COSTS OF RECLAIMING SURFACE MINED LANDS: SEVEN COUNTY
AREA OF THE OHIO COAL REGION

A Thesis
Presented in partial fulfillment of the Requirements
for the Degree Master of Science

by
Jennifer Cotterill Flocken, B.A.

The Ohio State University
1979

Approved by

[Signature]
Advisor
Department of Agricultural Economics
and Rural Sociology
ACKNOWLEDGMENTS

In the course of this undertaking I have become indebted to many very helpful people. I am indebted to my advisor, Dr. D. Lynn Forster for all his help and guidance and most of all for living through another mail survey and patiently awaiting the results. I am also indebted to the Ohio Agricultural Research and Development Center and The Ohio State University for their financial support of this project and of my graduate education.

Grateful appreciation is extended to Fred Lawson of the Geupel Construction Company for his knowledgeable, professional & neighborly time and advice.

I wish to express my deepest appreciation to my husband, Lou, for his inspiration, putting up with late nights & short tempers and loving me every minute.

To my wonderful parents, I wish to dedicate this thesis, for my motivation to strive for higher heights and my ingrained desire to know.
CONTENTS

ACKNOWLEDGMENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: PURPOSES AND PRINCIPLES OF THE STUDY

INTRODUCTION
ECONOMICS OF RECLAMATION
Externalities
BENEFITS OF RECLAMATION
COSTS OF RECLAMATION
ECONOMICS OF THE ENERGY MARKET
The Paradox of Coal in the Energy Market
Comparative Economics: A Market of Substitutes
LITERATURE REVIEW
OBJECTIVES OF THE STUDY

CHAPTER TWO: MINING THREATS, REGULATIONS AND METHODS

INTRODUCTION
ENVIRONMENTAL THREATS
Erosion
Sedimentation
Acid Mine Drainage
Summary
THE REGULATORY FRAMEWORK
Need for Regulation
Evolution and Development
Review of the Ohio Strip Mine Law
Effect of Federal Legislation
Other Laws Affecting Coal Mining
MINING METHODS AND COST FACTORS
Surface Mining Methods
Area Mining
Contour Mining
Block-cut Method
Mountaintop Removal Method
Auger Mining
FACTORS INVOLVED IN RECLAMATION COSTS
Materials Handling
Revegetation
Construction of Environmental Controls
Legal and Administrative Costs

CHAPTER THREE: THE QUESTIONNAIRE AND SURVEY

INTRODUCTION
DEVELOPMENT OF THE QUESTIONNAIRE
THE SURVEY
COST ESTIMATION PROCESS
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>DESCRIPTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Representative Rates of Erosion from Various Land Uses</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Comparative Rates of Erosion for Mining Areas</td>
<td>14</td>
</tr>
<tr>
<td>4.1</td>
<td>Reclamation Cost Estimates for Thirteen Ohio Mining Sites</td>
<td>54</td>
</tr>
<tr>
<td>4.2</td>
<td>Summary of Reclamation Costs for Thirteen Ohio Surface Mines by Activity</td>
<td>56</td>
</tr>
<tr>
<td>4.3</td>
<td>Tons/Acre for Each Specific Site, the Mean and Standard Deviation of Tons/Acre and the Correlation Coefficient of the Relationship</td>
<td>57</td>
</tr>
<tr>
<td>4.5</td>
<td>Proportion of Reclamation Cost for Thirteen Ohio Surface Mines, by Activity</td>
<td>58</td>
</tr>
<tr>
<td>4.6</td>
<td>Correlation Coefficients for Relationships Within the Reclamation Process</td>
<td>59</td>
</tr>
<tr>
<td>6.1</td>
<td>Comparison of Key Requirements of EM1395C to Existing State Regulations</td>
<td>90</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 The Concept of Integrated Mining, Reclamation, and Land-use Planning</td>
<td>20</td>
</tr>
<tr>
<td>2.2 Area Strip Mining with Concurrent Reclamation</td>
<td>28</td>
</tr>
<tr>
<td>2.4 Contour Strip Mining</td>
<td>31</td>
</tr>
<tr>
<td>3.1 1977 Surface Coal Production by County</td>
<td>41</td>
</tr>
<tr>
<td>3.2 Information Form Used for Cost Estimation Process</td>
<td>46</td>
</tr>
<tr>
<td>A.1 Slope Reduction Measures</td>
<td>68</td>
</tr>
<tr>
<td>A.2 Interception and Diversion Measures</td>
<td>69</td>
</tr>
<tr>
<td>D.1 Block-cut Method</td>
<td>92</td>
</tr>
<tr>
<td>D.2 Block-cut Method; Stripping Phase</td>
<td>92</td>
</tr>
<tr>
<td>D.3 Block-cut Method; Backfilling Phase</td>
<td>93</td>
</tr>
<tr>
<td>D.4 Head-of-Hollow Fill</td>
<td>93</td>
</tr>
<tr>
<td>D.5 Mountaintop Removal Method; First Cut</td>
<td>97</td>
</tr>
<tr>
<td>D.6 Mountaintop Removal Method; Second Cut</td>
<td>97</td>
</tr>
<tr>
<td>D.7 Mountaintop Removal Method; Fourth Cut</td>
<td>97</td>
</tr>
</tbody>
</table>
CHAPTER ONE: PURPOSES AND PRINCIPLES OF THE STUDY

INTRODUCTION

Increasing national concern over the growing demand for, yet dwindling supplies of energy has brought about a heightened interest in the extraction of coal in the United States. Approximately 295 million tons of coal were surface mined in this country during 1974. (Evans and Bitler) Forecasts from the Project Independence Blueprint predicts 675 million tons of coal will be produced by the nation's surface mines in 1985. (Evans and Bitler) The predicted increase in coal mining, especially surface coal mining, is partly due to recent significant technological innovations in the recovery and processing of coal and the opinion that coal is part of the solution to this nation's problems of inadequate current supplies of energy from domestic sources and overdependence upon imported oil.

ECONOMICS OF RECLAMATION

Externalities

Due to past increases and future expected increases in coal extraction, attention from many sectors is turning toward the externalities of surface mining. Externalities are roughly and generally defined as the impacts of the activities of households, public agencies or enterprises upon the activities of other households, public agencies, or enterprises which are exerted otherwise than through the market. More specifically, externalities are created when private and social costs of some action diverge and private profit-maximizing decisions are not socially efficient. The efficiency of competitive markets
depends on the identity of private costs and social costs. In the case of coal surface mining the social and private costs are not equal. External costs occur in the form of environmental pollution and the subsequent damages it causes. Before mining regulations were in effect the external costs caused by mining were not absorbed by the mine operator. These costs were passed on to others in society in the form of increased water treatment costs, reduced aesthetic and recreational value of surrounding land, direct damages caused by flooding, replacement costs for equipment corroded by acid water and stream clearing costs caused by siltation.

Reclamation of surface mined lands is seen as a means of bridging the gap between private costs and the private plus social costs of coal extraction. It is a means to internalize the social costs imposed by the mining process and making the industry a socially efficient one.

BENEFITS OF RECLAMATION

Benefits of reclamation occur in both tangible and intangible form. The narrowest view of the benefits of reclamation is that of the value, before and after reclamation, of the land actually mined. Before reclamation, surface mined land acreage has a near zero value. After reclamation the land surface value is, in most cases, returned to its original market value and, in some cases, to a greater than original market value. A broader view of the benefits of reclamation is one in which benefits are conceptualized in terms of the reduction in the social costs of mining. Some of these benefits are measurable.
in direct terms as in the reduction of water treatment costs, whereas other benefits are difficult to measure as in the prevention of damage to area aesthetics and the reduction in recreational value of surrounding lands. Other benefits include improved productivity from the reclaimed land and economic growth potential in the community surrounding surface mines. The monetary value placed on these benefits depends upon the social value that society places on the environment.

**Costs of Reclamation**

The materials handling or earthwork procedures, which are very site specific, present a problem in separating reclamation from normal mining practices. Production and reclamation procedures and costs are often jointly determined and difficult to identify as separate activities. In many cases the functions are not separable and joint costs are the rule. Backfilling is a good example of the difficulties encountered. For example, when a dragline is used in area stripping, the overburden material is replaced in the mined out area as mining continues across the site. Therefore, with the exception of the first and the last mining passes, the backfilling operation occurs simultaneously with stripping. Consequently, a large proportion of the backfilling costs is actually "production" rather than reclamation costs. On the other hand, with shovel and truck methods the backfilling is genuine reclamation, since the overburden is deliberately returned to the pit area rather than to an adjacent dump site.

Another problem in cost separation is that of topsoil removal and storage. Where topsoil is not salvaged, it becomes mixed with the...
remainder of the overburden as it is removed and spoiled. Therefore, what part of topsoil removal is for the purpose of reclamation? One study which estimates reclamation costs in the Western coal states believes the charges for topsoil removal should be allocated between mining and reclamation. (Perse, et al.) Conversely, through interviews with various company personnel throughout Ohio, it was found that the majority of those companies felt that the costs of topsoil removal and separation are totally a reclamation activity and should be accounted to reclamation costs.

Through these above examples it can be seen that in an analysis of the incremental costs of integrated mining and reclamation, problems are confronted: separation of reclamation costs, overburden stripping costs and the proprietary nature of such costs in an integrated mining and reclamation project. Another accounting problem in the separation of production and reclamation costs is one of the marginal costs of reclamation with shifting technologies. In some cases, a less efficient method of mining is substituted so as to make reclamation possible or easier to perform. When this occurs, the determination of production versus reclamation costs is compounded further. Should the increased costs of mining caused by the less efficient method be attributed to production or to reclamation, and how would these marginal costs be determined?

The companies surveyed in this study were unanimous in the belief that any earthwork performed because of the reclamation statutes or earthwork performed other than that required to remove the coal is considered as contributors to the cost of reclamation.
ECONOMICS OF THE ENERGY MARKET

The Paradox of Coal in the Energy Market: Conflict of Desires

For many years coal has occupied a paradoxical place in the American energy economy. The apparently enormous quantities of measured coal reserves have appeared to offer great potential for meeting the future energy needs of the nation. Yet, in practice, coal has become increasingly important in relative terms over most of the twentieth century, even though its production has increased in absolute terms.

A severe conflict exists between the desire to use domestic coal resources immediately to fill our energy needs and our desire to rapidly attain vigorous environmental control standards. It is believed by many that we are on the threshold of an era in which new techniques for the transformation of coal into synthetic fuels will lead to great increases in its use. Yet, at the same time, environmental considerations make it increasingly difficult to continue the present uses of coal. In short, the switch to coal is by no means a guaranteed physical necessity. We lack the information to prove or disprove conclusively that reliance on coal will increase greatly and, therefore, should be more cautious in our forecasts than often has been the case. The actual development will depend upon the comparative economics of fuels and the technologies for their use.

Comparative Economics: A Market of Substitutes

Just which fuels will be used is dependent upon the economics of the various substitutes available. Conceivably, enough lower cost reserves
of fuel other than coal might exist to meet a sizable proportion of our needs until a low-cost way of utilizing inexhaustible resources emerges. There are fossil fuels, such as oil from whale, which are not yet used but are potential competitors for coal. Virtually inexhaustible alternatives such as fueling nuclear fusion with deuterium from sea water or direct conversion of solar energy could be developed.

The nature of the energy market is one of many substitutes. Thus, the demand for coal is a relatively elastic one, depending upon the prices of the present substitutes. Because of this elastic demand, the increases in the cost of extraction, due to reclamation requirements, has so far been absorbed by the coal operators themselves. As a result of the price increases of crude oil due to the Embargo and gain in strength of OPEC in 1973 and 1974, and also the continuation of controls on natural gas prices and the resulting supply shortages, the owners of coal resources experienced a huge increase in the value of their coal because prices were allowed to increase along with those of its closest substitutes. Because of these windfall profits in the coal industry the costs associated with reclamation have not as yet place such a burden on the operators that they could not be absorbed. The most likely result of increased coal production costs due to reclamation is one of decreased value of mineral rights. This could be reflected in the recent prices of mineral leases as compared to lease prices before reclamation was required after taking account for inflation.

No matter which sector of the economy ultimately pays for required reclamation, everyone concerned has a stake in how much the clean-up process actually costs. Even though reclamation costs may have only
a small effect on consumer prices for energy, they affect the supply of coal as production decisions are modified to account for additional expenses. In addition, taxpayer costs for government subsidized reclamation programs are affected. By estimating these costs of reclamation, decision makers from all sectors of the economy, be it a coal mine operator or public official, are able to make their choices in positions of more perfect information.

LITERATURE REVIEW

Economic research has centered around three main questions concerning reclamation. These are:

1.) What are the societal benefits of reclamation?
2.) What are the societal costs of reclamation?
3.) Who bears these benefits and costs?

There has been a large amount of research performed to answer the second question. This study is another attempt to answer it. Evans and Hitler obtained data through on site inspection and interviews for twenty coal surface mining operations and estimated reclamation costs for premining planning, backfilling and revegetation. Results present an average per acre cost of $8,168 and $2.77 per ton of coal mined in the Appalachian and Midwestern coal supply districts.

U.S.E.P.A. finds the costs of reclamation for a typical surface mine in eastern Kentucky to be about 8% of total production costs. Baker develops information for the Appalachian Regional Commission to project pollution control costs in the Monongahela River Basin. Baker's research also provides a handbook for estimating pollution control
costs and the factors which affect these costs. Curry reports that the back-to-contour reclamation increases costs $2.40 to $2.93 per ton of coal in Tennessee. Neuhau and Spore use an economic engineering approach to simulate reclamation costs of forty-two hypothetical mines in the Appalachian region. The average cost of reclamation per ton of coal was found to be $3.46 in that particular study.

Several studies investigate the costs of reclamation in Western states. Leathers presents a comprehensive study of several sites in the west. Reclamation costs are derived using an activity analysis approach and a standard engineering cost analysis. Costs average $350.00 per acre or about $0.05 per ton. Bailey projects that reclamation costs in the West range from $0.02 to $0.20 per ton. Foreman, et al. uses data from thirteen mines in nine states west of the Mississippi River to estimate reclamation costs.

Schlottman reports on an engineering model used to estimate costs for a range of reclamation site characteristics. The simulation model is developed for application in any region within the United States. Results estimate that reclamation on an average site in Western regions cost an average of $0.32 per ton. Costs of reclamation for area mining in the Midwest average $1.30 per ton and costs of reclamation for area mining in Appalachia total $2.50 per ton.

One study performed by I.C.F., Inc. examines the incremental costs of reclamation due to more severe Federal legislation. Their estimates of incremental costs range from $0.32 to $1.99 per ton in the major coal mining states with a range from $0.50 to $1.00 per ton in Ohio. Environment and Natural Resources Policy Division of the Congressional
Research Service estimates of incremental costs due to the new Federal legislation range from $0.30 to $0.85 per ton of coal.

A study performed by Becker and Forster estimates costs for the legal and administrative requirements involved in reclamation. They estimate that costs for this phase of reclamation range between $100.00 to $500.00 per acre.

OBJECTIVES OF THE STUDY

The basis of this research is one of estimating the costs associated with internalizing the externalities caused by surface mining.

The major objectives of this study include the following:

1.) Identify the external costs of mining through examination of environmental threats. (Chapter Two)

2.) Identify the regulations passed to internalize environmental costs. (Chapter Two)

3.) Identify and examine the processes to internalize environmental costs including mining methods and the components of reclamation. (Chapter Two)

4.) Estimate reclamation costs for representative Ohio coal surface mines. (Chapter Three and Four)

5.) Compare the results of this study to the results of other cost estimation studies. (Chapter One--Literature Review and Chapter Five--Comparison)

6.) Test various relationships within the reclamation process by correlation analysis. (Chapter Four)

7.) Identify issues for further research. (Chapter Five)
CHAPTER TWO: MINING THREATS, REGULATIONS AND METHODS

INTRODUCTION

Due to increased public concern and the resulting regulations, the externalities of surface mining are being internalized by the mining operation in the form of better planning and construction and maintenance of controls.

The first section of this chapter will focus on the major threats to the environment and the external costs associated with the threats. A presentation of the rationale for various technical methods of control is presented in Appendix A.

The second major section will identify the regulations that have been created to internalize environmental costs including a review of the Ohio Strip Mine Law and an examination of the effects of the recently passed Surface Mining Control and Reclamation Act of 1977.

The third section of this chapter will focus on the various mining methods employed in the surface mining process and how some methods are better suited to reclamation than others. Appendix B presents the technical definitions of the newer methods of mining used to prevent damages.

Lastly, the components of reclamation, material handling, revegetation and construction of environmental controls will be identified and reviewed.

ENVIRONMENTAL THREATS

Erosion, sedimentation and acid mine drainage represent the major threats to the environment. This section will attempt to provide an
understanding of the mechanisms of soil erosion and sedimentation, causes and damages of acid mine drainage, and identify major sources of these problems.

Erosion

Soil erosion "is the detachment and movement of soil by the action of water, ice, gravity, or wind". (Mills and Czar) The problem most commonly found is erosion by falling and moving water. A very heavy rain can loosen as much as 100 tons of soil from an acre of exposed surface. (Buckman and Brady) Rain falling on an exposed soil surface results in the following:

- Soil structure at ground surface is destroyed, and crusting and hardening of the soil surface occur.
- Soil particles are detached, displaced and transported in runoff water.
- Infiltration decreases as a result of surface compaction and sealing; this causes increased runoff and further detachment of soil and transportation and downslope deposition of sediment.

There are various factors which influence the erosive potential of an area. These are:

- Climate; precipitation, temperature, and wind.
- Vegetative Cover; vegetation is the lands protection against soil erosion. Benefits of vegetation are that it shields the soil from the impact of rain, it slows the movement of surface water giving the water additional time to soak into the soil, and the root system binds the soil together and makes it more pervious.
- Soil Properties; the erosive potential of soil is dependent upon soil structure, texture, organic matter content and permeability. Fine textured or "heavy soils" made up of silts and clays are usually very cohesive and slow to
erode, but these types of soils are sometimes the worst polluters. These fine grained particles travel further and are the most difficult to settle out of suspension.

-Topography: slope steepness and length are important factors: As slope and length of slope increase, there is an associated rise in the velocity of the surface runoff, which results in greater erosion.

Sedimentation

Surface mining, as a large scale earth moving maneuver, has the potential to create large amounts of sediment. The sediment generated does not pose a problem as long as it is contained on the mining site. But, if the sediment is washed into adjacent waterways it is the cause of pollution, a "resource out of place".

Uncontrolled sediment is regarded by many to be the greatest source of water pollution in the United States and causes more offsite damage than any other surface mining water problem. The following are examples of some of its damaging effects: (Robinson)

-occupies water storage in reservoirs
-fills lakes and ponds
-clogs stream channels
-settles on productive land
-destroys aquatic habitat
-degrades water for consumptive use
-acts as a carrier of other pollutants (plant nutrients, insecticides, herbicides, heavy metals)
-acts as a carrier of bacteria and viruses

This form of pollutant has been costly to our nation. Annual damage from sediment in streams was estimated to be $352 million in 1966. (Stall)
Activities that disturb the land surface are the major sources of sediment. Table 2.1 lists representative rates of erosion from various land uses. From this it can be seen that active surface mining operations and construction site operations have the highest rates of erosion per land surface area.

The major sources of sediment around surface mining operations are as follows:

1) Cleared, Grubbed and Staked Areas
   This operation leaves the soil exposed and vulnerable to erosion and sedimentation.

2) Roadways (Haul and Access Roads)
   Roadways serve to intercept, concentrate and divert surface runoff, resulting in severe soil loss unless control measures are taken.

3) Spoil Piles and Areas of Active Mining

4) Areas Being Reclaimed
   Reclamation procedures can be a major source of sediment if not done properly or completely. The most crucial stage in the reclamation of spoil areas is from the start of grading operations to the stabilization of the area with vegetation.

Table 2.2 gives a comparison between rates of erosion for different areas within a monitored watershed in Appalachia.

Acid Mine Drainage

A comprehensive report on acid mine drainage that was issued by the Committee of Public Works of the U.S. House of Representatives in 1962 noted the extent of the mine drainage problem and stated that "elimination of this form of pollution would restore vast quantities of water for municipal and industrial use, propagation of fish, aquatic
### Table 2.1: Representative Rates of Erosion from Various Land Uses

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Metric tons per km²/year</th>
<th>Tons per mi² per year</th>
<th>Relative to forest land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>8.5</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Grassland</td>
<td>85.0</td>
<td>240</td>
<td>10</td>
</tr>
<tr>
<td>Abandoned Surface Mine</td>
<td>850.0</td>
<td>2400</td>
<td>100</td>
</tr>
<tr>
<td>Cropland</td>
<td>1700.0</td>
<td>4800</td>
<td>200</td>
</tr>
<tr>
<td>Harvested Forest</td>
<td>4250.0</td>
<td>12000</td>
<td>500</td>
</tr>
<tr>
<td>Active Surface Mine</td>
<td>17000.0</td>
<td>48000</td>
<td>2000</td>
</tr>
<tr>
<td>Construction</td>
<td>17000.0</td>
<td>48000</td>
<td>2000</td>
</tr>
</tbody>
</table>


### Table 2.2: Comparative Rates of Erosion for Mining Areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Yield (tons/mi²)</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unimined Watershed</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Spill Bank</td>
<td>1930</td>
<td>62</td>
</tr>
<tr>
<td>Haul Road</td>
<td>2700</td>
<td>968</td>
</tr>
<tr>
<td>Mined Watershed</td>
<td>57600</td>
<td>2065</td>
</tr>
</tbody>
</table>

life, wildlife and recreational purposes”.

The amount and nature of mine discharge is mostly determined by the mining and reclamation method, and the characteristics of the mine site. Four basic site characteristics contribute to the problem. They are pyrite and/or other acid forming compounds, moisture (as precipitation or humidity), oxygen and flowing water to transport the acid.

When water comes in contact with oxidized sulfuric materials, acid waters are produced. Surface mining areas are directly exposed to precipitation and the nature of the exposed materials will affect the quality of the surface runoff. The pollutants affect water quality by lowering pH, reducing natural alkalinity, increasing hardness and adding amounts of iron, manganese, aluminum and sulfates.

Mine drainage is a complex solution, varying in quality from seam to seam, mine to mine, and even within the same mine site. The water quality from a mine low in pyrite may be alkaline and closely resemble ground water, but often mines produce water high in ferrous iron and acidity.

Acid mine drainage from surface mining activities is particularly severe in the Appalachian States of Pennsylvania, West Virginia, Maryland, Ohio, and Kentucky due to high annual rainfall and an abundance of sulfur containing materials.

Summary

As can be seen above, water is a major component in the environmental threats related to surface mining and reclamation. The mining process greatly disrupt the normal land drainage patterns and exposes
sulfur bearing minerals resulting in the creation of acid drainage. Other problems such as soil erosion and subsequent sedimentation are also common occurrences connected with surface mining. Because of this, adequate control of water is one of the most important aspects of the surface mining reclamation process. The mine operator must manage his mining site as a watershed, taking into consideration erosion, sedimentation and water pollution caused by acid drainage.

There are various and many methods of pollution control which can be employed to prevent the environmental damages that occur on and off the mining site. A presentation of these methods is in Appendix A.

THE REGULATORY FRAMEWORK

Regulation of the surface mining process has been the means to require internalization of environmental costs. This section will identify the major regulations which affect surface mining and reclamation within Ohio.

Food for Regulation

The nature of surface mining requires disturbing the land surface in serious ways. The utility of land has, more often than not, been completely destroyed by surface mining without reclamation. It can mean the permanent loss of its productivity for agricultural, recreational, and other commercial purposes. Silt and acid mine drainage has polluted streams, lakes, and groundwater. Fish and wildlife populations have been destroyed by the introduction of toxic quantities of acid, iron
sulfate, aluminum and manganese into the environment. Also, the disruption of natural drainage networks at mine sites and the interference with groundwater aquifers and downstream water rights has resulted. Lives and property have also been endangered by landslides and floods resulting from inadequate reclamation. Human welfare has been affected in that abandoned mined land (orphan mines) does not lend itself to development of any kind. The potential for local economic development may, therefore, be eliminated by unreclaimed mined land. These are just some of the major externalities that are created by the absence of proper reclamation on surface mined land.

Previous state regulation's and, more recently, federal legislation's major concern with respect to surface mining has been in the area of environmental controls. Before any control regulations were in effect, operators had no reason to concern themselves with the environmental damages that would occur on and off the mining site. The costs of these damages were passed on to others as externalities both tangible and intangible. Costs have been passed on to adjacent landowners and water consumers in the form of silting and polluting of nearby waterways, replacement of equipment corroded by acid water and additional treatment costs. Intangible damages have resulted in the destruction of biological life in adjacent streams, reduced property aesthetics and reduced recreational value of waterways.

Surface mining has had a long history of causing adverse effects. The most direct method of controlling these impacts has been through regulatory policy. Public demand for action to stop unnecessary damage to mined and surrounding areas had led to legislation throughout the
mining states and ultimately to a comprehensive Federal law. Through these regulatory policies, most of the environmental costs create by surface mining have been internalized by the mining operation. Of course it should be kept in mind that severe reclamation laws may not benefit the area at all if they create a sharp decrease in the amount of mining in the area. In many cases, very stringent laws could create more harm than good to a local economy.

Recent years have seen the institution of numerous Federal, State and local laws designed to affect the supply and consumption of coal. It is becoming increasingly difficult to know whether the many new laws and regulations, by themselves, or in concert with each other, result in a net social benefit or cost to society. This chapter will focus on the State and Federal regulatory framework, focusing on the evolution and development of surface mining laws and summaries of the major regulations affecting mining within Ohio.

**Evolution and Development**

The first recorded attempts to reclaim surface mined lands in the U.S. date back some fifty years to the experimental programs of several midwestern mining firms. (Carter et al.) Reforestation proved successful in West Virginia, and in Indiana, spoil banks were reclaimed to productive cropland at Meadowlark Farms near Terre Haute (Leathers).

Among the first states to have "written" rules and standards of compliance were: West Virginia (1939), Indiana (1941), Illinois (1943), Pennsylvania (1945), Ohio (1947), Kentucky (1954). The number of
State programs designed specifically for strip mine reclamation of the United States has grown from one law in 1939 to over 39 in 1976. Thirty-three of these programs became effective in the past seven years. (Inhoff, et al.) New comprehensive Federal legislation was passed only recently, in mid 1977.

In the early years of surface mining, major emphasis was placed on the recovery of the mineral with little or no regard to "recovery of the land." Early control laws applied specifically to coal mining, in most cases only addressing erosion control and revegetation. The initial lack of concern for the environment caused increasingly stringent strip mine legislation. Various state programs expanded in scope during the 1950's and 1960's to include controls on water quality. (Leathers)

The significant emphasis of the 1970's has been the emergence of new programs that treat and view mining as an "interim" land use. Mining is now being defined as a "transitional phase" in the continuing economic use of a national resource. (I.C.P., Inc.) Figure 2.1 is a sketch of the concept of integrated mining, reclamation, and land-use planning. Interim use is only understood within the context of long term planning. This concept implies increasing involvement of the part of all concerned parties in the decision making process, including private firms, the local community, State and Federal Governments, and the taxing public. Reclamation has now become an integral part of most surface mining operations and has caused some major revisions in mining techniques, particularly in the West. Current practice is to incorporate reclamation with the mining sequence and not to regard it
Figure 2.1. The Concept of Integrated Mining, Reclamation and Land-use Planning
as a separate operation (Skelly and Loy).

Review of the Ohio Strip Mining Law

Before the Federal Surface Mining and Reclamation Act of 1977 was enacted, the requirement for reclamation varied quite a bit from state to state. Although a common thread runs through state statutory language, administrative requirements vary in order to meet different natural, economic, social and political consideration. A general trend could be seen in many state programs toward the requiring of an integration of land-use planning with increased local governmental involvement.

The basis of most state reclamation programs is as follows (Inhoff, et al.):

1) Successful transformation of surface mined land to a planned, productive and long term use.

2) The control of damaging side-effects stemming from mining activities.

In some states, including Ohio, the reclamation procedures and requirements are very detailed. In other states, the entire extent of the regulations applying to reclamation are contained in only three or four pages.

Reclamation statutes tend to go through a process of becoming more sophisticated with time. This is the case in Ohio. Ohio has one of the older regulatory histories, it also has one of the most stringent state reclamation laws. The detailed nature of this Ohio Strip Mine Law (Ohio Revised Code, Chapter 1513), effective 1972 as amended and effective September 27, 1974 and October 10, 1975, had placed Ohio's
coal operator's at a competitive disadvantage compared to other states. The contention of several Ohio mine reclamation engineers is that because of enactment of the new Federal reclamation law the disadvantage of Ohio's coal producers due to legal requirements has disappeared. It will be shown in the next section of this chapter that the Ohio Strip Mine Law is very similar to the new Federal Surface Mining and Reclamation Act.

The major provisions of the Ohio Strip Mine Law that pertain to the actual and physical reclamation of mined lands is presented in Appendix B.

Effect of Federal Legislation

Comprehensive Federal reclamation regulations were brought about with the passage of the Surface Mining Control and Reclamation Act of 1977 (PL95-87). There are two major objectives to this new Federal legislation. They are to, (1) reclaim abandoned mine lands and to, (2) control the environmental impacts of potential or ongoing surface coal mining.

Title V, the heart of the Act is the most significant section of the law pertaining to costs of reclamation. Title V, entitled "Control of the Environmental Impacts of Surface Coal Mining," authorized Federal surface mining controls. Any permit issued is to require that the mine operator meet the new statutory reclamation and environmental performance standards and comply with additional regulations to be promulgated. These performance standards cover, among other items, restoration of capability for original land use, restoration of original land
contour (with exceptions), stabilization of surface areas, replacement of topsoil, restoration of mined prime farmlands, water impoundments, hydrologic balance, mine spoil and waste disposal, blasting, access roads, revegetation, slide or erosion barriers, surface mining on steep slopes and proximity to underground mines.

The relationship between State laws and regulations on mined land reclamation and the new Federal Law is also addressed by Title V. A State law will prevail over the Federal law only if it "provides for more stringent land use and environmental controls and regulations of surface coal mining and reclamation operation than do the provisions of the Act ..."

The effect that PL95-87 will have on the costs of reclamation in Ohio is not yet known. All of the rules and regulations pertaining to the Act have not yet been promulgated. Hearings between federal officials and mining industry representatives continue to take place periodically.

As was stated previously, the Ohio Strip Mine Law is very similar in content to the Federal Law, therefore, operators in Ohio will have less adjustment and lower incremental costs compared with many of the other state mining laws.

Presented in Appendix C is a comparison prepared for the Senate Committee on Energy and Natural Resources by the Ohio Department of Natural Resources of the key provisions of the State's law with Sections 515 and 516 of the Federal Proposal HR13950. Most of the differences that do occur are differences in details required, otherwise the two laws bear a striking resemblance. Appendix C also contains a
table which compares the incremental requirements of RH3990 to the laws of all the coal mining states.

Through interviews with mine operators and reclamation engineers it was confirmed that many of the major changes brought about by the Federal law was in the area of application requirements. The prime farmland requirements were also cited as causing changes in some of their normal procedures but this doesn't affect Ohio as much as some of the other midwestern states. As the law stands presently, most of those interviewed agreed that the biggest cost factor, besides meeting water quality standards, was the cost of uncertainty. Much uncertainty surrounds not only the results of rules and regulations yet to be finalized, but also the correct interpretation of those rules that have been promulgated. No one seems to know anything for sure. Of those persons interviewed, many related that in most cases their firm was proceeding mainly according to the Ohio law except in the area of water quality.

Other Laws Affecting Coal Mining

One other law substantially effects the physical mining of coal and the costs of associated reclamation. This law is the Federal Water Pollution Control Act of 1972 (U.S. Congress). Under this act the National Pollutant Discharge Elimination System (NPDES) was established. The general objective of this law is to achieve or maintain specified ambient water quality standards. Any facility discharging water from a point source must apply and receive a permit before commencement of an operation involving discharge. The permits specify,
for each source, effluent limits to be achieved by certain dates and contain compliance schedules with interim milestones to assure progress in attaining those limits. Achievement of technology based standards for industrial dischargers, including coal mines, is a two stage process. By 1977, the best practicable control technology currently available (BPTCA) was required. By 1983, the best available technology economically achievable (BATEA) is required.

These costs are represented by the equipment, labor and materials used to comply with the pollution standards. This includes construction of sediment ponds and other control devices plus the neutralization agents.

MINING METHODS AND COST FACTORS

Surface mining, as the name implies, broadly covers any type of mining in which overburden (topsoil, rock and other strata) is removed in order to expose and extract the underlying mineral or fossil fuel deposit, in this case, coal.

Although mechanized surface mining for coal began in the late 1860's in the U.S., production was rather limited prior to World War II. High demand for fuel during the war led to rapid growth of the industry. Another surge of growth began in the early 1960's which has continued to the present day. This expansion has been caused by increasing energy demand and the competitive advantage that surface mining has over underground mining.

The very nature of surface mining creates the potential for massive
disturbance of land surfaces. This disturbance potential is much greater with surface mining methods than with conventional underground mining methods.

The spectacular growth in surface mining of coal has brought about widespread environmental damages. Although environmental damage has been severe, it is not an unavoidable consequence of all forms of surface mining. High levels of control can substantially reduce adverse environmental impacts in most areas. The types and severity of environmental damage depend not only on the mining method used, but also on the level and timing of the reclamation which follows. Mining and reclamation methods which significantly reduce these damages have been developed in the past few years.

Earthworks and material handling, the stripping, recontouring and hauling operations, are formidable engineering tasks in surface mining and land reclamation. It is these tasks that most affect the environment. To better appreciate the problems associated with surface mining, it is important that the stripping operation be understood. This section will examine the engineering requirements for the reclamation of surface mined land. Because the method of reclamation is often dictated by the method of mining, and vice versa, this section will also examine coal recovery methods and how mining method and reclamation are related to each other. The methods presented here and in Appendix D are examples from two major literature sources. These are: Environmental Protection in Surface Mining of Coal, E.C. Grin and R.D. Hill, U.S.E.P.A. Program Element No. 182300, Cincinnati, Ohio and Surface Mining Methods and Techniques, E.C. Grin and R.D. Hill, National Environmental Research
Surface Mining Method

The process of surface mining can be divided into three general types: area mining, contour mining, and augering. Area mining is performed in relatively flat to gently rolling terrain. Contour mining is performed where deposits are found in hilly or mountainous land. Augering, which is drilling horizontally into a coal seam, is usually used in conjunction with contour mining to increase the coal recovery rate. The major methods of surface mining are combinations and/or variations of area, contour and auger mining. The following are descriptions of the more common methods of mining employed in Ohio, along with some examples of reclamation that controls for pollution.

Area Mining

Area strip mining is usually limited to lands with slopes of 12 to 14 degrees or less with fairly horizontal coal seams and less than 200 feet of overburden. A trench or box cut is made through the overburden to expose the coal that is to be extracted. The cuts are made in long, narrow strips. All cuts are made parallel to the first, with the overburden from each new cut being placed in an adjacent, previous cut which has already had the coal removed. The series of parallel cuts continue across the site until the depth of overburden and/or coal quantity makes mining uneconomical. The final cut leaves an open trench bounded on one side by the last spoil pile and on the other by
Figure 2.2. Area Strip Mining with Concurrent Reclamation

(28)
the undisturbed highwall. If the spoil piles are left ungraded, the mined area resembles a large plowed field. (see figure 2.2)

Shovels, draglines, wheel excavators, pan scrapers, bulldozers, and front-end loaders are used to remove the overburden. The nature of the spoil and its surface configurations depends to a large degree upon the type and size of the equipment used to strip the area.

Without reclamation, area mining can destroy the future productivity of the stripped area. It can also pollute water with siltation and acid mine drainage, and destroy the aesthetic value in large areas. With responsible reclamation, the mined area need not be precluded from future productive land use. Grading and reclamation closely following a mining operation can return the land to its original contour and vegetation or other similarly appropriate condition. To accomplish contour grading, the spoil from the first cut is graded to blend into the contour of the adjacent land. Successive spoil piles are then graded with all material pushed toward the last cut, where it is deposited in the final pit. Finally, the separated topsoil is distributed evenly over the graded area. The topsoil insures that the best soil for plant growth is on top and not indiscriminately mixed with the subsoil.

In general, the pollution from area mines is not as severe as that from contour mines. Silt from erosion can often be confined to the mining area. Erosion and sedimentation can be controlled if surface water flow is managed and reclamation is timely. In effect, erosion and sediment loss from an area mining operation should not be substantially more than from a large farming enterprise with row crops.

Contour Mining
This method is used to extract coal that crops out along the sides of steep hills and terrain, usually above 12 to 14 degrees. In contour strip mining, the overburden is removed from the coal seam, creating a bench with a highwall often exceeding 100 feet in height. After the coal is removed from the uncovered seam, successive cuts are made into the hillside until the overburden becomes too deep for economical recovery of the coal. Then the operation continues along the hillside until the seam becomes too thin or the slope too steep.

In conventional contour mining the overburden removed from the coal bed is placed down the hillside and stacked along the outer edge of the bench, creating a mound that is often unstable. Handling overburden in contour stripping is a more challenging engineering task in comparison to area stripping, basically because of limited working space. (See figure 2.3 and 2.4)

Legislation has recently become more stringent, making it illegal to push overburden beyond the solid edge of the bench and over the downslope. This point has become a problem of interpretation. Through interviews with various mining engineers in Ohio, it was found that spoil is still placed on the downslope in certain cases (virgin, unmined land, relatively low slope, under conditions of extreme care). Some of the more modern methods of mining that do push spoil onto the downslope are slope reduction method (70° storage angle and parallel fill), and the two-cut box-cut method. Because these methods are technically illegal, this study will not go into detail about them. For excellent descriptions and procedures of these methods see Critz, R.C. and R.D. Hill, Environmental Protection in Surface Mining of Coal, EPA-670/2-74-073,
Figure 2.3. Conventional Contour Mining
Source: Environmental Protection in the Surface Mining of Coal. E.C. Gris and R.D. Hill. See figure 2.2.

Figure 2.4. Contour Strip Mining
Source: Environmental Protection in the Surface Mining of Coal. E.C. Gris and R.D. Hill. See figure 2.2.
Recently, concerned Federal and State agencies along with the coal industry have been working together to develop mining methods which minimize the adverse effects on the environment while allowing the maximum recovery of coal. Head of Hollow Fill and Modified Box Cut are now accepted methods of mining on steep slopes. These methods are not the final answer for all mining conditions and are being refined as more experience with varying conditions occurs. Below are general definitions of these newer methods. Appendix D presents more detailed definitions of the technical aspects of these methods.

**Block-cut Method**

This technique provides concurrent reclamation with minimal disturbance and environmental impacts on adjacent lands. Also known as the haul back and pit storage, this method is a simple innovation of the conventional contour strip mining method for steep terrain.

**Head-of-Hollow Fill Method**

This method was developed to improve aesthetics, reduce landslides, allow for full recovery of one or more coal seams and produce rolling mountaintop land that is suitable for other purposes besides forestry.

It provides storage space for spoil from the removal of entire mountaintops and is also used as a waste area for overburden from contour benches. Previously, islands of mountain were left, with no access, as the top coal seams were worked on the contour with a rim cut. These isolated areas left from past mining operations are now being removed.

**Mountaintop Removal Method**
This method, which is an adaptation of area mining for rolling
steep terrain, has been both encouraged and discouraged in the
Appalachian Coal Region. It is being practiced currently in Ohio.

Where coal seams are located near the tops of mountains, ridges,
knobs, or knolls, they can usually be economically surface mined. The
entire tops are removed down to the coal seam in a series of parallel
cuts.

Auger Mining

This method, which is usually associated with contour mining, is
a common practice used to recover additional tonnage after the coal
overburden ratio has become too small for economical contour recovery.
Where contour mining is prohibited by too steep of a slope, augering
is often performed directly into the hillside from a narrow bench. Like
a carpenter bores a hole in wood, augering produces coal by boring hori-
zontally into the seam. Cutting heads of some augers are as large as
seven feet in diameter, although most are much smaller. Holes can be
drilled in excess of 200 feet.

Wherever auger mining has been used to recover coal the holes must
be plugged to prevent the flow of water in or out of the holes and to
inhibit oxidation of the coal left behind.

Factors Involved in Reclamation Costs

The determination of reclamation costs and their comparison is at
best, a difficult process considering the complex combination of physi-
cal, economic and management properties affecting each mining operation.
Many factors contribute to these costs. This section will look at the
major contributors.

Cost factors can best be seen by breaking the process of reclamation into phases. Reclamation of a mined site involves topsoil removal and replacement, backfilling and regrading, revegetation and construction of environmental controls.

Materials Handling

This category includes the operations of topsoiling (removal, separation, and replacement), backfilling, and regrading of the affected area. The cost factors involved in this phase of reclamation are the equipment and labor costs.

Each mining operation has a specific combination of equipment that, depending on a number of factors, allows the materials handling phase of reclamation to be performed most efficiently and effectively. Factors which affect the choice and usage time of equipment are numerous, some affecting costs more than others.

Composition and depth of the overburden is a very important factor. Increases in reclamation costs are high when surface rock removal is necessary. Also, the deeper the overburden, the more material there is to move, therefore the equipment will have to be in use for a longer amount of time.

The terrain of the land before mining causes variances in costs. Steeply sloping and flatlands generally cost more to return to the original contour than a rolling topography.

Occasionally a mine operator or landowner will want the slope of the reclaimed land at a lesser angle or a different configuration than
required by regulation. Such desires require more grading than is ordinarily necessary; therefore the backfilling and grading costs are increased.

Land use after mining is another factor contributing to costs. Land to be used for wildlife habitat or a pasture does not require as much grading as land to be used for farming.

One other factor that affects costs in this category is the type of equipment used to strip the area. For example, draglines tend to pile overburden in long, steep banks with ridge lines 200 or more feet apart. Leveling such banks with conventional tractor-dozers is very costly. (Perese, et. al.) On the other hand, using smaller equipment to mine the area, spoiling the overburden in neat uniform rows, devoid of peaks, will lead to lower reclamation costs but higher mining costs.

Revegetation

The cost factors involved in the revegetation phase of reclamation are equipment and labor costs as well as costs for materials used.

Revegetation includes part or all of the following procedures: soil preparation, seeding and/or planting, reseeding and/or replanting, and irrigation. Preparation of the soil consists of one or more of the following: disk, laying, harrowing, mulching, adding soil conditioners and fertilizing. The equipment used ranges from conventional tractor-pulled farm equipment to specialized equipment such as a helicopter-mounted hydro-seeder. The materials used include line, lime stone, fertilizers, mulches, seed and seedlings.

The choice of technique and equipment to be used for revegetation
is determined by site accessibility, water availability, slope, size of the area to be revegetated, and the time of the year during which revegetation operations are conducted.

The amount and type of materials used are determined by acidity of the soil, fertility of the soil, slope of the affected area (mulch), and proposed future use of the site.

Construction of Environmental Controls

Again, the cost factors involved in this phase are equipment and labor costs. This includes the equipment and labor used in constructing sediment ponds, drainage ditches, dams and any other pollution control devices needed. Also included is the time and equipment used to dismantle and regrade the controls that are no longer needed after mining and reclamation are completed.

Factors which determine which control devices should be constructed include, slope, and erosion potential, size of the affected area, and physical characteristics of the overburden.

Legal and Administrative Costs

One component of costs directly related to reclamation is that associated with the legal and administrative requirements of opening and operating a mine site.

A brief summary of the major requirements will be presented here. This category of costs is not included in the cost evaluation of mining sites presented later. For a more complete presentation including cost estimates, see "Legal and Administrative Costs of Strip Mine Reclamation in Ohio", G.S. Becker and D.L. Forster, Department of
Agricultural Economics and Rural Sociology, The Ohio State University.

To operate in the state of Ohio, surface coal operators must:

Obtain a license ($150.00 per year)
Information required:
--phone of applicant and all partners
--number of previously or presently held licenses
--certificate of public liability insurance

Obtain a permit ($30.00 per affected acre)
Information required:
--name, address and phone of applicant
--description of the land to be mined
--estimate of acres to be affected
--name and address of owner of surface rights
--copy of deed, lease, or other instrument that authorizes entry upon affected land
--statement detailing strip mine permits currently held
--report of testing in affected area
--complete plan for mining and reclaiming the area
--an estimate of the cost of reclamation per acre
--a detailed topographic map

Obtain a surety bond in the amount equal to the estimated cost for a third party to perform any reclamation activities not performed by the operator ($5,000 minimum)

Submit quarterly reports indicating mining and reclamation program

File an annual plan

Additional Federal requirements include:
--cross-sectional maps
--water samples analyses
--hydrologic impact assessment
--permit fee
--minimum bond amount of $10,000
--prime farmland requirements
--soil surveys
--data on irrigation, flood control, and subsurface water management needs
--more explicit topographic maps
CHAPTER THREE: THE QUESTIONNAIRE AND SURVEY

INTRODUCTION

Surface mining under strict pollution control regulations has occurred in Ohio for several years. Surface mining companies are experienced at reclamation. It was decided that the most appropriate method of estimating reclamation costs would be to survey companies and estimate reclamation costs for representative mining sites. After review of various studies that examined and estimated reclamation costs (Evans and Bitter, I.C.E., Nephew and Spore, Leathers, Forese, et. al.) along with interviews and discussions with mining personnel, it was decided that an equipment-labor use approach would be the most direct and unique method of obtaining an estimate of these costs. This approach utilizes standardized hourly rates for equipment and labor. These rates are then applied to the number of hours that each piece of equipment was in use for specific reclamation purposes on a permit site. Through this method an equipment-labor cost figure is obtained for the various phases of the reclamation process. This figure is then added to any material costs that were involved.

DEVELOPMENT OF THE QUESTIONNAIRE

The actual questionnaire was developed by consultation with John Epbley, a well informed and knowledgeable reclamation engineer associated with the Central Ohio Coal Company. Through interviews and working sessions with Mr. Epbley the questionnaire shown in Appendix E was developed.

The various components of reclamation that were identified in
Chapter Two were used. These included topsoil removal and replace-
ment, backfilling, regrading, revegetation and the construction of
environmental controls. It was these processes for which equipment
and labor, as well as materials used, were surveyed.
Besides equipment, labor and materials, which create the monetary
costs of the study, other factors considered to be important in de-
termining the type of equipment and the hours they were in use were
surveyed. These factors included, average depth of overburden, phy-
sical makeup of overburden, average thickness of the coal seam,
average slope of the permit area before and after mining, the height
of the highwall after mining but before backfilling, and the average
length of haul for topsoil storage.
Any other information that was considered important was either
obtained from the mining permit on file with the Ohio Department of
Natural Resources and/or verbally through interviews with mining com-
pany personnel. Information obtained from the mining permits included
the complete plan for mining and reclamation, type of mining performed,
lists of size and type of equipment used and for which purposes, num-
ber of affected acres, land use before mining, land use after mining,
size and number of sediment ponds, and the amount of coal mined from
the site. Where the revegetation process was contracted to an outside
firm the soil fertility analysis and recommendations were also obtained
from the permits.
Along with these sources of information, attempts were also made
to secure corroborative evidence supporting the data given on the ques-
tionnaire through personal interviews with mining personnel within the
study area and from the mining permits.

Data obtained from the questionnaire are of a confidential nature and are therefore presented in a manner to avoid disclosure of the participating companies. The exact capacities of the draglines and other equipment are not indicated in order to avoid divulging information from which the identities of individual mining operations and firms can be determined.

THE SURVEY

It was decided that seven of the twenty-three Ohio counties involved in surface mining would be surveyed. The counties chosen: Belmont, Carroll, Columbiana, Guernsey, Harrison, Jefferson and Muskingum were picked because, (1) these seven counties represent a spectrum of mining intensities within Ohio, (2) they represent a range of the various mining methods, (3) they are mainly homogeneous in aspects other than surface mining, and (4) six of the chosen counties were used in another study with calculated the monetary effect which surface mining has had on surrounding land values. (Ibrahim, G., et. al.)

The 1977 tonnage figures in this seven county area range from a low of 306,646 short tons in Carroll County to a high of 7,073,584 short tons in Belmont County with varying degrees of intensity in between. (See Figure 3.1)

As a total population a list of permits released in the study area during the year 7-1-77 through 6-30-78 was obtained from the Ohio Department of Natural Resources. During this period 152 B-permits and 24 C-permits were released. Fifty permit sites were selected randomly from the total population which included twenty-three different mining
Figure 3.1. 1977 Surface Coal Production by County
(in thousands of short tons)
Source: Ohio Department of Industrial Relations.
1977 Division of Mines Report, Helen W. Evans, Director.
companies. The questionnaires were sent to the reclamation engineer of the various companies along with a cover letter stating the intent of the research. (Appendix F.) Each company was then contacted by telephone to see if the questionnaires had been received and if the company planned to participate. It was learned through these telephone conversations that the majority of the companies kept no records of equipment and labor use. Five of the twenty-three surveyed companies said they had records of equipment and labor hours and were willing to participate. This resulted in the thirteen permit sites represented in the final cost estimations.

It was hoped that a more representative response from the survey could have been obtained. With more than 175 surface mine operators in Ohio, over one-half of them produce less than 100,000 tons/year and more than 75 percent of them produce less than one million tons/year each (Recker and Forster, Ohio Dept. of Industrial Relations). The majority of mine operators are very small companies and most of the smaller companies have not kept the detailed records that were needed to answer all the questions on the questionnaire. This characteristic of the nonrespondents was proven through interviews with those companies which did not participate and through records kept by the Ohio Department of Industrial Relations. Another characteristic that was not documented but which may have affected the decision to participate in this study is the type of equipment used to mine and reclaim. As was mentioned in Chapter One part of the cost separation difficulties occur because of the type of equipment used. One company surveyed in this study declined to participate because it was felt that due to the equipment and
methods used by their company that it was impossible for them to separate production from reclamation processes. It would be valuable to know if equipment and type of mining was as important a factor in non-response as the lack of records. This point is an issue that could be researched further.

**Cost Estimation Process**

Equipment costs, labor costs, materials used in revegetation (such as seed, fertilizer, lime) and materials used in sediment pond construction (such as pumps and neutralizing agents) are the factors which cost figures were applied. The owning and operating costs for equipment use were obtained from various sources. These sources were the Caterpillar Performance Handbook, the Associated Equipment Distributors Rental Rates Compilation and consultation with personnel from a construction and mining firm independent of the reclamation survey. (Carl M. Guepel Construction Company, Inc.) Rates used were for 1978.

The factors which influence the equipment owning and operating costs used in the estimation process include the following:

- **Ownership Expenses**
  - Depreciation
  - Insurance
  - Interest on investment
  - Taxes

- **Operating Expenses**
  - Repairs and maintenance
  - Tires
  - Lubricant, filters, grease

Labor costs were obtained through use of the National Bituminous Coal Wage Agreement of 1978, effective March 27, 1978, and through consultation with the same outside construction and mining firm used in obtaining equipment costs.
Estimates for revegetation materials were obtained from two sources. One source was the Bicle Company of Norwalk, Ohio, a firm which deals in seed, fertilizers and lime. The other source was the Ohio Mining and Reclamation Association. This firm, besides dealing in seed, fertilizers, and lime, will perform the complete revegetation phase (or part of it) for Ohio mine operators on a contract basis. These costs were also in 1978 dollars. Five of the permit sites used for the cost estimation had contracted their total revegetation process to outside firms. In these cases, estimates of the contract costs were obtained from the Ohio Mining and Reclamation Association.

The process of estimation was then performed by compiling all the information together on the form shown in Figure 3.2. (The process is shown for Site 6 of the survey.) Finally, the total cost for the permit was obtained by applying the standardized rates to the reported hours in use and adding them to costs for any materials used. From this total cost the costs of reclamation per acre and the costs per ton of coal mined were derived.
<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acreage</td>
<td>32.0</td>
</tr>
<tr>
<td>Overburden Depth</td>
<td>20'</td>
</tr>
<tr>
<td>Physical Makeup</td>
<td>Sandstone and shale</td>
</tr>
<tr>
<td>Coal Seam</td>
<td>3'</td>
</tr>
<tr>
<td>Type of Mining</td>
<td>Contour</td>
</tr>
<tr>
<td>Average Size Before</td>
<td>10'</td>
</tr>
<tr>
<td>Average Slope After</td>
<td>8-10'</td>
</tr>
<tr>
<td>Highwall</td>
<td>65'</td>
</tr>
<tr>
<td>Length of Haul</td>
<td>150 yards</td>
</tr>
<tr>
<td>Stripping Equipment</td>
<td>Front-end Loader (7 Td.)</td>
</tr>
<tr>
<td></td>
<td>1-9 Granny, Caterpillar Front Loader (1 Td.)</td>
</tr>
<tr>
<td>Other Labor</td>
<td>20 Hours for rock picking</td>
</tr>
<tr>
<td>Blasting</td>
<td>none</td>
</tr>
<tr>
<td>Union or Non-union</td>
<td>Union Labor</td>
</tr>
<tr>
<td>Other Investments</td>
<td>none</td>
</tr>
<tr>
<td>Revegetation Contract</td>
<td>not contracted</td>
</tr>
<tr>
<td>Estimate by UPA</td>
<td>$</td>
</tr>
<tr>
<td>Previous Use</td>
<td>mature</td>
</tr>
<tr>
<td>Post Use</td>
<td>mature</td>
</tr>
<tr>
<td>County</td>
<td>Jefferson County</td>
</tr>
<tr>
<td>Tonnage Required</td>
<td>65,861.3'</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>35.37, 3.7 tons/acre</td>
</tr>
<tr>
<td>Cost per ton</td>
<td>$1.87</td>
</tr>
<tr>
<td>Total cost for reclamation</td>
<td>$102,142.12</td>
</tr>
<tr>
<td>Cost per acre</td>
<td>$563.91</td>
</tr>
</tbody>
</table>

Figure 3.2. Information Form Used for Cost Estimation Process
<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Cost</th>
<th>Labor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-9 Dozer</td>
<td>200</td>
<td>10880.00</td>
<td>1986.00</td>
<td>12866.00</td>
</tr>
</tbody>
</table>

$612.66/acre  
$0.195/ton

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Cost</th>
<th>Labor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-9 Dozer</td>
<td>1199</td>
<td>64253.46</td>
<td>11806.77</td>
<td>76060.23</td>
</tr>
<tr>
<td>Terex Pan TS18</td>
<td>163</td>
<td>8552.61</td>
<td>1618.19</td>
<td>10170.80</td>
</tr>
</tbody>
</table>

$418.62/acre  
$1.34/ton

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Cost</th>
<th>Labor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-9 Dozer</td>
<td>200</td>
<td>10800.00</td>
<td>1986.00</td>
<td>12786.00</td>
</tr>
<tr>
<td>TS18</td>
<td>100</td>
<td>5247.00</td>
<td>993.00</td>
<td>6240.00</td>
</tr>
</tbody>
</table>

$900.80/acre  
$0.295/ton

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Cost</th>
<th>Labor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>85 HP Tractor</td>
<td>64</td>
<td>992.00</td>
<td>635.52</td>
<td>1627.52</td>
</tr>
<tr>
<td>301 Grader</td>
<td>24</td>
<td>636.32</td>
<td>238.32</td>
<td>874.64</td>
</tr>
</tbody>
</table>

$119.45/acre  
$0.470/ton

**TOTAL AMOUNT FOR EQUIPMENT: $120003.69**

Figure 3.2. Information Form Used for Cost Estimation Process (Continued)
**Revegetation Materials**

<table>
<thead>
<tr>
<th>Seed</th>
<th>Type</th>
<th>Cost</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td></td>
<td></td>
<td></td>
<td>$727.50</td>
</tr>
<tr>
<td>Sweet Clover</td>
<td>GIVEN ON</td>
<td></td>
<td>1000 lb.</td>
<td>$225.00</td>
</tr>
<tr>
<td>Orchard Grass</td>
<td>QUESTIONNAIRE</td>
<td></td>
<td>and 50 bu.</td>
<td>$67.58</td>
</tr>
<tr>
<td>Kentucky 31 fescue</td>
<td>West</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Type</th>
<th>Cost</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUT GIVEN</td>
<td></td>
<td></td>
<td>7500 lb.</td>
<td>$487.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mulch</th>
<th>Type</th>
<th>Cost</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NONE GIVEN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Type</th>
<th>Cost</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRICULTURAL LINE</td>
<td></td>
<td></td>
<td>75 tone</td>
<td>$750.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trees and Shrubs</th>
<th>Type</th>
<th>Cost</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NONE GIVEN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Miscellaneous:**
36 hours labor for rock picking at labor class 2C-$9.52/hour = $343.68

**Revegetation Materials**

<table>
<thead>
<tr>
<th>ELEVATION MATERIALS</th>
<th>$243.43</th>
<th>$235.17/acre</th>
<th>$80.07/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL AMOUNT FOR MATERIALS</td>
<td>$2939.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3.2. Information Form Used for Cost Estimation Process (Continued)**
CHAPTER FOUR: RESULTS

INTRODUCTION

Because of the limited number of observations (11) obtained from the questionnaire survey, regression analysis was not practical, but correlation analysis was performed to test various relationships within the reclamation process. The actual results of the cost estimation are shown below in table form. (Table 4.1) By reading across as well as up and down, comparisons within and among mine sites may be made.

The next table (Table 4.2) presents category averages along with their corresponding standard deviations. The average costs are presented for per acre cost and per ton cost for each activity. (total reclamation, topsoil removal, backfilling, regrading, backfilling and revegetation and environmental controls) Also presented are the figures for tons/acre for each specific site, the mean and standard deviation of tons/acre and the correlation coefficient representing the relationship between tons and acres. (Table 4.3)

Table 4.5 presents each activity as a percentage of the total reclamation process. (e.g. \( \frac{\text{total topsoil cost}}{\text{total reclamation cost}} \)) This percentage is shown for each specific site as well as the average of the total and its standard deviation.

Table 4.6 presents the results of correlation analysis performed to test 11 relationships within the reclamation process. The coefficient represents the degree of relationship between the two variables. Correlation coefficients were calculated and are presented for the following relationships: cost/ton and cost/acre; cost/ton and over-
burden depth; cost/acre and overburden depth; cost/ton and width of
the coal seam; cost/acre and width of the coal seam; cost/ton and
beginning slope; cost/acre and beginning slope; cost/ton and the highwall
height; cost/acre and highwall height; cost/ton and the length of haul
for topsoil storage and cost/acre and length of haul.

ANALYSIS OF RESULTS

Per acre costs are presented to give some idea of the costs re-
quired to return the land affected by mining and its auxiliary operations
to an acceptable condition. For the thirteen observations and their
 corresponding cost estimates the average cost per acre for the physical
 phases of reclamation is $4886.26 with a range from $1923.61 to
$6999.79. When comparing the average per acre cost of $4886.26
 obtained from this study to the $9464.72 average per acre cost obtained
from eleven observations under similar mining conditions in the
study Coal Surface Mining Reclamation Costs--Appalachian and Midwestern
Coal Supply Districts (Evans and Bitler) the costs obtained in this
study appear rather low. However, the Evans and Bitler study contains
several sites with steeper initial slopes and deeper coal seams, thus
it's estimates are expected to be higher.

Per acre costs are less useful than those expressed in dollars/ton
of coal produced, especially when assessing the impact of reclamation
costs on coal mining operations and for making comparisons of the
reclamation costs for different operations. Stating reclamation
costs is dollars per ton provides greater comparability with the
other costs of mining and the revenues received from the sale of coal, clarifying the relationship between reclamation costs and the cost of coal. The importance of cost/ton over cost/acre can best be seen by looking at Table 4.3. Here the relationship between tons and acres is calculated. As can be seen by the tons/acre figures for each specific site and the negative value of the correlation coefficient there is little or no relationship between the number of acres affected by the mining process and the amount of coal mined from these 13 specific observations. Even though an operator may be paying over $6000/acre, his per ton costs may be relatively low as in the case of site 13 or relatively high as in the case of site 11 depending on the tons/acre ratio.

The average cost per ton of reclaiming is $2.25 with a range from $1.03 per ton to $3.64 per ton. This figure is very near the average cost of $2.66 per ton calculated by the same Evans and Bitler study mentioned above. This dissimilarity in per acre costs and similarity in per ton costs between the two studies occurred because of the differences in the tons/acre ratios between the two studies and differences in the width of the coal seams mined.

This study's average per ton cost of $2.25 can also be compared to the average per ton cost of $3.46 calculated by a study performed by Nephew and Spore which utilized 42 hypothetical mines. The difference in the two figures can best be explained by the difference in the average slopes of terrain and highwall height involved in the two studies. The average slope in this study is 17.07 degrees where the average slope in the Nephew and Spore study is 20.83 degrees. The
average height of the highwall in this study is 65.5 feet where the average height of the highwall in the Nephew and Spore study is 75 feet.

Another comparison that can be made concerning the resulting estimates for cost/ton of reclaiming is that of cost/ton and the average selling price of Ohio coal. Used primarily for steam generation, Ohio coal was selling for approximately $26.00 per ton in 1978. This results in an average of 8.6% of the selling price devoted to paying for the reclamation of the land. The range of per ton costs of $1.03 and $3.64 results in percentage of selling price figures of 3.9 and 14.0 respectively.

Table 4.2 presents the averages and standard deviations of the total, per acre, and per ton costs of each phase of the reclamation process. These tables are best summed up by Table 4.3 which shows the percentage portion of the total accounted for by each phase.

Backfilling accounts for, by far, the majority of reclamation costs with an average of 64.0% of the total and a range from 47.90% for site 10 to 70.0% for site 6. Backfilling combined with regrading accounts for 75.90% of total reclamation costs.

Table 4.6 presents the correlation coefficients of various relationships within the reclamation process. One relationship that was not tested was that between the costs of reclamation and the mining method. The relationship was not tested because many of the nine sites utilized more than one type of mining as in the case of sites one and two which used area, contour and auger. There was no way of knowing how many acres were area mined and how many acres were contour mined.
In the case of the relationship between cost/ton and cost/acre a weak negative correlation exists (-.1677) meaning that as costs per acre rise, the costs per ton will tend to drop. The unexpected nature of this relationship can be attributed to various factors. One factor is the occurrence of the negative relationship shown between tons of coal mined and the number of acres affected. (Table 4.3) The relative roughness of the terrain could also have contributed to the weak nature of the relationship.

The correlation between cost/ton and overburden depth is practically nonexistence (-.0490). This can also be attributed to the low correlation between tons of coal and number of acres affected.

The relationship between cost/acre and overburden depth is positive (.4475) as is expected, meaning that as the overburden gets deeper the cost per acre will tend to increase.

The correlation between cost/ton and the width of the coal seam also appears as expected showing a negative relationship (-.5942) telling us that as the width of the coal seam increases the costs per ton will tend to decrease.

It was also expected that little or no relationship would exist between costs/acre and coal seam width as was the case in this study with a correlation coefficient of .180. The same reasoning applies in the case between cost/ton and the beginning slope of the affected area (-.079). In both cases the depth of overburden and the slope of the terrain have no bearing on the width of the coal seam and therefore they have no bearing on the costs per ton.

The correlation coefficient between costs per acre and the degree
of beginning slope is positive (.3328) showing that as the degree of slope increases so also will the costs per acre of land affected.

The relationships between cost/ton or cost/acre and the highwall height are as expected with little or no correlation existing between cost/ton and highwall height (-.0228) because of the lack of physical relationship between highwall and the amount of tonnage mined and a positive correlation between cost/acre and highwall height (.4638).

Finally, as was mentioned by several mining and reclamation engineers who were interviewed, the relationship between cost/acre and the length of haul for topsoil storage is a positive one (.4084) with very low correlation between cost/ton and length of haul.
<table>
<thead>
<tr>
<th>SITE NO.</th>
<th>TOTAL</th>
<th>PER ACRE</th>
<th>PER TON</th>
<th>TOTAL ACRE</th>
<th>PER TON</th>
<th>TOTAL TONS</th>
<th>TOPSOIL</th>
<th>BACKFILLING</th>
<th>REGRADING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>$205965.08</td>
<td>$2993.67</td>
<td>$3.64</td>
<td>68.8</td>
<td>56505.34</td>
<td>6744.73</td>
<td>$666.00</td>
<td>2.23</td>
<td>374.00</td>
</tr>
<tr>
<td>Site 2</td>
<td>$171717.27</td>
<td>$2141.23</td>
<td>$2.42</td>
<td>33.4</td>
<td>76953.75</td>
<td>2925.50</td>
<td>495.00</td>
<td>1.39</td>
<td>263.00</td>
</tr>
<tr>
<td>Site 3</td>
<td>$163314.75</td>
<td>$1923.61</td>
<td>$3.41</td>
<td>84.9</td>
<td>47853.28</td>
<td>1299.32</td>
<td>720.00</td>
<td>2.52</td>
<td>combined</td>
</tr>
<tr>
<td>Site 4</td>
<td>$45732.92</td>
<td>$4083.30</td>
<td>$1.76</td>
<td>11.2</td>
<td>25926.00</td>
<td>499.27</td>
<td>144.10</td>
<td>1.13</td>
<td>675.39</td>
</tr>
<tr>
<td>Site 5</td>
<td>$121664.93</td>
<td>$3201.71</td>
<td>$1.66</td>
<td>38.0</td>
<td>72971.00</td>
<td>411.56</td>
<td>1193.12</td>
<td>324.31</td>
<td></td>
</tr>
<tr>
<td>Site 6</td>
<td>$123142.12</td>
<td>$5863.91</td>
<td>$1.87</td>
<td>21.0</td>
<td>65863.36</td>
<td>612.66</td>
<td>4106.26</td>
<td>909.80</td>
<td></td>
</tr>
<tr>
<td>Site 7</td>
<td>$70846.70</td>
<td>$2833.87</td>
<td>$1.52</td>
<td>25.0</td>
<td>46683.95</td>
<td>439.21</td>
<td>2030.28</td>
<td>98.51</td>
<td></td>
</tr>
<tr>
<td>Site 8</td>
<td>$104935.93</td>
<td>$6258.41</td>
<td>$2.85</td>
<td>167.7</td>
<td>367624.00</td>
<td>1464.60</td>
<td>3642.51</td>
<td>776.60</td>
<td></td>
</tr>
<tr>
<td>Site 9</td>
<td>$123009.40</td>
<td>$6479.17</td>
<td>$1.36</td>
<td>19.0</td>
<td>90138.08</td>
<td>603.06</td>
<td>4529.73</td>
<td>673.36</td>
<td></td>
</tr>
<tr>
<td>Site 10</td>
<td>$106114.66</td>
<td>$4539.81</td>
<td>$1.77</td>
<td>23.4</td>
<td>59801.51</td>
<td>1000.54</td>
<td>2178.41</td>
<td>693.44</td>
<td></td>
</tr>
<tr>
<td>Site 11</td>
<td>$111281.05</td>
<td>$6939.70</td>
<td>$3.50</td>
<td>16.9</td>
<td>33481.49</td>
<td>651.87</td>
<td>4787.92</td>
<td>914.91</td>
<td></td>
</tr>
<tr>
<td>Site 12</td>
<td>$78910.12</td>
<td>$6687.29</td>
<td>$2.48</td>
<td>11.8</td>
<td>31851.51</td>
<td>1119.07</td>
<td>3952.68</td>
<td>913.13</td>
<td></td>
</tr>
<tr>
<td>Site 13</td>
<td>$97524.28</td>
<td>$6589.48</td>
<td>$1.03</td>
<td>16.8</td>
<td>94123.15</td>
<td>481.89</td>
<td>4535.75</td>
<td>884.56</td>
<td></td>
</tr>
</tbody>
</table>

(54)
<table>
<thead>
<tr>
<th>NO.</th>
<th>REVEG.</th>
<th>ENVIR.</th>
<th>PREVIOUS USE</th>
<th>POST USE</th>
<th>OVERTHROWN</th>
<th>PHYSICAL</th>
<th>SLOPE</th>
<th>SLOPE BEFORE</th>
<th>HEIGHT OF</th>
<th>HAUL</th>
<th>TYPE OF MINING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2241</td>
<td>206.10</td>
<td>stripped-pasture</td>
<td>pasture</td>
<td>55°</td>
<td>sandstone shale</td>
<td>28°</td>
<td>21°</td>
<td>16°</td>
<td>80°</td>
<td>600°</td>
</tr>
<tr>
<td>2</td>
<td>156.16</td>
<td>559.43</td>
<td>pasture</td>
<td>pasture</td>
<td>55°</td>
<td>sandstone shale slate</td>
<td>29°</td>
<td>22°</td>
<td>16°</td>
<td>81°</td>
<td>500°</td>
</tr>
<tr>
<td>3</td>
<td>74.24</td>
<td>341.81</td>
<td>stripped-pasture</td>
<td>grazing</td>
<td>15°</td>
<td>limestone clay</td>
<td>52°</td>
<td>15°</td>
<td>12°/20°</td>
<td>75°</td>
<td>350°</td>
</tr>
<tr>
<td>4</td>
<td>291.24</td>
<td>145.99</td>
<td>spoils-pasture</td>
<td>hay production</td>
<td>30.5°</td>
<td>sandstone clay limestone</td>
<td>43°</td>
<td>10°</td>
<td>12°/20°</td>
<td>45°</td>
<td>400°</td>
</tr>
<tr>
<td>5</td>
<td>230.75</td>
<td>284.99</td>
<td>grazing</td>
<td>grazing</td>
<td>30°</td>
<td>sandstone shale limestone</td>
<td>55°</td>
<td>10°</td>
<td>15°</td>
<td>35°</td>
<td>200°</td>
</tr>
<tr>
<td>6</td>
<td>119.05</td>
<td>8.95</td>
<td>pasture</td>
<td>pasture</td>
<td>20°</td>
<td>sandstone shale</td>
<td>36°</td>
<td>10°</td>
<td>none</td>
<td>45°</td>
<td>contour</td>
</tr>
<tr>
<td>7</td>
<td>252.74</td>
<td>13.13</td>
<td>unused farm</td>
<td>farmland</td>
<td>65°</td>
<td>sandstone shale</td>
<td>36°</td>
<td>none given</td>
<td>65°</td>
<td>2000°</td>
<td>area</td>
</tr>
<tr>
<td>8</td>
<td>308.75</td>
<td>64.90</td>
<td>stripped-pasture</td>
<td>grazing-cattle</td>
<td>62°</td>
<td>shale limestone clay</td>
<td>47°</td>
<td>10°</td>
<td>12°/20°</td>
<td>65°</td>
<td>800°</td>
</tr>
<tr>
<td>9</td>
<td>297.75</td>
<td>265.58</td>
<td>scrub forest</td>
<td>wildlife refuge</td>
<td>60°</td>
<td>sandstone shale</td>
<td>30°</td>
<td>23°</td>
<td>16°</td>
<td>82°</td>
<td>450°</td>
</tr>
<tr>
<td>10</td>
<td>199.62</td>
<td>475.72</td>
<td>stripped</td>
<td>pasture</td>
<td>55°</td>
<td>sandstone shale</td>
<td>28°</td>
<td>21°</td>
<td>16°</td>
<td>80°</td>
<td>600°</td>
</tr>
<tr>
<td>11</td>
<td>172.69</td>
<td>360.39</td>
<td>stripped</td>
<td>pasture</td>
<td>59°</td>
<td>sandstone shale</td>
<td>28°</td>
<td>23°</td>
<td>16°</td>
<td>82°</td>
<td>600°</td>
</tr>
<tr>
<td>12</td>
<td>394.04</td>
<td>367.50</td>
<td>scrub forest</td>
<td>wildlife refuge</td>
<td>56°</td>
<td>sandstone shale</td>
<td>28°</td>
<td>21°</td>
<td>16°</td>
<td>80°</td>
<td>500°</td>
</tr>
<tr>
<td>13</td>
<td>184.66</td>
<td>441.89</td>
<td>pasture</td>
<td>pasture</td>
<td>60°</td>
<td>sandstone shale</td>
<td>30°</td>
<td>21°</td>
<td>16°</td>
<td>81°</td>
<td>450°</td>
</tr>
</tbody>
</table>

(55)
<table>
<thead>
<tr>
<th></th>
<th>$ Per Acre</th>
<th>$ Per Coal Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Reclamation Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4886.26</td>
<td>2.23</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1731.15</td>
<td>0.868</td>
</tr>
<tr>
<td>Cost of Topsealing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>674.65</td>
<td>0.316</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>363.36</td>
<td>0.1845</td>
</tr>
<tr>
<td>Cost of Backfilling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3119.79</td>
<td>1.44</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1191.20</td>
<td>0.6016</td>
</tr>
<tr>
<td>Cost of Grading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>698.35</td>
<td>0.269</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>266.60</td>
<td>0.118</td>
</tr>
<tr>
<td>Cost of Revegetation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>219.04</td>
<td>0.128</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>60.72</td>
<td>0.116</td>
</tr>
<tr>
<td>Cost of Environmental Controls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>257.42</td>
<td>0.107</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>191.72</td>
<td>0.0884</td>
</tr>
<tr>
<td>SITE NO.</td>
<td>TONS/ACRE</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>SITE 1</td>
<td>821.299</td>
<td></td>
</tr>
<tr>
<td>SITE 2</td>
<td>2124.364</td>
<td></td>
</tr>
<tr>
<td>SITE 3</td>
<td>663.643</td>
<td></td>
</tr>
<tr>
<td>SITE 4</td>
<td>2314.821</td>
<td></td>
</tr>
<tr>
<td>SITE 5</td>
<td>1920.289</td>
<td></td>
</tr>
<tr>
<td>SITE 6</td>
<td>3136.350</td>
<td></td>
</tr>
<tr>
<td>SITE 7</td>
<td>1867.358</td>
<td></td>
</tr>
<tr>
<td>SITE 8</td>
<td>2192.153</td>
<td></td>
</tr>
<tr>
<td>SITE 9</td>
<td>4744.109</td>
<td></td>
</tr>
<tr>
<td>SITE 10</td>
<td>2555.620</td>
<td></td>
</tr>
<tr>
<td>SITE 11</td>
<td>1891.153</td>
<td></td>
</tr>
<tr>
<td>SITE 12</td>
<td>2699.283</td>
<td></td>
</tr>
<tr>
<td>SITE 13</td>
<td>6352.916</td>
<td></td>
</tr>
</tbody>
</table>

MEAN——2559.566
STANDARD DEVIATION——1531.164
CORRELATION COEFFICIENT——(-.1777)

(57)
TABLE 4.5. Proportion of Reclamation Cost for Thirteen Ohio Surface Mines, by Activity

<table>
<thead>
<tr>
<th>SITE NO.</th>
<th>TOPSOIL</th>
<th>BACKFILL</th>
<th>REGRAD</th>
<th>REGRAD+</th>
<th>REVBL</th>
<th>REVBL+</th>
<th>ENVTL</th>
<th>CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE 1</td>
<td>.1593</td>
<td>.6115</td>
<td>.1028</td>
<td>.7143</td>
<td>.0615</td>
<td>.6689</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 2</td>
<td>.1210</td>
<td>.5759</td>
<td>.1419</td>
<td>.7178</td>
<td>.0303</td>
<td>.1088</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 3</td>
<td>.1036</td>
<td>.7388</td>
<td>--</td>
<td>.7388</td>
<td>.1394</td>
<td>.0181</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 4</td>
<td>.1222</td>
<td>.6545</td>
<td>.1694</td>
<td>.8200</td>
<td>.0562</td>
<td>.0096</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 5</td>
<td>.1285</td>
<td>.5965</td>
<td>.1113</td>
<td>.7079</td>
<td>.0746</td>
<td>.0890</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 6</td>
<td>.1045</td>
<td>.7005</td>
<td>.1548</td>
<td>.8594</td>
<td>.0401</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 7</td>
<td>.1349</td>
<td>.7166</td>
<td>.0948</td>
<td>.7512</td>
<td>.0892</td>
<td>.0046</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 8</td>
<td>.2342</td>
<td>.5820</td>
<td>.1241</td>
<td>.7061</td>
<td>.0493</td>
<td>.0104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 9</td>
<td>.1240</td>
<td>.6996</td>
<td>.1040</td>
<td>.8037</td>
<td>.0321</td>
<td>.0410</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 10</td>
<td>.2204</td>
<td>.4799</td>
<td>.1507</td>
<td>.6366</td>
<td>.0440</td>
<td>.1049</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 11</td>
<td>.0930</td>
<td>.6899</td>
<td>.1318</td>
<td>.8218</td>
<td>.0384</td>
<td>.0519</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 12</td>
<td>.1673</td>
<td>.5910</td>
<td>.1365</td>
<td>.7276</td>
<td>.0500</td>
<td>.0550</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE 13</td>
<td>.0731</td>
<td>.6883</td>
<td>.1312</td>
<td>.8196</td>
<td>.0423</td>
<td>.0670</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MEAN    | .1366   | .6404    | .1241  | .7550   | .0567 | .0519  |

STANDARD DEVIATION | .0472 | .0741 | .0342 | .0642 | .0302 | .0375 |
<table>
<thead>
<tr>
<th>Relationship</th>
<th>Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per ton and</td>
<td></td>
</tr>
<tr>
<td>1. cost per acre</td>
<td>-0.1677</td>
</tr>
<tr>
<td>2. overburden depth</td>
<td>0.0390</td>
</tr>
<tr>
<td>3. coal seam width</td>
<td>-0.3942</td>
</tr>
<tr>
<td>4. beginning slope</td>
<td>-0.0079</td>
</tr>
<tr>
<td>5. highwall height</td>
<td>0.0238</td>
</tr>
<tr>
<td>6. length of haul</td>
<td>0.0829</td>
</tr>
<tr>
<td>Cost per acre and</td>
<td></td>
</tr>
<tr>
<td>1. cost per ton</td>
<td>-0.1677</td>
</tr>
<tr>
<td>2. overburden depth</td>
<td>0.4475</td>
</tr>
<tr>
<td>3. coal seam width</td>
<td>0.1780</td>
</tr>
<tr>
<td>4. beginning slope</td>
<td>0.3328</td>
</tr>
<tr>
<td>5. highwall height</td>
<td>0.4698</td>
</tr>
<tr>
<td>6. length of haul</td>
<td>0.4084</td>
</tr>
</tbody>
</table>
As has been shown in the descriptive portions of this study, the nature of surface mining requires disturbing the land surface in serious ways. In many cases it has meant the permanent loss of the land's productivity and has created many and various externalities.

Water is the major component of the environmental threats related to surface mining and reclamation. The mining process greatly disrupts the normal land drainage patterns of the land and exposes sulfur bearing materials resulting in the creation of acid drainage. Other problems, such as soil erosion and subsequent sedimentation are also common problems caused by water in surface mining. Adequate control of water is one of the most important aspects of the surface mining reclamation process.

Previous state regulation's and, more recently, federal legislation's major concern with respect to surface mining has been in the area of environmental controls. Before any control regulations were in effect, operators had no reason to concern themselves with the environmental damages that occurred on and off the mining site. The costs of these damages were passed on to others as externalities both tangible and intangible. Public demand for action to stop unnecessary damage to mined and surrounding areas has led to legislation throughout the mining states and ultimately to a comprehensive Federal law.

Through these regulatory policies, most of the environmental costs created by surface mining have been internalized by the mining operation. The significant emphasis of reclamation legislation in the 1970's has been programs that treat mining as an interim or transitional land use.
The Ohio Strip Mine Law is very similar to the new Federal Surface Mining Control and Reclamation Act of 1977 (PL95-87). The contention of several Ohio mine reclamation engineers is that because of enactment of the new Federal reclamation law the disadvantage of Ohio's coal producers due to legal requirements has disappeared.

Although environmental damage due to surface mining has been severe, it is not an unavoidable consequence of all forms of surface mining. High levels of control can substantially reduce adverse environmental impacts in most areas. The types and severity of damage depend not only on the mining method used, but also on the level and timing of the reclamation which follows. Mining and reclamation methods which significantly reduce these damages have been developed in the past few years. The major methods of surface mining are combinations and/or variations of area, contour and auger mining.

The determination of reclamation costs and their comparison is at best, a difficult process considering the complex combination of physical, economic and management properties affecting each mining operation. Many factors contribute to the costs of reclamation.

It was determined within this study that the cost contributing components of reclamation are the operations of topsealing, backfilling and regrading, the process of revegetation, construction of environmental controls and the materials used to perform these activities. It was these components that were surveyed to determine the costs of reclamation by obtaining the types of equipment used to perform the reclamation activities, their hours in use, and the labor involved in their use. Once this information was obtained, through questionnaires, standardized hourly
rates for operating and ownership of equipment and union wage rates for labor were applied. It was hoped that a more representative response from the survey could have been obtained, however, with the lack of company records, this was not possible. Because of this disappointing response rate (26%) it would be heroic to assume that the survey results are representative of the industry as a whole. The results do provide an estimate of the reclamation costs borne by part of Ohio's coal industry.

All in all, the results of this study and the labor-equipment cost approach taken appear fairly consistent with the results of various other studies using alternative methods of cost estimation. (Evans and Bitler, Nephew and Spore) The average cost of reclamation per acre was estimated to be $6886.26 and the average cost per ton was estimated as $22.25 or 8.2% of the selling price of Ohio coal.

Backfilling appears to be the most time consuming and therefore expensive phase of the reclamation process accounting for an average of 64.0% of the total.

Eleven relationships within the reclamation process were tested by correlation. Most of the results were as expected except when affected by the low negative correlation that resulted between tons and acreage.

As has been displayed by the results of this study, restoration of the land surface after mining entails expenses and in some cases great expense. Because of the increased costs involved in reclamation, decisions must be made on various levels. The mine operator must decide if it is worth his company's time, money and bureaucratic
redtape to mine and reclaim. It is left up to the individual consumer of coal to decide for himself if reclamation costs are worth the inevitable reduction in coal supplies resulting from reclamation. Will reclamation be worthwhile if coal supplies are reduced and less of our most abundant energy source is available? Finally, it is up to the government to listen to and watch the public, both as coal producers and coal consumers, to determine if the coal industry can absorb the increased reclamation costs and if the economy is best served by sacrificing some coal supplies for improved environmental amenities.

ISSUES FOR FURTHER RESEARCH

The issue at hand is a complex one requiring difficult compromises among competing concerns. The ability to choose among alternatives has been limited by the absence of information necessary to understand the implications of decisions. The decisions that must be made concerning our coal resources can better be made under conditions of more perfect information. With the advent of PL05-87 many more of the mining companies within Ohio are starting to keep records on equipment and labor use. Because of this, more and more data will be available for cost estimation in the future. With more data, more sophisticated analysis can be performed leading to greater insight into the cost structure of surface mine reclamation, thus enabling the decision maker to better realize the consequences of his choices. By looking further into the characteristics of the respondents versus the nonrespondents in this study, more insight could be gained into the process of estimating reclamation costs and the process of
separating reclamation from production costs. The cost differences, if any, experienced by larger mine operators versus smaller operators could better be seen if the smaller companies were better represented. Also, it was felt that the type of equipment used to mine an area had an effect on whether a company would participate because of the difficulty in separating production from reclamation activities when certain equipment and methods were used. This could be verified or disproved by further research into respondent versus nonrespondent characteristics.

Another issue that would be helpful to have greater insight into is the degree of relationship between the costs of reclamation and the type of mining method utilized, be it area, contour, or a combination. This would require research into the actual number of acres on each site that was area mined or contour mined as well as obtaining reclamation cost estimates.

Finally, the broader issue seems to be how reclamation requirements affect our supply of coal. Given the current economic problems associated with energy imports, the impact of reclamation costs on supplies of coal and ultimately on the quantity of energy imports bears serious consideration.
APPENDIX A. METHODS OF SURFACE MINING POLLUTION CONTROL

CONTROL RATIONALE

Reasonable control means that every effort should be made to achieve the greatest control without placing unreasonable demands on other activities of the mine. Control of environmental threats and production objectives should be combined and integrated when mining operations are planned.

According to one erosion and sediment manual (Mills and Clar) there are five basic common principles that govern the development and implementation of a sound erosion and sediment control plan for any surface coal mine. These are:

1) Preplanning
   Emphasizes the need to plan the total mining operation to fit the topography, waterways, vegetation and future use of the land and to minimize short and long term damages. This is most effectively done by conducting a complete site investigation at the time of the promising resource investigation.

2) Scheduling of Mining Operations
   Emphasizes the need to expose the smallest practical area of land for the shortest possible time. The way that the various mining activities are scheduled will have a major impact on both the amount of land exposed at any one time and the length of time it remains exposed.

3) Erosion Control
   Emphasizes the need to apply soil erosion control practices as a "first line of defense" against offsite damage. This is done by controlling the vulnerability of the soil to erosion processes or the capability of moving water or wind to detach soil particles.

4) Sediment Control
   Emphasizes the need to apply sediment control practices as a "second line of defense" against damage. Even with a very complete and effective erosion control plan, some sediment will be produced. Sediment controls are designed to slow the flow of water by spreading, ponding, or filtering,
therefore reducing the ability of the water to transport sediment and settling it out of suspension.

5) Maintenance and followup
Emphasizes the need for a thorough maintenance and follow-up plan, which is vital to the success of any erosion and sediment control operation. It calls for thorough, periodic control checks of all erosion and sediment control practices and when problems are revealed it calls for immediate action, for modifications, repairs, cleaning or other maintenance operations. Particular attention should be paid to waterhandling structures (diversions, sediment traps, grade control structures and basins) and areas being revegetated.

Erosion Control Practices

Erosion control technology can be broken into two basic functions, runoff control and soil stabilization.

Stormwater runoff, the principal cause of soil erosion, can be handled in one or a combination of the following:

Reduction and Detention of Runoff
This is accomplished by manipulating the slope length and gradient to reduce the velocity of flow and by grading and shaping the surface to detain the water and increase infiltration. Also, areas of natural vegetation should be preserved to act as buffer zones along streambanks, below spoil sites, around the perimeter of disturbed areas, and above and below access roads.

Interception and Diversions
A key concept is to intercept runoff before it reaches a critical area and to divert it to a safe disposal area. As stated above, this also is a method used in avoiding formation of acid mine drainage. Various diversion structures include such methods as reverse benches or terraces, ditches, earth dikes and combined ditch and dike. See figures A.1 and A.2.

Handling and Disposal of Concentrated Flow
In handling concentrated flow, the objective is to detain the runoff by increasing the flow distance, decreasing the flow gradient and obstructing the flow.

Soil stabilization is the second means of preventing soil erosion.

It is done by protecting the soil from the erosive action of rain, run-
Figure A.1. Slope Reduction Measures.
Figure A.2. Interception and Diversion Measures.
off and wind.

Vegetative establishment is the most effective and the most common means of stabilizing soil, both during the mining process and after mining in the revegetation process. Long term vegetative stabilization (for final revegetation) is accomplished by the proper planting of various combinations of grasses, legumes, shrubs, and trees. Short term vegetative stabilization (for stabilizing spoil during mining) involves the use of low cost, quick growing perennial and annual plants.

The effectiveness of vegetation in stabilizing the soil will be limited unless existing and future site conditions are adequately assessed in the selection of plant material and proper establishment practices are used.

Preparation of the soil is essential to the success of a surface mining reclamation site. After grading, contouring, and topsoiling of the mine site, the soil will require treatments before planting.

Two of the most commonly encountered problems and their treatments are as follows:

Acidity

An important factor in limiting plant growth on surface mined soil is acidity, expressed as pH. Lime, which helps to neutralize the acid condition resulting from exposing layers in the crust which contain iron pyrite, should be applied to raise the pH to acceptable levels.

Low Fertility

The soil, after being mined and graded can be low in nutrients such as nitrogen, phosphorus and sometimes potassium. These are essential for plant establishment and sustained growth. Fertilizers should be added to provide required plant nutrients as determined by soil tests.
To insure success of surface mining reclamation an adequate vegetative cover must be established. The primary objective of planting on surface mined sites is to provide immediate cover for stabilization and erosion control.

Grasses and legumes are very well suited to stabilizing and re-vegetating mined sites. They are adaptable to a number of site conditions and provide a fast, thick and lasting cover.

Trees and shrubs are not very effective in controlling erosion in the early stages of re-vegetation because of their slow growth. But, after their development they form a protective canopy and provide a necessary buildup of surface organic material.

Planting methods vary depending on topography, type of vegetation, stoniness of soil surface and equipment availability.

Currently used methods are:

Hydrosowers; application process where grass seed, mulch, fertilizer and finely ground agricultural lime are sprayed onto a surface in a water solution. The mixture is sprayed under pressure from a truck mounted container.

Aircraft; used for broadcast seeding on large areas, inaccessible areas, and during thawing and freezing periods.

Cyclone Sowers; well suited for broadcasting seed on level areas.

Belt Mounted Blowers; can be attached to line trucks to spread both seed and fertilizer.

Hand Planting; generally used when trees and shrubs are planted. This method is costly and time consuming.

Mulching is required to protect newly seeded areas from erosion during and right after the germination period. Mulch also encourages germination of seed by increasing the amounts of water available and protecting them from wind drying.
Sometimes it is asked why the mine area cannot be left to revegetate itself in a natural manner. Invasion of an abandoned surface mined site by the transported seed of nearby species is very variable, slow, and prone to low coverage percentages. Some areas of a site may never revegetate naturally. Mostly, the invading plant species are undesirable in that they are of little aesthetic, commercial, wildlife or site benefiting value. One 1955 study (Bramble and Ashley) reported that no vegetation was present for the first three years. Considerable erosion could occur during this time. The more favorable areas of the mine site are invaded after four years. The cover value at four to five years may be as high as it will be for the next twenty years.

Sediment Control Practices

The major objective of sediment control is to filter or settle out waterborne sediment sufficiently to meet lawful effluent limitations. For the best possible degree of control, some basic factors must be considered. At-source control is essential. Control should be made at, or as near to, its source as feasible. Also, before at-source control can be performed the source must be identified. Any control plan should clearly identify all major sediment source areas at the mine and also show how the drainage from these areas will be controlled. As in erosion, the concept of runoff control is also a basis for sediment control. Even though the nature of the sediment being transferred cannot be controlled extensively, it is possible to control the velocity and turbulence of the water itself.

Some more common types of control include vegetative buffers,
Sediment traps and sediment basins.

Vegetative Buffers: Natural and installed vegetative buffers used to detain, absorb, and filter overland runoff, therefore trapping sediment.

Sediment Traps: These are small, temporary basins formed by an excavation and/or embankment to intercept runoff containing sediment thereby trapping and retaining it. The traps are installed in roadway ditches and in small drainageways within the site.

Sediment Basins: Sediment basins are the most effective structures for trapping sediment. The purpose of the basin is to remove sediment from runoff and thus protect drainageways, properties, and right-of-way below the sediment basin from sedimentation. The basin is constructed on a waterway to impound runoff. The pond is formed by placing an earthen dam across the waterway, by excavating a depression, or by a combination of the two. This is the conventional method of controlling sediment that reaches the periphery of the mining operation. Because they are installed below the mining operation, on or adjacent to the major waterways, they act as a last line of defense against off-site sediment drainage. They act to reduce the suspended solids concentration to acceptable levels. The amount of sediment removed from runoff depends upon the speed that the water flows through the trap or basin, the amount of time the water is held and the size, shape, and weight of the sediment particles.

All sediment control structures require maintenance throughout their use to perform effectively and efficiently. The most important maintenance problem is the removal of accumulated sediment. Filling of sediment basins reduces its capacity to retain runoff long enough for sediment to settle out of the water before it is carried downstream.

Sediment containment structures are temporary structures, therefore, once the mining is completed all sediment control structures, as well as the accumulated sediment should be disposed of in a proper manner. Natural streams should be returned to original profile and cross section and off-channel excavated ponds should be backfilled and revegetated to blend with surrounding reclamation.
Acid Mine Drainage Control Practices

Acid mine drainage can also be controlled through various measures. Keeping the mining area, especially the pit, free of water is very important. This can be accomplished by pumping and/or diverting the water around and away from the area. Also, water treatment impoundments can be constructed to trap acid water. Once trapped, chemical treatment procedures can be used to neutralize the acid before it is released into the natural waterways. Also, by separating and immediately burying all toxic materials, contact time can be reduced.

Water diversion is frequently used to ease the physical and financial burden of pumping large quantities of water. In surface mining operations, the most commonly used method is to construct a ditch on the uphill (highwall) side of the open cut. Other methods used are diversion of streams into new channels to prevent seepage into or flooding of the work areas and construction of trenches or installation of pipes at the downhill side of the open cut. It is usually possible to construct the channel so that flow will be efficient, therefore, reducing contact time with the acid-producing materials.

The water that does become toxic has to be neutralized. In the neutralization process, an alkali is mixed with acid mine water to neutralize the acid and to precipitate the contaminating metal salts which can then be separated by sedimentation and/or filtration.

Most neutralization processes use lime and limestone as the alkali agent. Other agents may be used in some situations. One study recommends that the choice of an alkaline agent should be based on the following considerations. (Baker, Inc.)
1) Cost of the Agent
   the least expensive agent capable of fulfilling the requirements.

2) Availability of the Agent
   availability, although partially reflected in the cost,
   certain agents may not be possible over the long run.

3) Basicity Factor
   the amount of alkali per unit weight of material varies
   among different alkaline agents.

4) Reaction Time
   rates of reaction vary over a considerable range and are
   important factors in the size of the mixing tanks.

5) Sludge Characteristics
   the settling rate and properties of the sludge are impor-
   tant factors.
APPENDIX B. Major Provisions of the Ohio Strip Mine Law

Below is a presentation of the major provisions of the Ohio Strip Mine Law that pertain to the actual and physical reclamation of mined lands (Energy and Environmental Analysis, Inc.). These are the legal requirements that lead to costs that are involved in the physical reclamation process (backfilling and grading, revegetation and provisions pertaining to water deadlines). Without regulation of these processes there would be no reclamation costs.

I. BACKFILLING AND GRADING

Topsoil
Topsoil shall be segregated and maintained in a condition capable of sustaining vegetation (1533.16 (B)(2)). Topsoil shall be returned to the top of the regraded surface and shall not contain rocks, or other material of a size unsuitable for future use (1533.16 (C)(2)).

M(heap)
Toxic or acid producing materials, roof coal, pyritic shale, or fire hazards shall be immediately covered with nontoxic materials, and shall be buried under adequate fill. All mining refuse shall be buried or removed (1533.16 (B)(3)).

Regrading
The affected land shall be contoured, defined as backfilling and grading the area of land affected, beginning at or beyond the top of the highwall and sloping to the toe of the soil bank at an angle not to exceed the approximate original contour of the land, with no depressions to accumulate water with adequate provisions for drainage (1533.010M), unless approved plan and future use provides for other topography. (1533.16 (G)(1)) The steepest highwall shall not be greater than 35° (1533.07 (A)(8)). The chief of the division of reclamation shall make an inspection of the regrading and topsoiling upon completion.

II. REVEGETATION

No reclamation plan shall be approved which does not provide for immediate establishment of a covering by grasses and legumes,
including a preliminary cover of such plants in areas which are to be planted in trees (1513.07 (A)(8)).

III. PROVISIONS PERTAINING TO WATER

Water impoundments must not result in dilution or acid water problems, and shall be at least six (6) feet deep. While mining and reclaiming, an operator shall prevent pollution of waters of the state, substantial erosion, substantial deposition of sediment, landslides, accumulation or discharge of acid water, and flooding, and shall maintain ditches, dikes, and other drainage facilities necessary to prevent acid water from draining into or accumulating in the pit.

IV. DEADLINES

Backfilling, grading, and topsoiling shall commence within 3 months of the overburden removal, and these operations shall be completed within a year after the end of the license year, or the completion of the operation, whichever is first.

Whenever possible, reclamation shall be required as mining progresses. Planting shall be done not later than the first appropriate season after completion of backfilling, grading and re-soiling (1513.16 (A)).
APPENDIX G. A Comparison Between Sections 515 and 516 of the Federal Proposal RS13700 and the Key Provisions of the Ohio Law and Table C.1, A Comparison of Key Requirements of RS13700 to Existing State Regulations

Section 515 of Title V of PL95-07 contains the specific performance standards for surface mining operations. It is this section that the differences in cost factors between the Ohio law and the Federal law can be seen. (Comparison begins on next page)
the coal deposit, and the thickness of the coal deposit relative to the volume of the overburden is large and where the operator demonstrates that the overburden and other spoil and waste materials at a particular point in the permit area or otherwise available from the entire permit area is insufficient, giving due consideration to volumetric expansion, to reduce the approximate original contour, the overburden, or a minimum, shell, backfill, grade, and compact (where advisable) using all available overburden and other spoil and waste materials to attain the lowest practicable grade but not more than the angle of repose, and to cover all acid-forming and other toxic materials to the extent of the area originally sound land use compatible with the surrounding region: And provided that in surface coal mining where the volume of overburden is large relative to the thickness of the coal deposit and where the operator demonstrates that due to volumetric expansion the amount of overburden and other spoil and waste materials required in the course of the mining operation is more than sufficient to reduce the approximate original contour, the operator shall after restoring the approximate contour, backfill, grade, and compact, (where advisable) the excess overburden and other spoil and waste materials to attain the lowest grade but not more than the angle of repose, and to cover all acid-forming and other toxic materials, in order to achieve an ecologically sound land use compatible with the surrounding region and that such overburden or spoil shall be shaped and graded in such a way as to prevent slope erosion and water pollution and to reverts to the source with the requirements of this Act
(4) stability and reclamation standards for piles affected by the surface coal mining and reclamation operation to prevent slope erosion and attendant air and water pollution;
(5) remove the topsoil from the land in a separate layer, replant it on the backfill area, or, if not utilized immediately, segregate it in separate piles from other spoil and, when the topsoil is not replaced on a backfill area within a time short enough to avoid deterioration of the topsoil, maintain a survea

Ohio’s law is similar but does not address potential air pollution.
Ohio’s law has similar topsoil requirements.
ful cover by quick growing plant or other means thereafter so that the top soil is preserved from wind and water erosion, remains free of any contamination by acid or toxic material, and is in a suitable condition for sustaining vegetation when re-stored during reclamation, except if top soil is of insufficient quantity and quality and a suitable substitute can be shown to be more suitable for vegetation require-ments, then the operator shall remove, acquire, and preserve in a like manner such other strata which is best able to support vegetation;
(5) restore the topsoil or the best available strata which has been removed and preserved;
(7) protect surface areas from slides or damage occurring during the surface coal mining and reclamation operations, and not deposit spoil material or locate any part of the operations or waste accumulations outside the permit area;
(8) create, if authorized in the approved mining and reclamation plan and permit, permanent impoundments of water on mining sites as part of reclamation activities only when it is adequately demonstrated that:
(A) the site of the impoundment is adequate for its intended purposes;
(B) the impoundment dam construction will be so designed as to achieve necessary stability with an adequate margin of safety comparable with that of structures constructed under Public Law 85-256 (19 U.S.C. 1001);
(C) the quality of impounded water will be suitable on a permanent basis for its intended use and that discharges from the impoundment will not degrade the water quality in the receiving stream;
(D) the level of water will be reasonably stable;
(E) final grading will provide adequate safety and access for proposed water uses; and
(F) such water impoundments will not result in the dissolu-
H.R. 13550—Continued

(9) plug all auger holes to a minimum of six feet in depth with an imperious and noncombustible material (such as clay) to prevent the flow of water in or out of such holes;

(10) ameliorate the disturbances to the prevailing hydrologic balance at the mine site and in adjacent surface areas and in the quality and quantity of water in surface and ground water systems both during and after surface coal mining operations and during reclamation by use of fill or other toxic mine drainage by such measures as, but not limited to,

(i) preventing or removing water from contact with toxic producing deposits;

(ii) treating drainage to reduce toxic content which adversely affects downstream water upon being released to water courses;

(iii) sealing, sealing, or otherwise managing boreholes, shafts, and wells and impound or other toxic drainage from entering ground and surface waters;

(iv) conducting surface coal mining operations so as to prevent, to the extent possible using the best technology currently available, additional contributions of suspended solids to streamflow or runoff outside the permit area above natural levels under normal flow conditions as measured prior to any mining, and avoiding channel deepening or enlargement in operations requiring the discharge of water from mines;

(C) removing temporary or large structure structures from drainage ways after disturbed areas are regraded and stabilized;

(D) ensuring recharge capacity of the mined area to approximate premining conditions;

(E) replacing the water supply of an owner of interest in real property who obtains all or part of his supply of water for domestic, agricultural, industrial, or other legitimate uses from an underground or surface source where such supply has been affected by contamination, diminution, or interruption proximately resulting from mining.
(F) preserving throughout the mining and reclamation process the essential hydrologic functions of surface water sources in the soil and upland areas of the country; and
(G) such other actions as the regulatory authority may prescribe:
(11) with respect to surface disposal of mine wastes, tailings, coal processing wastes, and other wastes in areas other than the mine working or reclamation, stabilize all waste piles in designated areas through construction in compact layers, including the use of incombustible and impermeable materials, if necessary, and assure the final content of the waste pile will be compatible with natural surroundings and that the site can and will be stabilized and revegetated according to the provisions of this Act;
(12) refrain from surface coal mining within five hundred feet from active and abandoned underground mines in order to prevent breakthroughs and to protect health or safety of miners; Provided, That the regulatory authority shall permit an operator to mine closer to an abandoned underground mine: Provided, That this does not create hazards to the health and safety of miners; or shall permit an operator to mine within five hundred feet of an active underground coal mine; Provided further, That any mining under conditions of the law, including those necessary to establish and continue surface mining where such mining through will achieve improved water recovery, abatement of water pollution or elimination of public hazards and such mining shall be consistent with the provisions of this Act;
(15) do not locate, construct, operate, maintain, modify, and remove, or abandon, in accordance with the standards and criteria developed pursuant to subsection (e) of this section, all existing and new coal mining waste piles consisting of mine wastes, tailings, coal processing wastes, or other liquids and solid wastes and used either temporarily or permanently as dams or embankments;
(14) insure that all debris, acid forming materials, toxic materials, or materials constituting a fire hazard are treated or disposed of in a manner designed to prevent contamination of ground or surface waters or sustained combustion;

The Ohio Strip Mine Law does not include regulation of disposal of mine wastes, tailings, etc. The Division of Water within the Department of Natural Resources has control over the safety and stability of water holding embankments associated with coal processing. There is no physical reason why the Ohio Strip Mine Law would not be similar to the proposed Federal regulations with regards to this item.

Ohio has similar language in the proposed Strip Mine Rules.

Same response as in Sec. 815(b)(11). Control is presently carried only with consideration to safety and stability by the Division of Water.

Ohio's law has similar language.
(15) insure that explosives are used only in accordance with existing State and Federal law and the regulations promulgated by the regulatory authority, which regulations include provisions to—
(A) provide adequate advance written notice by publication and/or posting of the planned blast; (B) provide advance regulation of governments and to residents who might be affected by the use of such explosives and materials for a period of at least two years; a log of the magnitude and time of blasts; and
(B) limit the type of explosives and detonating equipment, the size, the timing and frequency of blasts based upon the physical conditions of the site as to prevent (1) injury to persons, (2) damage to public and private property outside the permit area, (3) adverse impacts on any underground mine, and (iv) change in the course, channel, or availability of ground or surface water outside the permit area;
(16) insure that all reclamation efforts proceed in an environmentally sound manner and as contemporaneously as practicable with the surface coal mining operations;
(17) insure that the construction, maintenance, and maintaining conditions of access roads into and across the site of operations will control or prevent erosion and siltation, pollution of water, damage to fish or wildlife or their habitat, or public or private property; Provided, That the regulatory authority may permit the retention after mining of certain access roads where consistent with State and local land use plans and programs and when necessary may permit a limited exception to the restoration of approximate original contours for that purpose;
(18) prohibit the construction of roads or other access ways up a stream bed or drainage channel or in such proximity to such channel as seriously after the normal flow of water; to such changes in the channel, and all other lands affected, a diverse, effluent, and permanent vegetative cover native to the area of land to be affected and capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area; except, that intro-

Ohio Law—Continued
Ohio has similar blasting rules.

Ohio's law is similar.

Ohio law does not specifically prevent construction of haul road up stream beds.

Ohio's revegetation requirements are similar.
(b) by removing all of the overburden and creating a level plateau or a gently rolling contour with no highwals remaining, and capable of supporting postmining uses in accord with the requirements of this subsection.

(3) In cases where an industrial, commercial (including commercial agricultural), residential or public facility (including recreational facilities) development is proposed for the postmining use of the affected land, the regulatory authority may grant a variance for a surface mining operation of the nature described in subsection (c)(2) where—

(A) after consultation with the appropriate land use planning agencies, if any, the proposed development is deemed to constitute an equal or better economic or public use of the affected land, as compared with the prevailing use;

(B) the equal or better economic or public use can be obtained only if one or more exceptions to the requirements of section 355(c)(3) are granted;

(C) the applicant presents specific plans for the proposed postmining land use and appropriate assurances that such use will be—

(i) compatible with adjacent land uses;

(ii) obtainable according to data regarding expected need and market;

(iii) assured of investment in necessary public facilities;

(iv) supported by commitments from public agencies where appropriate;

(v) practicable with respect to private financial capability for completion of the proposed development;

(vi) planned pursuant to a schedule attached to the reclamation plan so as to integrate the mining operation and reclamation with the postmining land use; and

(vii) designed by a registered engineer in conformance with professional standards established to assure the stability, drainage, and configuration necessary for the intended use of the site.

Ohio Law—Continued

Ohio can grant variances from "original contour" for agricultural, residential or public facilities but does not require the detailed information as proposed in the Federal law Sec. 355(c)(3)(C). However, other variance provisions are similar.
(D) the proposed use would be consistent with adjacent land uses and existing state and local land use plans and programs;

(E) the regulatory authority provides the governing body of any pertinent local or regional government in which the land is located and any state or federal agency with which the regulatory authority has an agreement, determinations to have an interest in the proposed use, an opportunity of not more than sixty days to review and comment on the proposed use, and an opportunity of not more than sixty days to hold a public hearing or otherwise take action on the proposal;

(F) a public hearing is held in the locality of the proposed surface coal mining operation prior to the grant of any permit including a variance; and

(G) all other requirements of this section will be met.

(4) In granting any variance pursuant to this subsection the regulatory authority shall require that:

(A) the toe of the lowest coal seam and the overburden associated with it are retained in place as a barrier to acid and erosion;

(B) the reclaimed area is stable;

(C) the resulting planes or rolling contour drains inward from the catwalks except at specified points;

(D) no damage will be done to natural watercourses;

(E) all other requirements of this Act will be met.

(5) The regulatory authority shall promulgate specific regulations to govern the granting of variances in accord with the provisions of this section, and may impose such additional requirements as he deems to be necessary.

(6) All applications for variances under the provisions of this subsection shall be reviewed not more than three years from the date of issuance of the permit, unless the applicant affirmatively demonstrates that the proposed development is proceeding in accordance with the terms of the approved schedule and reclamation plan.

Ohio law does not specifically consider the leaving of the toe of the lowest coal seam.

Ohio’s Chief of the Division of Reclamation may promulgate regulations governing variances.

Ohio law does not consider a three-year review of these types of permits.
H.R. 12306—Continued

(d) The following performance standards shall be applicable to
steep-slope surface coal mining and shall be in those general per-
formance standards required by this section: Provided, however,
That the provisions of this subsection (d) shall not apply to those
situations in which an operator is mining on flat or gently rolling
terrain, on which an occasional steep slope is encountered through
which the mining operation is to proceed, having a plain or pre-
dominantly flat area:

(3) Insure that when performing surface coal mining on steep
slope, no debris, abandoned or disabled equipment, spoil material,
or waste mineral matter be placed on the downslope below the
leach or mining cut, except that where necessary spoil or spoil ma-
terial from the initial block or short linear cut of earth necessary to
obtain initial access to the coal seam in a new surface coal mining
operation can be placed on a limited and specified area of the
downslope below the initial cut if the permits demonstrates that
such spoil or spoil material will not slide and that the other require-
ments of this subsection can still be met: Provided, That spoil
material in excess of that required for the reconstruction of the ap-
propriate original contour under the provisions of paragraph 815
(5)(6) or 843(4)(6) or excess spoil from a surface coal mining op-
eration granted a variance under subsection 843(c) may be per-
labeled or used, by any mining operator, and the mining oper-
tory authority shall designate and for the purposes of this Act such
areas shall be deemed in all respects to be part of the lands selected
by surface coal mining operations. Such offsite spoil storage areas
shall be designed by a registered engineer in conformance with
professional standards established to ensure the stability, damage,
and configuration necessary for the intended use of the site.
(2) Complete backfilling with spoil materials shall be required to cover completely the highwall and return the site to the approximate original contour, which material will maintain stability following mining and reclamation.

(3) The operator may not disturb land above the top of the highwall unless the regulatory authority finds that such disturbance will facilitate compliance with the environmental protection standards of this section. Provided, however, that the land disturbed above the highwall shall be limited to that amount necessary to facilitate said compliance.

(4) For the purposes of this section, the term "steep slope" is any slope above twenty degrees or such greater slope as may be defined by the regulatory authority after consideration of soil, climate, and site conditions.

(5) The Secretary, with the written concurrence of the Chief of Engineers, shall establish within one hundred and thirty-five days from the date of enactment, standards and criteria regulating the design, location, construction, operation, maintenance, enlargement, modification, removal, and abandonment of new and existing coal mine waste piles referred to in section 5514.13 and section 5513.02(15). Such standards and criteria shall conform to the standards and criteria used by the Chief of Engineers to ensure that flood control structures are safe and effectively perform their intended function. In addition to engineering and other technical specifications the standards and criteria developed pursuant to this subsection must include provisions for review and approval of plans and specifications prior to construction, enlargement, modification, removal, or abandonment; performance of periodic inspections during construction; issuance of certificates of approval upon completion of construction; performance of periodic safety inspections; and issuance of notices for required remedial or maintenance work.

Ohio's law is similar. No such wording in the Ohio law. Ohio has no such steep slope definition. However, 20 degrees is a good cutoff point for Ohio conditions. We have problems on slopes steeper than 20 degrees.
<table>
<thead>
<tr>
<th>Permit Application and Bonding</th>
<th>Arkansas</th>
<th>West Virginia</th>
<th>Kentucky</th>
<th>Virginia</th>
<th>Maryland</th>
<th>New Jersey</th>
<th>Pennsylvania</th>
<th>Ohio</th>
<th>Indiana</th>
<th>Illinois</th>
<th>Missouri</th>
<th>North Dakota</th>
<th>Montana</th>
<th>Utah</th>
<th>Nevada</th>
<th>Alaska</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Mining and reclamation plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Core and auger analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Topographic maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Core location maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Water quality analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hydrologic impact assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Peatland soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inspections and reporting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Bonding criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Minimum bond amount</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Reclamation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Spills at downsteam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Topsoil handling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Auger holes plugged</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Acid mine drainage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sedimentation control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Vegetation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Surface effects of deep mine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Indicates that provisions in H.R. 13950 appear considerably more stringent than existing requirements.

g/ mining is on Indian, federal, and/or state lands; case-by-case exceptions and/or federal regulations apply. Comparison shown in federal leases that conflict against H.R. 13950.

h/ Note: H.R. 13950 the permit application fee is based upon (but may be less than) anticipated cost of reviewing, administering, and enforcing permit.

i/ Assume that in H.R. 13950, "best technology currently available" is equivalent to EPA's 1983 standard, or "best available technology economically achievable.

Table C.1: Comparison of Key Requirements of HR 13950 to Existing State Regulations.


(90)
APPENDIX D. Definitions of Newer Methods of Mining Used to Prevent Environmental Damages

BLOCK-OUT METHOD

This technique provides concurrent reclamation with minimal disturbance and environmental impacts on adjacent lands. Also known as the modified block-cut, haul back, and pit storage, this method is a simple innovation of the conventional contour strip mining method for steep terrain. (See Figure D.1, D.2, and D.3) No spoils are deposited on the downslope below the coal seam, topsoil is saved, overburden is removed in blocks and deposited in prior cuts and the outcrop barrier is left intact.

When beginning the mine, a block of overburden is removed down to the coal seam. This first cut spoil can be placed above the highwall or moved laterally and deposited in a head-or-hollow fill or ridge fill. After the coal is removed, the overburden from the second cut is placed in the first pit and the coal from the second cut is removed. This process is repeated as mining progresses around the mountain.

West Virginia Reclamation Chief, Benjamin C. Greene, has stated the following about the block-out method:

"as far as we're concerned its the way of the future if we are to continue contour surface mining... The environmental effects are very minimal and can be totally controlled by this mining method." (Greene)

Benefits and advantages of the block-out method over conventional contour strip-mining have been demonstrated at producing mines under varying conditions and include: (Grim and Hill, 1974)
Figure D.1. Block-cut Method


Figure D.2. Block-cut Method: Stripping Phase

Source: Environmental Protection in the Surface Mining of Coal. E.C. Grim and R.D. Hill. See figure D.1.
Figure D.3. Block-cut Method: Backfilling Phase
Source: Environmental Protection in the Surface Mining of Coal. E.D. Grim and R.D. Hill. See figure D.1.

Figure D.4. Head-of-Hollow Fill
Source: Environmental Protection in the Surface Mining of Coal. E.D. Grim and R.D. Hill. See figure D.1.
1.) Spoil on the downslope is totally eliminated. Since no fill bench is produced, landslides have been eliminated.

2.) Mixed area is completely backfilled, and since no highwall is left, the area is aesthetically more pleasing.

3.) Acreage disturbed is approximately 60% less than that disturbed by conventional contour mining.

4.) Reclamation costs are lower, as the overburden is handled only once instead of 2 or 3 times.

5.) Slope is not a limiting factor.

6.) This method is applicable to multi-seam mining.

7.) Bonding amounts and acreage fees have been reduced.

8.) Size of the disturbed area drainage system is smaller.

9.) Size and number of sediment control structures have been reduced.

10.) Revegetation costs have been considerably reduced and it is easier to keep the seeding current with the mining. Bond releases are quicker.

11.) Overburden is easily aggregated, topsoil can be saved, and toxic materials can be deeply buried.

The modified block-cut method of surface mining adapts the block method to steeply sloped areas. The modification essentially is back-filling with spoil from succeeding blocks rather than from the spoil-producing block.

**HEAD-OF-HOLLOW FILL METHOD**

This method was developed to improve aesthetics, reduce landslides, allow for full recovery of one or more coal seams and produce rolling mountaintop land that is suitable for other purposes besides forestry.

It provides storage space for spoil from the removal of entire mountaintops and is also used as a waste area for overburden from con-
tour benches. Previously islands of mountains were left, with no access, as the top coal seams were worked on the contour with a rim cut. These isolated areas left from past mining operations are not being removed.

Narrow V-shaped steep sided valleys, or hollows, close to the top of the ridge, which are absent of underground mine openings or wet weather springs, are chosen for filling. The size of the selected location must be such that the overburden from mining will completely fill the treated head of hollow. (See Figure D.4)

If constructed correctly, the fill can be expected to be stable. Failure in the fill is prevented because adequate friction is provided from the horizontal and vertical pressures that are created.

A large, stable and fairly level area can be constructed with this method, instead of leaving miles of unstable outcrops with the possibility of slides and erosion, or the aforementioned islands of isolated land. Several head-of-hollow fills have passed through five winters with no slides and little or no erosion.

MOUNTAINTOP REMOVAL METHOD

This method, which is an adaptation of area mining for rolling to steep terrain, has been both encouraged and discouraged in the Appalachian Coal Region. It is being practiced currently in Ohio.

Where coal seams are located near the tops of mountains, ridges, knobs, or knolls, they can usually be economically surface mined. The entire tops are removed down to the coal seam in a series of parallel cuts. Excess overburden that can't be kept on the mined
area is taken to head-of-hollow fills, stored on ridges or placed in
natural depressions. This method produces large plateaus of level,
rolling land that in some circumstances may have great value in moun-
tainous regions. (See Figures D.5, D.6, and D.7)

Some advantages and disadvantages of this method are as follows:
(Grin and Hill, 1974)

Advantages:

1.) Coal is recovered from areas that would not be mined
because they are unsuitable for underground mining.
Since all the coal is recovered the reclaimed areas
won't be disturbed again by future mining.

2.) The method creates large, flat to rolling areas that
are vitally needed in mountainous regions. The end
result has an enormous post-mining land use potential
when properly completed.

3.) Spoil has been totally eliminated on the down-slope.
Since no fill bench is produced, landslides are eliminated.

4.) Mined area is completely backfilled and more acceptable
aesthetically, because no highwall is left.

5.) Size of the drainage system is smaller and the number
of sediment control structures have been reduced.
Erosion is easily controlled because of the low velocity
and quantity of surface water runoff.

6.) Overburden is easily segregated, topsoil can be saved,
and toxic materials can be deeply buried.

Disadvantages:

1.) Detailed topographic maps must be available if proper
preplanning is to be accomplished. Before mining begins
the final spoil thickness above the bottom of the coal
pit must be estimated. If the estimate is low then the
pits must be narrowed, and in some instances the operation
will become spoil bound. The result of underestimating
is unnecessary double handling of spoil material which
increases cost and ties up the earth moving machines.

2.) Investment costs for spoil haulage equipment are increased.
Figure D.5. Mountaintop Removal Method; First Cut
Source: Environmental Protection in the Surface Mining of Coal, E.C. Cris and R.B. Hill. See figure D.1.

Figure D.6. Mountaintop Removal Method; Second Cut
Source: Environmental Protection in the Surface Mining of Coal, E.C. Cris and R.B. Hill. See figure D.1.

Figure D.7. Mountaintop Removal Method; Fourth Cut
Source: Environmental Protection in the Surface Mining of Coal, E.C. Cris and R.B. Hill. See figure D.1.
3.) Special precautions must be taken in scheduling the various phases of mining so as to realise maximum production and eliminate downtime.

4.) It is the opinion of many that because the natural and original shape of the terrain is not restored that this method should be discouraged.
APPENDIX E. Questionnaire used for Survey of Sampled Ohio Mine Sites

Survey of Reclamation Activities

This study is being conducted by the Ohio State University and the Ohio Agricultural Research and Development Center in cooperation with the Surface Mining Industry. All individual responses will be kept in strictest confidence. Please answer completely and to your best knowledge.

The following questions pertain to surface mine permit # ______

1. What was the average depth of overburden over the permit area?

2. Before mining, what was the general physical makeup of the overburden? (Shale, limestone, clay, etc.)

3. What was the average thickness of the coal seam over the permit area?

4. What was the average slope of the permit area before mining? After mining?

5. What was the average length of haul for the storage of topsoil?

6. a) What was the approximate height of the highwall before backfilling?

   b) Was blasting used to lower the highwall before backfilling? If yes, what was used and in what amounts.

7. a. List each piece of equipment used along with the amount of hours it was in operation on this permit site.

   b. How many hours was each piece used for reclamation only?
c. Breakdown the usage hours of each piece of equipment by completing the accompanying table.

| Equipment Used  | Hours in Use | Construction of Environmental Contro
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ponds, ditches, etc.</td>
</tr>
<tr>
<td>Topsoil Removal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.  
2.  
3.  
4.  
5.  
6.  
7.  
8. What type and capacity was the equipment used to strip the area?  
9. Was any labor other than that for the operation of equipment and machinery used in the reclamation process?  
   If yes, how many hours were used and for what general purposes?  
10. Is your labor union or non-union?  
11. a. Was the revegetation process performed by your operation or was it contracted to another firm?  
b. If done by another firm, what was the contract price?  
c. If done by your operation, list the amount of materials used in both temporary and permanent revegetation.  
   
<table>
<thead>
<tr>
<th>Amount of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
</tr>
<tr>
<td>Fertilizer</td>
</tr>
<tr>
<td>Mulch</td>
</tr>
<tr>
<td>Lime stone</td>
</tr>
<tr>
<td>Trees - shrubs</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
12. Did you make any investments (other than moving costs) in water pollution control structures or neutralizing agents such as lime stone, etc.  
   If yes list them and their purposes.
September, 1978

Dear Sirs:

In partial fulfillment of ongoing research for the project titled "Research on Hydrology and Water Quality of Watersheds Subjected to Surface Mining," a questionnaire is enclosed for completion by your company. This project is being funded, in part, by The Bureau of Reclamation, and several Ohio coal companies are cooperating in project activities.

Your company's permits were selected at random from a Department of Natural Resources list of permits released during the year 1-1-77 through 8-31-78.

The information obtained from the questionnaire and other sources will be used to estimate the importance of several variables to the mining and reclamation process as well as their effect on pollution control.

With your cooperation in completing this form, it is hoped that this project will be of benefit to the Coal Mining Industry. Our goal is to provide the mine operator with more complete information to be utilized in operating decisions and to reduce costs through more efficient use of mining, reclamation, and pollution control methods.

Answer completely and to your best knowledge. A researcher will be in contact with you to set up a time to pick up the forms. She will also answer any questions you may have about the questionnaire itself or the actual research. All information obtained will be held in strictest confidence.

Your cooperation is voluntary, but, the greater the response rate, the more valuable will be the results of our work, therefore, your contribution is greatly appreciated.

Sincerely,

Jennifer C. Flacken
Graduate Research Associate

D. Lynn Foster
Associate Professor

(101)
Bibliography and References


Lawson, Fred. Personal Contact. Carl H. Guepel Construction Company, Inc. and Freeman Branch Mining Company, 1661 West Henderson Road, Columbus, Ohio.


Ohio Department of Industrial Relations. 1977 *Divisor of Mines Report*. Helen K. Evans, Director. Columbus, Ohio.

Ohio Department of Natural Resources, Division of Reclamation. *Ohio Strip Mine Law*.

Ohio Department of Natural Resources, Division of Reclamation. *Strip Mine Rules*.

Ohio Revised Code, Chapter 153. *Ohio Strip Mine Law*. Ohio Department of Natural Resources, Division of Reclamation.


Schottman, A. A Regional Evaluation of Surface Mining Regulations. Appalachian Resources Project, University of Tennessee, 1975.