pollutants from nonpoint sources: A water quality perspective. J. of Soil and Water Conservation, 44(6):568-576.

Ohlsson, K.E., A.E. Robb, Jr., C.E. Guindon, Jr., D.E. Samuel, and R.L. Smith. 1982. Best current practices for fish and wildlife on surface-mined land in the northern Appalachian coal region. U.S. Fish and Wildlife Service. FWS/OBS-81/45. 305 p.

Opeka, T. and R. Morse. 1979. Use of Green-manure Amendments and Tillage to Improve Minesoil Productivity. EPA-600/7-79-257, U.S. Environmental Protection Agency.

Pennsylvania Department of Environmental Resources. 1988. Approval of Constructed Wetlands for the Treatment of Mine Drainage. Program Guidance Document. 4 p.

Pfannenstiel, V., L. Ballek, and J. Krueger. 1993. Utilization of site-adapted containerized plant material for successful woody plant restoration. In Planning, Rehabilitation, and Treatment of Disturbed Lands, Vol. 2, Sixth Billings Symposium, March 21-27, Montana State Univ. Reclamation Research Unit Publ. No. 9301.

Pitt, R., M. Lalor, D.D. Adrian, R. Field, and D. BarbÅ. 1993. Project Summary: Investigation of inappropriate pollutant entries into storm drainage systems: A user's guide. U.S. Environmental Protection Agency, Research and Development, EPA/600/SR-92/238, 5 p.

Powell, J.L., M.L. Ellis, R.I. Barnhisel, and J.R. Armstrong. 1982. Suitability of Various Cool-Season Grass Species for Reclamation of Acid Surface-Mined Coal Spoils of Western Kentucky. In D. Graves, Proceedings, Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, University of Kentucky, Lexington, KY, p. 503-526.

Purvis, A., J.P. Hoehn, V.L. Sorenson, and F.J. Pierce. 1989. Farmers' response to a filter strip program: Results from a contingent valuation survey. J. Soil and Water Conservation, 44(5):501-504.

Rafaill, B.L. and W.G. Vogel. 1978. A Guide For Vegetating Surface-Mined Lands for Wildlife in Eastern Kentucky and West Virginia. USDA Forest Service.

Rasnake, M. and L. Murdock. 1988. Liming acid soils. AGR 19. University of Kentucky, Cooperative Extension Service, Lexington, KY.

Rasnake, M., J. Reid, and J. Henning. 1990. Warm Season Perennial Grasses for Forage in Kentucky. University of Kentucky, Cooperative Extension Service, AGR-145.

Renard, K.G., G.R. Foster, G.A. Weesies, and J.P. Porter. 1991. RUSLE:Revised universal soil loss equation. J. Soil and Water Conservation, 46(1):30-33.

Richards. T.W. 1983. Establishing Trees by Direct-Seeding. Reclamation News and Views, Vol. 1, No. 11, University of Kentucky, Lexington, KY.

Rogowski, A.S., B.E. Weinrich, and R.M. Khanbilvardi. 1990. A nonparametric approach to potential erosion on mined and reclaimed areas. J. Soil and Water Conservation, 45(3):408-412.

Rosso, W.A. 1980. Revegetation Augmentation of Surface Mines with Treated Acid Mine Drainage, EPA 600/7-80-055, U.S. Environmental Protection Agency, Office of Research and Development.

Rowe, J.E. 1979. Coal surface mining: Impacts of reclamation. Westview Press, Boulder, CO. 490 p.

Schadel, A.V., T.B. Koons, and G.W. Root. Soil Erosion and Sedimentation Control Manual. Pennsylvania Department of Environmental Resources, Office of Resources Management, Harrisburg, PA.

Schuman, G.E., E. M. Taylor, Jr., F. Rauzi, and B.A. Pinchak. 1985. Revegetation of mined land: Influence of topsoil depth and mulching method. J. Soil and Water Conservation, March-April, p. 249-252.

Schwab, G.O., D.D. Fangmeier, W.J. Elliot, and R.K. Frevert. 1992. Soil and Water Conservation Engineering. 4th ed. John Wiley & Sons, Inc., N.Y.

Setia, P. and R. Magleby. 1987. An economic analysis of agricultural nonpoint pollution control alternatives. J. Soil and Water Conservation, 42(6):427-431.

Simmons, Li, and Associates, Inc. 1982. Surface Mining Water Division Design Manual, OSM/TR-82/2, U.S. Office of Surface Mining.

Skelly and Loy. 1979. A Compliance Manual. McGraw-Hill, NY, NY.

Skousen, J. 1989. Coal mining effluent limitations. In Proceedings: A Conference on State Surface Mining Regulation. May 1989. Richmond, VA. 8 p.

Smith,, J.W. Jr. 1991. Engineering Manual for Coal Mining Operations. Pennsylvania Department of Environmental Resources. Bureau of Mining and Reclamation. DER No. 540. Harrisburg, PA. 131 p.

Smith, M.S. 1983. Inoculation of Legumes Used in Reclamation. Reclamation News and Views 1(10), University of Kentucky, Lexington, KY.

Smith, M.S., K.L. Wells, and G.W. Thomas. 1981. Fertilization and liming for corn. AGR 105. University of Kentucky, Cooperative Extension, Lexington, KY.

Sobek, A.A., W.A. Schuller, J.R. Freeman, and R.M. Smith. 1978. Field and laboratory methods applicable to overburdens and minesoils. College of Agriculture and Forestry, Univ. of West Virginia, Morgantown, WV.

Sopper, W.E. and D.T. Murray. 1981. City Sludge Heals Strip Mine Scars. Waste Age, September.

Tennessee Department of Agriculture and Department of Forestry. 1993. Guide to Forestry Best Management Practices. 41 p.

Thomas, D. and I. Jansen. 1985. Soil development in coal mine spoils. J. Soil and Water Conservation, 40(5):439-442.

Thom, W.O., K.L. Wells, and L. Murdock. 1992. Taking Soil Test Samples. University of Kentucky, Cooperative Extension Service. AGR -16.

Thom, W.O. 1990. Land Application of Wastewater Treatment Sludge. University of Kentucky, Cooperative Extension Service, AGR-120.

Thom, W.O., K.L. Wells, and L.W. Murdock. 1992. Soil testing: What it Is and What it Does. University of Kentucky, Cooperative Extension Service. AGR-57.

Thom, W.O. 1993. Training Manual for Land Farming Operators. Kentucky Division of Waste Management, Frankfort, KY.

Tollner, E.W., B.J. Barfield, C. Vachirakurnwatana, and C.T. Hean. 1977. Sediment deposition patterns in simulated grass filters. Trans. ASAE, p. 940-944.

Tourbier, T.T. and R. Westmacott. 1980. A Handbook for Small Surface Coal Mine Operators. Water Resources Center, Univ. of Delaware for the U.S. Office of Surface Mining.

Turner, D. and D. McCoy. 1990. Anoxic alkaline drain treatment system, a low-cost acid mine drainage treatment alternative. p. 73-76 In Graves, D. (ed). Proceedings of the National Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, KY, May 14-18, 1990.

University of Kentucky, Cooperative Extension Service. 1993. 1992-93 Lime and Fertilizer Recommendations. AGR-1.

U.S. Bureau of Mines. 1983. Control of Acid Mine Drainage Using Surfactants. Technology News, No. 167.

U.S. Department Agriculture, Forest Service. 1981. A Guide for Revegetating Coal Minesoils in the Eastern United States. Technical Report NE-68.

U.S. Department Agriculture, Forest Service. 1983. Growth-Limiting Soil Bulk Densities as Influenced by Soil Texture. WSDG Report TN-00005. Dadow and Warrington.

U.S. Department Agriculture, Soil Conservation Service. 1987. Estimated Crop Yields on Prime Farmland Soils in Western Kentucky Coalfields. KY TP-2. 9 p.

U.S. Department Agriculture, Soil Conservation Service. 1985. Estimated crop yields on prime farmland soils in eastern Kentucky Coalfields. KY TP-2. Lexington, KY. 10 p.

U.S. Department Agriculture, Soil Conservation Service. Predicting Rainfall Erosion Losses. Agricultural Handbook AH 537.

U.S. Department of Agriculture, Soil Conservation Service. 1980. Mine Soil Classification and Use: A Kentucky Guide for Vegetative Treatment. Lexington, KY.

U.S. Department of Agriculture, Soil Conservation Service. 1984. Engineering Field Manual for Conservation Practices. Washington, D.C.

U.S. Department of Agriculture, Soil Conservation Service. 1986. Soil Conservation Service Kentucky Standard and Specifications for Land Restoration, Currently Mined Prime Farmland.

U.S. Environmental Protection Agency. 1981. NPDES Best Management Practices Guidance Document. Office of Water Enforcement and Permits, NPDES Technical Support Branch, 34 p.

Ventura, J.D., J.R. Sefton, and M.K. Robinson. 1983. Durable Rock Fills. National Symposium on Surface Mining Hydrology, and Sedimentology, and Reclamation, Lexington, Kentucky, 28 November.

Vining, K.C. and S.A. Schroeder. 1993. Compaction amelioration on soil properties and crop yields from reclaimed minesoils. In Planning, Rehabilitation, and Treatment of Disturbed Lands, Vol. 1, Sixth Billings Symposium, March 21-27, Montana State Univ. Reclamation Research Unit Publ. No. 9301, p. 273-281.

Virginia Soil and Water Conservation Commission. 1980. Virginia Erosion and Sediment Control Handbook.

Vogel, W.G. 1981. A Guide for Revegetating Coal Minesoils in the Eastern United States, USDA Forest Service.

Wahler, W.A. and Associates. 1978. Pollution Control Guidelines For Coal Refuse Piles and Slurry Ponds. U.S. Environmental Protection Agency, Office of Research and Development.

Wang, S. and K. Grubbs. 1990. Tennessee Erosion and Sediment Control Handbook: A Guide for Protection of State Waters Through Effective Management Practices During Construction Activities. Tennessee Department of Health and Environment, 65 p.

Warner, R.C. and P.J. Schwab. 1992. SEDCAD^{+} Version 3 Training Manual. Civil Software Design, Ames, IA.

Weigle, W.K. 1965. Designing Coal-Haul Roads for Good Drainage. USDA Forest Service, Central States Forest Experiment Station.

Wells, K. 1978. When to apply lime and fertilizer. AGR 5. University of Kentucky, Cooperative Extension, Lexington, KY.

West Virginia Department of Natural Resources. 1975. Drainage Handbook for Surface Mining.

West Virginia Mining & Reclamation Association. 1989. Handbook for use of ammonia in treating mine waters. 28 p.

Williams, R.D. and A.D. Nicks. 1988. Using CREAMS to simulate filter strip effectiveness in erosion control. J. Soil and Water Conservation, 43(1):108-112.

Wilmoth, R. 1978. Combination Limestone-Lime Neutralization of Ferrous Iron Acid Mine Drainage, EPA-600/2-78-002, U.S. Environmental Protection Agency.

Wittwer, R.F., S.B. Carpenter, and D.H. Graves. 1980. Effects of Hardwood Bark, Wood Fiber and Straw Mulches and Temperature and Moisture Content of Mine Spoils. In D. Graves, Proceedings, Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, University of Kentucky, Lexington, KY, p. 193-198.

Young, C.E. and J.S. Shortle. 1989. Benefits and costs of agricultural nonpoint-source pollution controls: The case of St. Albans Bay. J. Soil and Water Conservation, 44(1):64-67.

Zurbuch, P.E., R. Mendez, and J.L. Clayton. 1993. Dogway Fork Acid Precipitation Mitigation Project. Final Report. West Virginia, Wildlife Resources Section/U.S. Fish and Wildlife Service.

GLOSSARY

GLOSSARY

A -- Acre.

Acid drainage -- Water with a pH of less than 6.0 and total iron greater than 10.0 mg/l.

Acid producing-acid forming -- A substance that causes an acid reaction that lowers the pH of the spoil material. This is usually caused by a sulfide mineral or minerals; e.g., pyrite or marcasite FeS_2. The spoil may not be acid when first exposed during mining but may become acid as the sulfide minerals are exposed to weathering by water and air.

Acid soil -- Root zone soil with a pH less than 7.0; a "sour" soil. Usually not a serious problem until a pH less than 5.8 occurs.

Acre-foot (ac-ft) -- Term used in measuring water volume, equal to the quantity required to cover 1 acre, 1 foot deep, or 43,560 cu. ft.

Act -- Surface Mining Control and Reclamation Act of 1977, also known as Public Law 95-97. Commonly referred to as SMCRA.

Adjacent area -- Land located outside the affected area or permit area, depending on the context in which "adjacent area" is used, where air, surface or ground water, fish, wildlife, vegetation or other resources protected by KRS Chapter 350 may be adversely impacted by surface coal mining and reclamation operations.

Aerobic bacteria -- Types that need oxygen to live.

Affected area -- Any land or water area that is used to facilitate, or is physically altered by, surface coal mining and reclamation operations. The affected area includes the disturbed area; any area upon which surface coal mining and reclamation operations are conducted; any adjacent lands the use of which is incidental to surface coal mining and reclamation operations; all areas covered by new or existing roads used to gain access to, or for hauling coal to or from, surface coal mining operations, except as provided in this definition; any area covered by surface excavations, workings, impoundments, dams, ventilation shafts, entryways, refuse banks, dumps, stockpiles or depressions, repair areas, storage areas, shipping areas; any areas upon which are located structures, facilities, or other property or material on the surface resulting from, or incident to, surface coal-mining and reclamation operations; and the area located above the underground mining activities, auger mining, or in-situ mining. The affected area shall include every road used for the purposes of access to, or for hauling coal to or from, surface coal-mining and reclamation operations unless the road:

(a) Was designated as a public road pursuant to the laws of the jurisdiction in which it is located;
(b) Is maintained with public funds and constructed in a manner similar to other public roads of the same classification within the jurisdiction; and
(c) There is substantial (more than incidental) public use.

Alkaline soil -- Root zone soil having a pH greater than 7.0; a "sweet" soil. Usually not a problem until the pH exceeds 8.5

Anaerobic bacteria -- Types that do <u>not</u> need oxygen to live and grow best when it is absent.

Annual plant -- Plant that completes its life cycle and dies in one year or less.

Anthracite coal -- A hard black vitreous coal containing a high percentage of fixed carbon and a low percentage of volatile matter. Occurs primarily in eastern Pennsylvania.

Anti-seep collar -- A metal, plate-like collar welded around a buried principal spillway conduit pipe to prevent or reduce pond water seepage through the dam.

Anti-swirl plate -- Flat plate welded upright atop a riser pipe to prevent whirlpools.

Anti-vortex plate -- See Anti-swirl plate.

Approximate original contour (AOC) -- That surface configuration achieved by backfilling and grading of the mined area so that the reclaimed area, including any terraces or access roads, closely resembles the general surface configuration of the land prior to mining and blends into and complements the drainage patterns of the surrounding terrain, with all highwalls and spoil piles eliminated; water impoundments may be permitted where the Cabinet determines that they are in compliance with KRS 350.455.

Aquifer -- A zone, stratum, or group of strata that can store and transmit water in sufficient quantities for domestic, agricultural, industrial, or other beneficial use.

Area mining-area stripping -- Open cut or pit surface mining that is carried on the level or along the prevailing topography in which relatively large tracts are disturbed, usually mined with large shovels or draglines.

Arid or semiarid -- Land west of the 100th meridian west longitude, experiencing water deficits. Average annual precipitation of less than 26 inches. Regulations follow a different time schedule with respect to bond release.

Aspect -- Direction a slope faces as a cardinal direction (N, S, E, or W).

Auger mining -- Mining of coal from an exposed vertical cut, usually created by contour stripping, in which an auger forces the coal out of coal bed like a brace-and-bit is used in wood.

Available nutrient -- Soil nutrient that can be used by plants for growth. Common nutrients include nitrogen, phosphorus, potassium, calcium, magnesium, etc.

Available water -- Water in the soil that can be used by plants for growth. In general, it is the water in soils/spoils retained between wilting point and field capacity.

Back-blade -- To drag the blade of a bulldozer as the machine moves backward as opposed to pushing the blade forward. Used in final grading or smoothing spoils or soils.

Back-fill -- Place spoil materials back into area that had been excavated to a predetermined slope.

Back-hoe -- A loader on rubber-tired tractor. Used to load soil into trucks or to dig pits or holes.

Background level -- Natural or normal water quality before mining.

Base flow -- Fairly steady part of stream flow that comes from groundwater.

Bed load -- Sediment that rests or is carried along on the stream bottom.

Bedrock -- Solid rock that lies beneath the soil and weathered rock.

Bench -- The surface of an excavated area created as the result of mining or in the preparation for mining. More commonly used to describe a more or less level surface in mountainous mining provinces. This surface is commonly located below the highwall and may be used to describe the area on which the haul road is located, etc.

Berm -- Earthen mound along the outside edge of a road, the top of an embankment or spoil pile, or a diversion.

Best technology currently available -- Equipment, methods, or techniques that will prevent water pollution as much as possible. The term includes construction practices, site requirements, scheduling of activities and design of sedimentation ponds which are currently available, even if they are not in routine use. DSMRE may decide what is best technology currently available on a case-by-case basis.

Biennial plant -- Plant that takes two years to complete its life cycle.

Bituminous coal -- A middle rank coal occurring between lignite and anthracite. Usually has a high volatile content and a high BTU or heat content. This is the type of coal mined in Kentucky.

Black water -- Water carrying a heavy load of suspended coal particles.

Block cut method -- Method of surface mining where overburden is removed and placed around the edges of a box-shaped cut. After coal is removed, the spoil is pushed back into the cut and the surface is blended into nearby areas.

Box cut method -- Area mining method where a box-like excavation is made to the coal, and the seam is worked to the right and left.

Breakthrough -- Punching through into an underground mine by strip or auger mining.

Broadcast seedling -- Scattering seed on top of the soil. Compare to Drill Seeding.

Brush matting -- Brush wired together and staked onto stream banks to protect them from erosion.

BTU-British Thermal Unit -- Amount of heat required to raise the temperature of one pound of water 1 degree F.

Buffers -- Substances in soil or water that act chemically to neutralize acidity thus resisting changes in pH.

Bulk density -- See moist bulk density.

Bulking factor -- Proportion of extra space spoil fills after it has been stripped.

Canopy -- Cover over the land provided by leaves of trees or other plants.

Cast overburden -- A bank or deposit of overburden (spoils), which has been removed during surface mining process.

CFS -- Cubic feet per second, a measure of water flow.

Channel stabilization -- Erosion prevention using riprap and/or vegetation.

Chiseling -- Operation to loosen spoil that creates parallel slots on the contour in the soil or spoil surface to reduce overland water flow and increase infiltration.

Clay -- Firm, fine-grained earth that is plastic when wet. It has a diameter of less than 0.002 mm.

Closed drainage system -- Small watershed shaped so all runoff flows to one water body within the watershed.

Coal exploration -- Field gathering of surface or subsurface geologic, physical, or chemical data by mapping, drilling, trenching, etc., to determine quality and quantity of overburden or coal.

Coal seam-coal bed -- A layer, vein, or deposit of coal. Usually needs to be a single layer at least 24" thick to be economical to mine,and this depends on overburden thickness and coal quality.

Combustible material -- Organic material that can be burned.

Compaction -- Increasing the density of a material by reducing the voids between particles. Excessive soil or spoil compaction may cause serious reductions in plant growth or crop yields.

Concentration -- Amount of a pollutant in a given amount of water. Common units are parts per million (ppm) and milligrams per liter (mg/l).

Condensation trap -- Plastic sheet placed over a tree seedling. A center hole allows the plant to grow through. The sheet collects condensed moisture, which trickles down, watering the plant.

Conifer -- "Softwood" tree, usually evergreen, with cones and needles.

Contour -- On a map or diagram, a line connecting points of equal elevation.

Contour stripping or mining -- The removal of overburden and mining the coal seam that approaches the surface at the same elevation in steep or mountainous areas. Resembles a contoured terrace that goes around the hill or mountain.

Copperas water -- Water containing ferrous sulfate, usually green but when oxidized will turn reddish-brown as a result of ferric oxide material. The latter is usually a suspension rather than solution. Doesn't usually contain copper.

Cool season cover crop -- Crop that grows mainly in cold weather and is planted to protect the soil from erosion until the permanent vegetation can be planted.

Creep -- Slow movement of a mass of soil, acting under the force of gravity. A creep is much smaller and shorter than a landslide.

Crest -- Top of a spillway to where water must rise before flowing over it.

Cropland -- Land used for production of adapted crops for harvest, alone, or in a rotation with other crops, grasses, and/or legumes. Usually this type of land is the better farmland. It may or may not be synonymous with prime farmland. All prime farmland is cropland, but the reverse may not be true. Prime farmland must be restored to the same productivity it had prior to mining.

Crossfall -- Slope across the width of a roadbed.

Crust -- Surface layer of a soil that becomes hard when dried. It reduces the water infiltration rate and may restrict seed emergence.

Culvert -- Conduit for the free flow of runoff under a road or dam embankment.

Cut -- A longitudinal excavation made by a surface mining machine to remove the overburden in a single progressive line from one side to the other side of the property. A cut usually refers to one pass of the mining machine.

Cutoff trench -- Long, narrow trench dug along the upstream side of a dam's center line or length. It is often dug down to the bedrock.

Deciduous -- A type of tree that generally sheds all its leaves every year in the fall.

Deep mining-underground mining -- The opposite of surface mining to remove product without significantly disturbing the surface except near mine portal or other openings such as air shafts.

Detention time -- The time in hours that runoff is in a sediment pond, to allow sedimentation prior to its removal through a spillway.

Dewater -- To drain off or pump out water from a pit or sediment pond.

Dibble -- A pointed tool used to make a hole in which to plant a tree seedling.

Disturbed area -- A vegetated area upon which topsoil or overburden is removed or upon which topsoil, spoil, coal processing waste, underground development waste, or non-coal waste is placed by surface coal mining operations. Those areas are classified as "disturbed" until reclamation is complete and the performance bond or other assurance of performance required by 450 KAR Chapter 10 is released.

Down cutting -- Stream channel erosion; may eventually erode down to bedrock.

Downslope -- Area downhill from the point under consideration.

Dozer -- Bulldozer or tractor equipped with a blade or steel plate on the front end so that it may be used to push earth or spoils or other mining equipment primarily in the forward direction. It may be on tracks or rubber tires.

Dragline -- An excavating machine that uses a bucket operated and suspended by cables and a boom. The bucket is dragged back to the machine along the surface and usually operates from the highwall or above the area in which soil or spoil is being removed.

Drainage basin -- See watershed.

Drill -- A machine with a rotating bit used to drill holes in overburden materials. In the case of rock, these holes are partially filled with explosives for loosening up the rock to be removed in mining.

DSMRE -- Department for Surface Mining Reclamation and Enforcement, which is within the Kentucky Natural Resources and Environmental Protection Cabinet.

Dugout pond -- Sediment ponds built by digging a pit in the ground.

Ecology -- Science that deals with the relationships of plants and animals (including humans) to one another and to their environment.

Ecosystem -- Self-supporting natural system of living organisms and their environment.

Effective precipitation -- Water that infiltrates into the soil or spoils and is eventually used by plants or passes into the ground water.

Effluent -- Water flowing out of the ground, pond, or pipe.

End-loader -- A large machine with a bucket, which is used to move or load soil, spoils, coal, or other materials into trucks.

Engineer -- Someone trained in engineering science and technology, and registered as a Kentucky-licensed Professional Engineer (P.E.).

Environment -- All external conditions that affect living things, such as soil, sunlight, temperature, moisture, and other organisms.

Ephemeral stream -- One that flows only during and after a storm or snowmelt.

Erodibility -- Relative ease with which a soil erodes compared to other soils.

Essential element -- Nutrient required for the normal growth of plants or animals.

Evapo-transpiration -- Loss of water to the atmosphere from both evaporation and transpiration by vegetation.

Ferric iron -- Form of iron (Fe^{+3}) that causes red, yellow, and brown colors in soils and water.

Fertility -- Soils ability to produce crops.

Fertilizer grade -- Guaranteed minimum (in percent) of the major plant nutrients contained in a fertilizer. For example, a fertilizer with a grade of 20-10-5 contains 20 percent nitrogen (N), 10 percent available phosphorus (P), and 5 percent available potassium (K). Micro-nutrients may also be included.

Filter cloth -- Plastic cloth that water can pass through, but most sediment cannot. It is used in constructing silt fences and riprap filters.

Flora -- The plants of an area.

Flushout -- Water suddenly removed from mine pits by heavy rain.

Flyash -- Non-burnable remains left after coal is burned, usually precipitated from gases exhausted from power plants.

Forage -- Plants grown mainly for hay, silage, or green feed.

Forest land -- Land used or managed for the long-term production of wood, wood fiber, or wood products. Land used for support facilities is also included.

Fragile lands -- Geographic areas containing natural, ecologic, scientific, or aesthetic resources that could be damaged or destroyed by surface coal mining or other activities or operations.

Freeboard -- Distance between the maximum water level during peak storm events and the top of a dam or diversion. It is provided to prevent overtopping.

French drain -- Generally 2-inch minus rock wrapped in geotextile filter cloth and placed in an excavated ditch that is then covered with earth.

Geology -- Science that deals with the rocks of the Earth.

Germination -- Sprouting; beginning of seed growth. Normally not complete until the seedling is emerged from the soil.

Gob -- Waste coal, rock, slate, etc., from coal processing plants. It often contains a high amount of sulfide-bearing materials that cannot be pumped without crushing to refuse disposal site. It is the material from the breaker or the first phase of coal preparation that breaks the coal into lumps 2-3 inches and smaller.

Gouging -- Roughening method, which leaves very small dips in the soil surface that trap runoff so it can soak into the ground instead of eroding it.

Grassed waterway -- Machine-made, broad and shallow channel, planted with erosion-resistant grasses, used to carry runoff from one place to another.

Greasy spots -- see hot spoils.

Green manure -- Crops grown and plowed under to enrich the soil. Examples include sweet clover and buckwheat.

Ground cover -- Any vegetation providing a protective mat on the soil surface.

Ground water -- Subsurface water that fills openings in rock or soil materials to an extent that they are considered water saturated.

Growing season -- Season that, in general, is warm enough for the growth of plants. The extreme limits are from the average dates of the last killing frost in spring to the first killing frost in autumn.

Grub -- To clear by digging up roots and stumps.

Grubbing -- Operation of removing stumps and roots.

Gully erosion -- Soil removal by running water, leaving channels (usually deeper than 9 inches) that cannot be smoothed out completely by normal tillage.

Habitat -- Region where a plant or animal naturally grows or lives.

Hard rock spoil -- Fill material consisting of at least 80 percent (by volume) of sandstone, limestone, or other rocks that do not crumble in water.

Hardpan -- Hard layer of soil surface, which reduces plant and water movement within the soil. It is usually caused by working the soil when it is too wet and is 1 to 2 feet below the soil surface.

Harm to land, air, or water resources -- An environmental harm is an adverse impact on land, air, or water resources. It is "imminent," if a condition or violation exists that is causing such harm or may be expected to do so. An environmental harm is "significant" if that harm is appreciable and not immediately repairable.

Haul road -- Road from pit to loading dock, tipple, ramp or preparation plant. More commonly referred to gravel or shale roads designed for "off" road trucks.

Haulback method -- Overburden is hauled by a truck along the bench and then backfilled against highwall.

Hazard classification of impoundments -- The design engineer determines the class based on both current and future hazards using the following guidelines:

Class A, Low Hazard -- failure would cause little or no damage to other property.

Class B, Moderate Hazard -- failure would cause significant damage to other property but no loss of human life.

Class C, High Hazard -- failure would cause loss of life or serious damage to homes, industrial or commercial buildings, important public utilities, main highways, or major railroads.

Head -- Top of a slope, roadcut, embankment, pile or fill. Compare with Toe.

Head-of-hollow-fill -- A fill structure of any material except coal processing waste and organic material, placed in the uppermost reaches of a hollow. Used to dispose of excess spoils due to need for leaving bench for roads or for mountain top removal.

Herbaceous -- Plant with little or no woody above-ground stem.

Highwall -- The face of exposed overburden and coal in an open cut of a surface mining activity or for entry to underground mining activities.

Historic lands -- Historic or cultural districts, places, structures, objects, including archaeological and paleontological sites.

Historically used for cropland --

(a) Any land that has been used for cropland any 5 or more of the last 10 years immediately preceding:
   1. The application or
   2. The acquisition of the land for the purpose of conducting surface coal mining and reclamation operations.

(b) Lands meeting either paragraph (a)1 or paragraph (a)2 of this definition shall be considered "historically used for cropland."

(c) In addition to the lands covered by paragraph (a) of this definition, other lands shall be considered "historically used for cropland" as described below:
   1. Lands that would likely have been used as cropland for any 5 out of the last 10 years immediately preceding the acquisition or the application but for some fact of ownership or control of the land unrelated to the productivity of the land; and
   2. Lands that the Cabinet determines, on the basis of additional cropland history of the surrounding lands and the lands under consideration, are clearly cropland but fall outside the specific 5 years in 10 criterion.

(d) Acquisition includes purchase, lease, or option of the land for the purpose of conducting or allowing through resale, lease, or option the conduct of surface coal mining and reclamation operations.

Hot -- Refers to overburden or gob material able to either burn on its own or produce acid mine drainage.

Hot spoils-greasy spots-hot spots -- Acid spoils, overburden or gob piles, in the latter case, when enough coal is present it is capable of spontaneous ignition. Areas or materials appear wet from condensation of water in association with sulfuric acid generated by the sulfide in material having undergone oxidation.

Hydrology -- The study of water and its behavior from both a physical and chemical viewpoint, its locations underground and on the surface, and the water cycle of evaporation, precipitation, etc.

Hydroseeding -- Sowing seed mixed into a water spray with or without mulch, lime, and fertilizer.

Imminent danger to the health and safety of the public -- The existence of any condition or practice, or any violation of a permit or other requirements of KRS Chapter 350 in a surface coal mining and reclamation operation, which could reasonably be expected to cause substantial physical harm to persons outside the permit area before the condition, practice, or violation can be abated. A reasonable expectation of death or serious injury before abatement exists if a rational person, subjected to the same condition or practice giving rise to the peril, would avoid exposure to the danger during the time necessary for abatement.

Impervious -- Does not allow fluid or air flow. Some clay soils when evaporated may be impervious to water.

Impoundment -- A closed basin that is dammed or excavated for retention of water, sediment, or waste.

Infiltration -- Water soaking into the soil, into the ground water system.

Inlet -- Upstream end of a pond or pipe through which water passes.

Intermittent stream -- Stream or part of a stream that: (1) drains a watershed of one square mile or more but does not flow nonstop year-round or (2) is below the local water table at least some part of the year and obtains its flow from both surface runoff and groundwater discharge.

Jute -- String fiber used for making burlap and erosion-control netting.

KAR -- Kentucky Administrative Regulation.

Kentucky Small Operator Technical Assistance Project -- Kentucky Department of Energy program which checks permit applications for operators mining under 200,000 tons per year. (Not to be confused with SOAP.)

KPDES -- Kentucky Pollutant Discharge Elimination System.

KRS -- Kentucky Revised Statutes

L- Liter, a metric unit measure of volume (about 0.95 quarts).

Land use -- Specific functions, uses, or management-related activities of an area. May be identified in combination when joint or seasonal uses occur and may include land use for support facilities that are an integral part of the use. In some instances, a specific use can be identified without active management.

Lands Unsuitable for Mining Program (LUMP) -- DSMRE program dealing with petitions seeking protective status of certain sites as unsuitable for some or all coal mining.

Land farming -- Land farming is the application of wastes on or just below the surface of the land.

Landslide -- Sliding of a large mass of wet or dry soil.

Latitude -- Distance north or south from the Equator as measured in degrees, minutes, and seconds on a map.

Lbs/day -- Pounds per day. When used in water quality testing, it refers to a measure of the amount of a pollutant carried in water.

Leach -- To move water through a material as to leach out salts. Such liquid may reappear as surface water down slope.

Legume -- Nitrogen-fixing plants that provide an important source of nutrient in revegetation. The legume family includes many valuable food and forage species, such as peas, beans, peanuts, clover, alfalfa, lespedeza, and vetch.

Lignite -- A brownish-black coal in which the alternation of vegetal material has progressed further than peat but not so far as bituminous. Usually this coal has a low BTU but is also low in sulfur. Coal commonly mined in Texas, Louisiana, and North Dakota.

Litter -- Organic debris (leaves, twigs, manure, etc.) lying on the soil or spoil surface.

Load -- Amount of pollutant carried by water generally expressed in (lbs/day) or (mg/l).

Loam -- Fertile soil made of clay, silt, sand, and organic matter.

Loess -- Soil made of fine primarily wind-blown silt.

Long ton -- 2240 pounds of weight.

Longitude -- Distance east and west along the Equator, between the meridian passing through a site and the Greenwich meridian. Measured in degrees, minutes, and seconds on a map.

Longwall -- An underground mining method that extracts large blocks of wall 400'-1000' wide and 1000'-5000' long with planned collapse of overbearing rock or soil.

Macro-invertebrate -- Living creature that can be seen without a microscope and does not have a backbone and is retained by a No. 30 U.S. sieve. Aquatic macro-invertebrates include aquatic insects, mollusks, flatworms, roundworms, and crustaceans.

Macro-nutrients -- Most important plant nutrients: nitrogen, phosphorus, potassium, calcium, and magnesium.

Mattress -- See Brush Matting.

Meridian -- Imaginary line around the earth passing through the north and south poles.

Metric ton -- 2205 pounds of weight.

mg -- Milligram, a metric unit of weight (one thousandth of a gram).

mg/l -- Milligram per liter, used in water quality testing to measure the weight of a pollutant in one liter of water.

MGD -- Millions of gallons per day, a unit of flow rate.

Micro-invertebrate -- Living creature that can be seen only with the aid of a microscope and does not have a backbone.

Micro-organism -- Plant or animal that can be seen only with a microscope.

Micro-nutrients -- Plant nutrients required in only small or trace amounts. Some examples are iron, manganese, copper, and zinc. Compare with macro-nutrients.

Moist bulk density -- Weight of oven-dry soil per unit volume in which volume is measured when soil is at field capacity. Measure of soil compaction and expressed as grams per cubic centimeter (g/cc).

Mollusks -- Animal group including oysters, clams, mussels, and snails.

Mountain top removal -- A mining method in which the top of the mountain or ridge is flattened in the process of mining. The excess spoil is placed in approved areas such as head-of-the-hollow fills.

Mulch -- Usually a vegetation residue or organic material that aids in soil stabilization and soil moisture conservation.

Natural revegetation - Establishment of new plants over an area without the benefit of seeding.

Neutralization -- Addition of an acid or base material to water or soil to adjust it to the neutral pH of 7.

Neutral soil -- Root zone soil that is neither acid nor alkaline. For most mining purposes, soil with a pH ranging from 6.6 to 7.3 is considered neutral.

Nitrogen fixation -- Conversion of nitrogen gas in the air to nitrogen soil nutrient by nitrogen fixing plants such as legumes. Other plants can then use that nitrogen.

Noncompliance -- Violation of surface mining laws, regulations, or permit conditions.

Non-point source -- Diffuse sources of pollution not regulated under the KPDES program. A dusty field or an eroding hillside are examples.

Nutrient -- Any element used by a plant for healthy growth.

Organic matter -- Decaying animal and plant material in the soil.

Orphan spoils-orphan banks-abandoned land -- Areas mined or disturbed as the result of surface mining that were abandoned or not planted to vegetation or otherwise successfully reclaimed. Usually applies to pre-law mining operations but also could apply to land for which the bond was forfeited.

Outcrop -- Natural exposure of rock or coal which occurs at or near the surface.

Outslope -- Face of the spoil or embankment sloping downward from the highest elevation to the toe.

Overburden -- Material of any nature, consolidated or unconsolidated, excluding topsoil, which lies above a natural deposit of coal. Also means the material after removal from its natural state in the process of coal mining.

Parent material -- Material from which the soil above it develops. It may be rock or unconsolidated materials. Also referred to as the C horizon.

Peat -- An unconsolidated deposit of semi-carbonized plant remains of a water saturated environment such as a bog. Very low BTU and sulfur content. Rarely used in the U.S. as an energy source.

Perched water -- Water-saturated zone of a relatively impermeable layer of soil or rock that overlies an unsaturated zone.

Percolation -- Water passing through porous soil or spoil materials by gravity.

Perennial plant -- Plant that lives longer than two years. Compare with annual plants and biennial plants.

Perennial stream -- Stream that flows all year around.

Performance bond -- Surety, collateral, or self bond or combination thereof by which a permittee assures faithful performance of the surface mining regulations.

Permeability -- Rate of fluid flow through a porous soil or spoil.

Permit -- Written approval issued by the Cabinet to conduct surface coal mining and reclamation operations.

Permit area -- The land and water within boundaries designated in the approved permit application, which shall include, at minimum, all areas that are or will be affected by surface coal mining and reclamation operations under that permit.

pH -- The symbol or term referring to the acidity or alkalinity of a material. The negative log of the H ion concentration.

Photosynthesis -- Natural process by green plants which converts CO_2 and H_2O in the presence of sunlight into food energy.

Pit -- A specifically describable area of open cut or surface mining from which coal is being actively removed or the entire continuous mined area.

PL 95-87 -- Federal 1977 Surface Mining Reclamation and Control Act (SMRCA).

Point source -- Water pollution source which flows into water from a restricted source and is regulated under the KPDES program. A sediment pond spillway and sewage treatment plant effluent pipe are point sources.

Porosity -- Ratio of open space or pore volume to total volume of rock, soil, or spoil.

Potential Acidity -- The potential to produce acidity in spoils after oxidation of sulfides has occurred. The total potential acidity is the potential acidity plus the free acidity of the spoil.

Pounds/day -- See lbs/day.

Pre-law -- Term used to refer to a surface coal mining operation begun mine stripped before the states first comprehensive reclamation law was passed in 1977.

Precipitation -- Water in the form of rain, sleet, or snow.

Preparation plant -- Operations to process coal, including sizing and removal of minerals or other materials such as pyrite and shale.

Prime farmland -- Lands designated by the Secretary of Agriculture as prime farmland, which have historically been used for cropland.

Public Law 95-87 -- See PL 95-87.

Pyrite -- A yellowish mineral, FeS_2, metallic in appearance - fools gold, found naturally in and near coal.

RA -- Regulatory authority.

Raw coal -- Coal that has not been processed.

Recharge capacity -- Ability of the soils, spoils, or underlying porous materials to allow rainfall and snowmelt to seep down and fill these pore spaces until saturated.

Reclamation -- The reconditioning of the area affected by surface coal mining operations under a plan approved by the Cabinet.

Red dog -- Material in a gob pile after it has burned.

Reference area -- A land unit maintained under appropriate management for the purpose of measuring vegetative ground cover, productivity, and plant species diversity that is representative of the geology, soil, slope, and vegetation of the permit area.

Refuse pile -- A surface deposit of coal-mine waste that is not retained by an impounding structure and does not impound water, slurry, or other liquid or semi-liquid material.

Reserve -- Portion of the coal deposit that can be economically and legally mined.

Retention -- Amount of precipitation over a drainage area that does not escape as runoff, equal to the difference between the total precipitation and total runoff.

Reverse osmosis -- Process that removes impurities or pollutants of water via diffusion through membranes under pressure.

Revetment -- Bankside layer of stone riprap or staked brush mats that protect the bank from erosion.

Rhizomes -- Horizontal underground stem or rootstalk.

Rider coal seam -- A "stray" coal seam usually above the main coal bed separated by shale or other strata. This seam is generally thin and seldom marketable over large areas unless associated with a thicker coal seam. Often not named on geologic maps.

Riffles -- Shallow sections of stream bottoms where water flows quickly over stones and gravel.

Rill -- Channels left by erosion that can be removed with normal tillage. Rills become gullies as the soil or spoil continues to erode.

Ripping -- Use of large shanks behind a dozer or tractor to either loosen rock or compacted soil or spoils in the process of mining or reclamation.

Riser -- Vertical pipe of a principal spillway.

Rock core chimney drain -- Rock column, toe-to-head and base-to-surface, within a fill that is used to transmit drainage water through a head-of-hollow fill.

Rock dust -- Finely ground limestone used to coat the walls of underground coal mines to reduce hazards of explosions from coal dust.

Rooms -- Refers to the dimensional mined-out areas in underground mine networks.

Safety factor -- Ratio = (total resisting forces)/(total loading driving forces), as determined by accepted engineering practices by a registered engineer.

Sand -- Mineral matter with grain diameter in the range 0.02 mm to 2 mm.

Sandstone -- A medium-grained sedimentary rock of abundant fragments of sand with a matrix of silt, and other cementing agents.

Saturation -- The point at which all the pore space of a soil or spoil is filled with water so that it can no longer absorb any more water.

Scour -- Quick and severe channel eroding action.

Scraper pan -- Large off-road, rubber-tired vehicle used to remove, transport, and deposit soil or spoils during mining.

SCS -- U.S. Department of Agriculture Soil Conservation Service. Recently renamed the Natural Resources Conservation Service NRCS.

Sediment -- Soil and rock material transported by water, gravity, or wind.

Sediment storage -- Volume within sediment pond where sediment collects.

Sedimentation -- A primary sediment control structure designed, constructed, and maintained in accordance with 405 KAR 16:090 or 405 KAR 18:090 and including but not limited to a barrier, dam, or excavated depression that slows down water runoff to allow suspended solids to settle out. A sedimentation pond shall not include secondary sedimentation control structures, such as straw dikes, riprap, check dams, mulches, dugouts, and other measures that reduce overland flow velocity, reduce runoff volume, or trap sediment to the extent that the secondary sedimentation structures drain to a sedimentation pond.

Sedimentation pond -- A primary sediment control structure. May also serve as a water source in mining; i.e., dust control for surface mines.

Seep -- Poorly defined area where water oozes from the earth in small quantities.

Seepage -- Slow movement or percolation of water through small cracks or pores in unsaturated soil or overburden, ending in a body of surface or subsurface water.

Shale -- Sedimentary or stratified rock material generally formed from clay or clay-like material -- silt stone is often included with clay shale.

Sheepsfoot rollers -- Heavy, spiked roller used for compaction of spoil materials during road or dam construction.

Short ton -- 2,000 pounds of weight.

Shot -- An explosion or blast used to loosen rock for mining. The explosive commonly used is a mixture of ammonium nitrate and diesel fuel.

Shovel -- Machine used to excavate for coal or loading of coal. Bucket is loaded from the top and has a bottom that is opened for emptying the contents.

Silt -- Small mineral soil with grains in the 0.02 mm to 0.002 mm diameter range.

Slag -- See Refuse pile.

Slake -- To crumble when covered or soaked by water.

Slash -- Vegetation stripped after timber has been cut and before scalping.

Slate -- Fine-grained rock, often black, and tending to split along cleavage planes resulting in flat rocks. Usually found above and next to some coal beds.

Slip -- See Creep.

Slope stability -- Resistance of a slope to sliding or collapsing.

Sludge -- Loose solid from sedimentation or chemical treatment of water.

Sludge density -- Weight of solids in sludge as a percent of the total weight.

Slump -- Sudden, but small, slide of spoil, topsoil, etc.

Slurry -- Refuse from a coal preparation plant that is pumpable. Contains fine-grained coal, as well as soil or shale sedimentary material.

Small operator -- As used in 405 KAR 7:080, means an operator whose combined actual and attributed production of coal does not exceed 300,000 tons during any period of 12 consecutive months.

Small Operator Assistance Program (SOAP) -- DSMRE program that pays fees for the pre-mining testing and provides regional background data needed to get a permit.

SMIS -- See Surface Mining Information System.

SOAP -- See Small Operator Assistance Program.

Soil horizons -- Contrasting layers of soil parallel or nearly parallel to the land surface. Soil horizons are differentiated on the basis of field characteristics and laboratory data. The 4 master soil horizons are:

- A horizon -- The uppermost mineral layer, often called the surface soil. It is the part of the soil in which organic matter is most abundant, leaching of soluble or organic matter is most abundant, and leaching of soluble or suspended particles is typically the greatest.
- E horizon -- The layer commonly near the surface below an A horizon and above a B horizon. An E horizon is most commonly differentiated from an overlying A horizon by a lighter color and generally has measurably less organic matter than the A horizon. An E horizon is most commonly differentiated from an underlying B horizon in the same sequum by color of higher value or lower chroma, by coarser texture, or by a combination of these properties.
- B horizon -- The layer that typically is immediately beneath the E horizon and often called the subsoil. This middle layer commonly contains more clay, iron, or aluminum than the A, E, or C horizons.
- C horizon -- The deepest layer of soil profile. It consists of loose material or weathered rock that is relatively unaffected by biologic activity.

Soil porosity -- Pore or airspace percentage of the soil.

Soil reconstruction -- The process of reclamation of prime farmland in which the A, B, and/or C horizons are replaced in their relative position on some part of the disturbed mining area.

Soil structure -- Arrangement of small soil particles into larger particles.

Soil survey -- Permit application map showing the location of different kinds of soils with a report that describes uses of the soils. There are maps published for most Kentucky counties.

Soluble -- Capable of being dissolved.

Sour soil -- Acid soil.

Special wastes -- Those wastes used in land farming that are of high volume and low hazard and include mining wastes, utility wastes, (fly ash, bottom ash, scrubber sludge), sludge from water treatment facilities and waste water treatment facilities, cement kiln dust, gas and oil drilling muds, and oil production brines.

Species -- Division of plant or animal classification systems.

Specific gravity -- Density of a material compared to distilled water at 4°C.

Spoil -- Overburden and other materials, excluding topsoil, coal mine waste, and mined coal, that are excavated during surface coal mining and reclamation operations.

Stabilized -- Spoil material which is fixed in place, non-moving usually revegetated by trees, shrubs or grasses or by mechanical compaction or aging.

Static safety factor -- See Safety Factor.

Steep slope -- Any slope steeper than 20° (roughly equal to 37 percent or 1v:2.7h).

STORET -- National computer data base for the STOrage and RETrieval of water quality information.

Stratified -- Underground mineral materials arranged in strata or layers. Layers in soils are called "horizons"; in rocks, they are called "strata."

Strike-off -- Mechanically removing the apex of the spoil bank or ridged spoil area to provide a truncated condition.

Subsidence -- Refers to the collapse of rock above underground mining areas. May occur immediately following mining by long-wall methods or take place several years following room-pillar mining.

Subsoil -- The soil below the topsoil. The second or B horizon and usually the thickest subsurface layer. It is usually higher in clay than either the A or C horizons.

Succession planting -- Planting a temporary crop until it can be replaced with a permanent crop.

Sulfuric materials -- Mineral material containing sulfur that can react with air and water to form acid mine drainage.

Surface mine or strip mine -- A procedure of mining that entails the complete removal of all overburden material.

Suspended solids -- Organic or inorganic materials carried by water, measured in milligrams per liter.

Sweet -- Refers to lime content or calcareous condition of soil or spoil or overburden that is neutral or slightly alkaline and/or capable of supporting plants without the addition of calcium carbonate limestone.

Sweet soil -- Alkaline soil with a pH of 7 or above.

Swell factor -- Ratio of overburden volume in its solid state to that when it is broken up through mining.

Switch back -- Zigzag road arrangement that aids in climbing a steep hill.

Tailing pond -- Settling pond used to separate tailings from water for non-coal preparation plants.

Tailings -- Mineral refuse from the milling operation. For coal, this is referred to as slurry.

Temporary diversion -- Temporary ditch used to divert overland flow during exploration, mining, and reclamation and then removed.

Toe -- The lower or outside portion of the highwall or spoil where the sloped surface meets the horizontal.

Topography -- The Earths surface shape, such as hills, mountains, or plains.

Topsoil -- The A and E soil horizon layers of the four master soil horizons.

Transpiration -- Normal plant loss of water vapor to the atmosphere.

Trash rack -- Metal rack welded atop the riser to pipe (beneath or over the anti-swirl plate) deep branches and other floating objects out of the pipe.

Tributary -- Stream that flows into a large stream or river.

Uke -- Large off-road vehicle used to transport coal, soil, or spoil. Usually refers to an end-dump truck as opposed to a scraper pan. Must be loaded with shovel or end-loader.

Unconsolidated soil -- Loose soil material.

Undercut -- To erode away the base.

Undergrowth -- Bush, seedlings, and small saplings growing under a stand of trees.

USGS -- United States Geological Survey of the Department of Interior.

Volunteer plant -- Plants that germinate from seed or other derived plant parts without being planted.

Warm-season plant -- Plant that grows most during late spring and early summer. More commonly refers to grasses.

Water bar -- Log or rock mound placed crosswise across a haul road to divert water off the road.

Water conservation -- Management and careful use of water resources in such a way as to maintain maximum benefits to people, agriculture, and industry.

Water table -- Upper surface of a zone of saturation, where the body of ground water is not confined by an overlying impervious zone.

Watershed -- Land area from which runoff feeds a stream or lake. Also called drainage area, drainage basin, and catchment area.

Weathering -- Chemical actions of air, water, plants, and bacteria and mechanical actions of erosion and temperature changes that cause rocks or minerals to change in character and decay, and finally crumble.

Weir -- Notch over which water flows that can be used to measure the rate of flow. Water flows through an orifice but over a weir.

Wetlands -- Land areas containing ponded water at least some portion of the year. Those that have standing water for long periods may be mined only under special conditions, and the company usually must reconstruct more acres of wetlands than originally found.

Wetlands-constructed -- Refers to planned wetlands either to replace those prior to mining or designed to treat acid mine drainage.

Wild rivers -- Rivers and their visual horizon (not to exceed 2,000 feet from stream center) designated by the General Assembly. They are portions of the Cumberland, Red, Rockcastle, Green, Big South Fork, Martin Fork, Rock Creek, and Little South Fork Rivers.

INDEX

Acid drainage, 4, 6, 9, 10, 13,
Acid spoil, 9, 16, 21, 23, 48, 53-54, 72,
Aeration, 10, 15,
Agencies, 1, 7,
Approximate original contour, 49, 50, 55
Backfilling, 2, 15, 49-53
Berm, 19, 35, 36, 60
Best management practices, 7-8
Bibliography, 97-105
Buffer zone, 9, 31, 41
Caustic soda, 13, 14
Channel protection, 20, 22-28,
    Check dams, 20, 22, 24-28, 41
    Gabion, 26, 27
    Grass linings, 23
    Log check dams, 26
    Riprap linings, 19, 21, 22-23, 58
    Rock check dams, 26-27,
    Straw bale check dams, 25-26
Check dams, 22, 24-27
Clearing and grubbing, 4, 15, 34,
Compaction, 35, 36, 43, 49, 50-53, 59, 67
Constructed wetlands, 10, 15-16
Contemporaneous reclamation, 47
Crushed limestone, 13
Culverts, 37-39
Debris, 2, 4, 6, 9, 36, 49
Design storm, 18, 56, 95-96
Diversions, 9, 16-20, 31, 36, 45, 46, 51, 56
    Construction, 18-19
    Erosion control, 19-20
    Removal, 20
Dozer, 49, 50, 51, 52
Emergency spillway, 21
End-dumped fills, 55, 59, 60
Erosion, 20, 22, 28, 29, 36, 39, 41, 43, 49-53, 57, 60, 63, 83
Excess spoil, 17, 41, 49, 55-60
Fertilizers, 31, 62, 64, 66
Filter strips, 5, 9, 31
Filter cloth, 29, 36, 58
Flocculants, 15, 21
Fly ash, 62, 64
Gabion, 26-27
Glossary, 106-124
Grading -see backfilling
Grasses, 31, 64, 67-73, 74-75, 79
Grass linings, 23
Hydrated lime, 13, 64
Kentucky Division of Water, 86
Kentucky. Department. of Surface Mining Reclamation and Enforcement, 87
Kentucky Division of Forestry, 89
Kentucky Soil and Water Conservation Districts, 90-91
Legumes, 64, 65-66, 71-73, 75
Lime, 13, 21, 23, 62-64
Log check dams, 26
Metal removal, 10, 12, 13, 14-15
Mining and reclamation plan, 2, 10, 44, 52, 54, 57, 60
Mulch, 4, 9, 15, 41, 43, 52, 55, 82-84
    Anchoring, 83
    Materials, 84
Neutralization, 13-15, 52
Non-woody plants, 64-75
Non-coal mine waste, 54
Non-point sources, 20, 53
Overburden, 34, 40-49, 53, 55
pH adjustment, 10, 12
Phosphorus (P or P_2O_5), 6, 62-63
Pipe underdrains, 58
Pit dewatering, 48, 53
Point sources, 16
Potash (K or K_2O), 6, 62, 63
Prime farmland, 41-43
Pyrite, 6
Quick lime, 13
Revegetation, 51, 55, 61-82
Revised Universal Soil Loss Equation, 5
Ripping, 50, 65, 79
Riprap, 19, 20, 21, 23, 24, 28, 29, 38, 58
Roads, 34-40
    Berm, 19, 35, 36, 60
    Construction specifications, 35-38
    Crossfall, 35, 37
    Culverts, 37, 38, 39
    Drainage, 34, 36, 38, 39
    Restoration, 31, 39
Rock check dams, 26-27,
Rock underdrain, 57, 58
Rock-core chimney drains, 55, 58
Scarification, 49, 51
SEDCAD$^+$, 21, 31
Sediment, 4-6, 9, 21-22, 28-29, 31, 41, 45
Sedimentation, 4-6, 10, 15, 20-22, 25, 34, 48, 53, 57, 64
Sedimentation ponds, 20-22
    Embankments, 21-22, 41
    Emergency spillway, 21
    Erosion control, 9, 20, 41, 43

Pond removal, 21-22
Seedbed, 31, 65
Seeding rates, 74-75
Shrubs, 41, 76, 79-80
Silt fence, 28-30, 43, 45, 46
Installation, 28-30
Removal, 29
Weir, 24, 26, 29, 30
Slope, 5, 9, 15, 16, 19, 25, 29, 31, 34, 35, 49, 59
Slope measurement, 94
Soda ash, 13, 14
Soil amendments, 62-64
Soil horizons, 41-44
Special wastes, 62, 64
Straw bale, 25
Straw bale check dams, 25-26
Storm data, 94-95
Subsoil, 41, 43, 50, 72, 79
Suspended solids, 5, 12, 22
Topsoil, 20, 39, 41-44, 48, 50, 51-52, 56, 63
Toxic Materials Handling Plan, 52
Toxic spoil, 52-54
Tracking, 50, 51, 52
Trees, 41, 63, 76, 77-79
Vegetative filters, 31, 41
University of Kentucky Agriculture Extention
Agents, 92-93
U.S. Office of Surface Mining , 88
Water pollutants, 2, 4, 53
Weir, 24, 26, 29, 30
Woody plants, 31, 76-82