THE PENNSYLVANIA STATE UNIVERSITY

Report of Research

on

Pennsylvania's Coal Resources

Conducted Under the Auspices of the

Department of Mines and Mineral Industries
of the
Commonwealth of Pennsylvania

NUMBER IPR-20
JANUARY 1, 1967

University Park, Pennsylvania
REPORT OF RESEARCH

conducted by

The Pennsylvania State University

on

PENNSYLVANIA'S COAL RESOURCES

under the auspices of the

DEPARTMENT OF MINES AND MINERAL INDUSTRIES

of the

COMMONWEALTH OF PENNSYLVANIA

H.B. Charmbury, Chairman

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Interim Progress Report
Number IPR-20
for the period of
July 1, 1966 through December 31, 1966
Submitted
via the
Coal Research Committee
The Pennsylvania State University

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University Park, Pennsylvania
January 10, 1967
STATEMENT OF TRANSMITTAL

This Interim Progress Report contains the technical and fiscal reports on Department of Mines and Mineral Industries Projects for the six month contract period beginning July 1, 1966. As per established practice, the report consists of two major sections. Section I contains the technical reports, projected plans and information on project personnel. Section II contains the fiscal reports on each project.

During the period, July 1, 1966, through December 31, 1966, thirteen programs of research were active under Department of Mines and Mineral Industries contracts at The Pennsylvania State University. Four Special Research Reports were issued during the period bringing the total to 60. Requests for 321 copies of Special Research Reports were received and fulfilled during the period.

William Spackman, Director
Office of Coal Research Administration
Institute for Science and Engineering
and
Coal Research Section
College of Earth and Mineral Sciences
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SECTION I

RESEARCH REPORTS
College of Earth and Mineral Sciences

INTERIM RESEARCH REPORT

Contract Number: CR-38

Title of Investigation: Investigation of the Technical Aspects of Deep Well Disposal of Mine Water

SUMMARY OF PROGRESS AND PROJECTED PLANS

Objectives: The main objectives of this investigation were:

1. To assist the Bethlehem Mines Corporation in all ways possible in the development, completion, testing and utilization of a disposal well and disseminate the results in a special report.

2. To continue the study of Pennsylvania geologic formations in an attempt to locate suitable subsurface disposal zones in the central Pennsylvania bituminous region and the anthracite area.

3. Investigate other approaches to the abatement or control of mine water.

Results:

The first objective has been achieved. A special report (SR-60) has just been released that describes the experimental well in detail.

The second objective has also been achieved. Extensive data have been compiled for the central Pennsylvania area. A special report is now being prepared. Unfortunately, due to a complete lack of suitable drill hole data, no report can be made on the anthracite area.
Emphasis has been placed on achieving the third objective. The full-time field man working on this project resigned his position August 31, 1966. Fortunately, the work on the deep well disposal aspect of this project was largely completed, and thus his loss has not been as serious as it might otherwise have been. However, because of the uncertainties associated with a renewal of this project, he has not been replaced nor are plans being made to replace him at this time.

Present efforts are being concentrated on determining other aspects of abatement and control. At this time, it is thought that the project should concern itself with an operations research approach to the overall problem. This research would include:

1. Mathematical modeling of stream, acid, and treatment systems.
2. Manipulation of the model by mathematical programming to find the cheapest treatment system that will keep the stream system clean.
3. Development of a control system (cybernetics) to monitor conditions in streams and to initiate actions to keep all streams clean.
4. Monte Carlo simulation of the developed treatment and control system to evaluate expected performance.

Coincident with this, an experimental phase of the study will be developed wherein the above methods can be applied to an existing watershed.
Obviously, an operations research approach would require a considerable commitment in terms of time, personnel and money. Since funds are now nearly exhausted, this is an appropriate time to propose such a program in order that the appropriate personnel might be secured. Therefore, such a proposal is being prepared to present to the Coal Research Board.

Prepared by:
R. Stefanko

PERSONNEL:  R. Stefanko, Principal Investigator, Professor of Mining Engineering
Charles B. Manula, Assistant Professor of Mining Engineering
INTERIM RESEARCH REPORT

Contract Number: CR-39

Title of Investigation: Strip Mining and Land Restoration

SUMMARY OF PROGRESS AND PROJECTED PLANS

Statement of Progress:

All collection of data has been completed, and the final reports are in the process of preparation.

Prepared by:

B.J. Kochanowsky

PERSONNEL: B.J. Kochanowsky, Principal Investigator, Professor of Mining
L. Perichon, Research Assistant
B. Trafton, Graduate Assistant
INTERIM RESEARCH REPORT

Contract Number: CR-40

Title of Investigation: Optimization of Mine Production Systems for Low Cost Mining

SUMMARY OF PROGRESS AND PROJECTED PLANS

During the past six months, three industry-submitted problems have been received from operating management. The first of these from central Pennsylvania requested a simulation study to determine future operating policies for an existing belt conveyor system as a result of expanding production. This study has been completed and a Special Report is being prepared along with a written evaluation by company personnel on the quality of work done. A paper (preprint No. 67-AR-28) has been written for SME as part of the study and will be presented at the February AIME Meeting in Los Angeles.

A second operating group located in southwestern Pennsylvania asked for technical assistance and research information to aid company engineers in the simulation of a three shuttle-car system. A Special Research Report is not warranted here; however, written testimonials will be secured from operating management regarding the level of assistance received.

We are currently engaged in gathering and coding field data for problem three. Management's desire in this case is the application
of mathematical programming techniques to solve the problem of production scheduling and stockpiling of coal as it is found to exist in anthracite mining. A Special Report will be submitted for printing upon completion of this study.

Prepared by:

C.B. Manula

PERSONNEL: C.B. Manula, Principal Investigator, Assistant Professor of Mining Engineering
INTERIM RESEARCH REPORT

Contract Number: CR-44

Title of Investigation: Study of High Moisture Pulverized Coal
Flames with Supplementary Study of Time-to-Ignition of Coal
Dusts and Their Dependence on Moisture Content

SUMMARY OF PROGRESS AND PROJECTED PLANS

As indicated in the last Interim Progress Report, work has been completed on this project and, as shown in the fiscal report contained in Section II, all monies have now been expended.

Prepared by:

R.H. Essenhigh

PERSONNEL: R.H. Essenhigh, Principal Investigator, Associate Professor of Fuel Science
INTERIM RESEARCH REPORT

Contract Number: CR-45

Title of Investigation: Economic Importance of the Coal Industry to Pennsylvania

SUMMARY OF PROGRESS AND PROJECTED PLANS

Chapter II, The Coal Industry of Pennsylvania, has been completed for multilith reproduction by the Coal Research Section. Chapter I, Measures of Importance, and Chapter III, A Look at Two Counties, are in preparation. A Summary and Introduction plus the concluding chapters will be completed during the Spring for assembly into the completed report before the end of the fiscal year.

The following presentation was given at the annual meeting of the Coal Mining Institute of America on December 16th and is provided as a preliminary resume of the full report.

COAL IN THE ECONOMY OF PENNSYLVANIA

To understand the impact of one body on another, you must know the characteristics of both bodies. So it is with regional economies and their subsectors. Pennsylvania has been characterized as a bi-polar economy with its centers at either end of the state, Philadelphia and Pittsburgh. It is oriented to heavy industry for historical as well as reasons of natural resources availability. The historical reasons are more important now that the character and location of national economic activity has shifted significantly.
THE ECONOMY OF PENNSYLVANIA

Since a developed economy such as that of the United States needs relatively less of the heavy industrial goods, which Pennsylvania is best equipped to manufacture, and relatively more of the consumer goods and services that mean the good life in a society as affluent as ours, Pennsylvania has lost economic position relative to the nation as a whole.

To judge how coal contributes to the economy, it is necessary to first take a broad look at where coal fits. Our study is based on 1963 data for the good reasons that that was the year preceding the start of the study and also because a Federal Census of the Mineral Industries was taken that year. Presented below are some gross figures dealing with the Pennsylvania economy.

SELECTED MEASURES OF PENNSYLVANIA ECONOMY - 1963

(employment in thousands, dollars in millions)

<table>
<thead>
<tr>
<th></th>
<th>Employment</th>
<th>Wages and Salaries</th>
<th>Value of Shipments</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>4,279</td>
<td>19,066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1,397</td>
<td>7,896</td>
<td>28,215</td>
<td>13,792</td>
</tr>
<tr>
<td>Mining</td>
<td>48</td>
<td>268</td>
<td>809</td>
<td></td>
</tr>
<tr>
<td>Coal Mining</td>
<td>36</td>
<td>200</td>
<td>535</td>
<td>396</td>
</tr>
<tr>
<td>*Coal Trspt.</td>
<td>9</td>
<td>48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*estimate based on use of ratios calculated from public statements of railroad and trucking officials.
You will note immediately that coal accounts for a little over one per cent of wages and salaries paid in the state (it is even less of total personal income which was over $28 billion in 1963). If you select just Mining and Manufacturing to review, then Coal mining accounts for just two and one half per cent of the total paid to employees of these groups. Because coal is a natural resource, the value added in mining is proportionally higher than are value added figures for manufacturing. The table shows shipment values also. Value added by coal mines comes to 75 per cent of shipments. Manufacturers, on the other hand, who process materials supplied by others, only increase the value of the materials they work on by 50 per cent.

The discussion so far may make coal look pretty insignificant. We need to look at other figures before the impact of coal on the economy can be judged. Before that, though, the position of Pennsylvania coal in relation to the rest of the coal industry should be examined.

THE INDUSTRY'S BACKGROUND

Pennsylvania has been a primary source of mineral fuels in the United States since about 1840, just a few years after the advent of sustained interstate transport of coal. In 1963, the Commonwealth ranked sixth among all states in value of fossil fuels produced. Over 90 per cent of such output was coal, worth approximately $500 million at the mines. About 36,000 men earned over $200 million working Pennsylvania coal and railroads received $150 million for carrying it.

The latter half of the 19th century saw a rapid rise in the use of all mineral fuels. Three generations and at least a third of Americans
recognized anthracite as a superior space heating fuel until about the
time of the Great Depression. This high fixed carbon material accounts
for about one quarter of value of coal production in the State.

Because of its excellent coking characteristics, bituminous coal
from the famed Pittsburgh seam at Connellsville lead the State to
supremacy in steel production following the Civil War. At the same
time, Pennsylvania crude oil served as the basis for the growth of
the U.S. petroleum industry into a young giant.

These examples help to illustrate much about the Keystone State's
greatest present mineral resource - coal. First, exports of coal to
other states and Canada have long been important. Second, coal
attracted certain major manufacturing industries to the State and third,
petroleum has been a major competitor for Pennsylvania coal* for about
a century.

Figure 1 shows the record of coal production in Pennsylvania.
Construction of at least three major generating plants in the coal fields
of the State during the next five years assures that 1961 will remain
the low year for the foreseeable future. It is clear that bituminous and
anthracite have followed different paths, at least since the late 1950's.
The strong recovery of anthracite in 1963 due to a surge in exports was
short lived because it stemmed from a record European cold wave.

*In this analysis, coal is a general term that refers to all grades.
When one particular grade is the subject, specific references to
either anthracite or bituminous is made.
PRODUCTION OF COAL IN PENNSYLVANIA

Figure 1

Year of European record cold

BITUMINOUS

ANTHRACITE

51 m 54 57 58 59 60 61 62 63 64 65 1966
The decline for anthracite so far this year has been 12 per cent. Conversely, bituminous coal production has risen at better than six per cent since 1963 until last spring when a wildcat coal strike set the average back temporarily.

THE STATE AND THE NATION

Coal has been a positive contributor to the State's interstate as well as Canadian balance of trade since the 19th century, but overseas exports weren't significant before World War II. Earnings from sales of coal outside Commonwealth boundaries enabled citizens of the State to buy products from other areas with the money earned. Examples of such items are agricultural commodities, machinery, and consumer goods.

Coal as an energy source and chemical raw material acted as a magnet to draw the metals industry to the State because it was often cheaper to manufacture near coal mines than to transport the fuel for industrial use elsewhere. Sales of refined metals and semi-fabricated items brought rich rewards to the Commonwealth as it became a leader in heavy industry. However, the share of our national product originating in this sector of the economy is steadily becoming less significant and cheap energy is no longer as important in attracting new economic activity as it was in years past.

Changing technology in consuming industries such as power generation, steel making, and transportation as well as changes in the structure of the national economy have greatly altered coal's role in the commerce of both the nation and the State.
From the foregoing, it should be clear that coal marketing is dynamic as customer preference shifts among alternative energy sources. A basic factor in the five per cent average annual growth in coal consumed by electric utilities has been the ability of producers to supply adequate tonnages at favorable prices. Without the present capability of innovating new production, distribution, and consumption techniques, the coal industry would surely lose market position rapidly to competitive fuels.

More coal is consumed in the Keystone State than elsewhere in the U.S. The top ranking producer, West Virginia, is far down the list of consumers, below the non-producing states of Michigan and New York. About one-third of total Pennsylvania demand is accounted for by the far above national average use of coal to produce coke.

In 1917, a total of 278 million tons of coal was produced by 329,000 men and its value was $705 million. These workers represented close to 10 per cent of the State's labor force and an even larger proportion if associated railroad employees, wood cutters and other service workers were added. As noted previously, coal employment is now down to 1-1/4 per cent from the 10 per cent just mentioned. Coal isn't as important to the economy as it once was.

APPALACHI

Pennsylvania sits at the northern end of the rich Appalachian coal fields which account for about three-quarters of national coal shipments.
The map presented as Figure 2 gives an idea of the relative importance of coal in the 11-state area included within the boundary area of the Appalachian Regional Commission. Pennsylvania and West Virginia dominate eastern coal mining; together they produce two-thirds of the output.

Two principal nodes of coal production in Appalachia are shown on the second map (Figure 3). Node A encompasses Pennsylvania, Eastern Ohio, Northern West Virginia and Western Maryland with combined production of 167 million tons. This exceeds Node B where 154 million tons were mined from Southern West Virginia, Eastern Kentucky and southwestern Virginia. Production from these two major nodes accounts for 95 per cent of Appalachian coal sales.

The Figure also shows the destination of shipments of Appalachian mines. Notable is the fact that for Node B, 60 per cent of production was exported interstate and 24 per cent international, leaving only 16 per cent to be consumed in the producing area. Contrast this to regional consumption in Node A of 59 per cent, interstate exports 34 per cent and international exports of only nine per cent. Node B marketings overwhelm sales of Node A coal except in New York, New Jersey, Delaware-Maryland and Connecticut, a sweeping arc of land contiguous to A.

Node B has increased its market penetration along the eastern seaboard at the expense of A by almost 50 per cent since 1957. During the same period, B lost heavily to Illinois in the North Central markets.
Map showing 1963 production of coal in Appalachia Counties
Figure 2
17.2

Note: P/C=0/0, shows production to consumption tonnage for each node.


Figure 3
Node B with its small regional consumption is forced to practice a "we try harder" market philosophy to promote its "total export" sales. Thus, as B was pushed out of North Central markets, its coal producers sought and gained a larger share of the eastern trade.

WHERE PENNSYLVANIA COAL GOES

As was noted earlier, Pennsylvania's consumption of coal is greater than that of any other state due to heavy use of coal for coking. Such use has always exceeded that of other states and, in recent years, has been at least double that of Indiana, the next largest coke producer.

Over half the coal mined in the Commonwealth is shipped outside the State, the greatest share going for power generation. New York's demand is almost twice that of Connecticut, the next most important customer in this category. Central Pennsylvania coal has always found a ready market in New York power plants just to the north.

The Empire State is clearly Pennsylvania's best coal customer, taking almost 30 per cent of "total exports." Ohio's take accounted for another 15 per cent and over eight per cent went to each of the following five regions: New Jersey, Canada, Delaware-Maryland, New England, and West Virginia.

MARKETS IN PENNSYLVANIA

The fact that over one-third of Pennsylvania's bituminous coal consumption is now met with out-of-state coal, is due largely to receipts of coking coal from West Virginia. Also, in the two years since 1963, the 3.2 million ton growth in electric utility demand in the State has
been shared about equally between local coal and Northern West Virginia coal. As a result, a larger share, 25 per cent, of utility demand in the State is now met from just south of the Mason-Dixon Line.

COAL BALANCE FOR PENNSYLVANIA - 1963
(millions of tons)

<table>
<thead>
<tr>
<th></th>
<th>Penn. Origin</th>
<th>&quot;Total Exports&quot;</th>
<th>Inter-Penn.</th>
<th>Into Penn.</th>
<th>Apparent Pennsylvania Consumption</th>
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<td><strong>A. BITUMINOUS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>36.6</td>
<td>34.4</td>
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<td>51.0</td>
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<tr>
<td>Coking*</td>
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<td>11.6</td>
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<td>14.0</td>
<td>4.2</td>
<td>18.2</td>
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<td>.8</td>
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<td><strong>B. ANTHRACITE</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Total</td>
<td>18.3</td>
<td>10.0</td>
<td>8.3</td>
<td></td>
<td>8.4</td>
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<td>International*</td>
<td>4.2</td>
<td>4.2</td>
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**C. PRO FORMA INDUSTRIAL-COMMERCIAL DETAIL**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>At Mine</td>
<td>.4</td>
</tr>
<tr>
<td>Cement Mills</td>
<td>na</td>
</tr>
<tr>
<td>Steel Mills</td>
<td>na</td>
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At Mine Cement Mills Steel Mills
Penn. .2 .2 1.4
-Origin "Total " .2 .2 1.0
Exports" Inter- Penn. 0 0 Penn. 2 2
Into Penn. .2 .2 .2

**Overseas exports of bituminous coal were for coking. End use was unavailable for exports of anthracite.

**These figures are based on analysis of AISI annual report and private communication with USBM commodity specialist.

A major share of West Virginia's gain in Pennsylvania has been in the eastern part of the State where electric utilities have steadily shifted away from anthracite because of the increasing relative price of "culm-bank" and "river" anthracite. Retail dealer sales of anthracite are still important but have been dropping at a 15 per cent annual rate during recent years as homeowners seek more convenient fuels. Retail sales are insignificant for all bituminous producers except the smaller mines.

Of the combined total of 14.1 million tons of anthracite and bituminous used by industry and commerce, the Census* indicates that 10.5 million tons were used industrially. Subtracting mine and railroad use leaves a balance of 2.8 million tons which probably were consumed by commercial establishments such as stores and apartment houses buying direct from coal producers.

* 1963 Census of Manufacturers
OUTLOOK FOR PENNSYLVANIA PRODUCERS

Pennsylvania coal has a geographical advantage due to its location in the fuel hungry Northeast. Investment in the State of about $750 million in mine mouth power stations, their associated transmission networks, and mines to supply the required bituminous coal assure an increased consumption of Pennsylvania soft coal by electric utilities.

With four major nuclear power plants now building or announced for New Jersey and Pennsylvania, it appears that severe price pressure will meet all attempts to sell coal to electric utilities at any distance from the coal fields. Fortunately, unit trains have helped to place bituminous mines in the State in better competitive stature to coal coming to tidewater from the Cumberland County, Node B and to nuclear fuels whose national impact is shown in Figure 4.

It would be difficult for demand for coking coal to rise significantly in the State because of the static level of blast furnace capacity in Central and Western Pennsylvania. Any national gains in net coking capacity are, therefore, likely to be in areas where the Pittsburgh seam does not have a significant locational advantage and, therefore, do not offer much of a potential market.

There also is a threat that a larger proportion of higher grade metallurgical coals from Southern districts will be substituted for Pennsylvania coal as part of a continuing effort by steel producers to upgrade blast furnace raw materials. The Pittsburgh seam appears to have serious deficiencies in ash, sulfur, and coke strength when compared to some Node B coals.
NUCLEAR TIMETABLE, in terms of generating capacity in service, as forecast by Fremont Felix in the 11th Nuclear Report of Electrical World, shows relatively slow growth to about half the total at the end of the century.

Figure 4
Industrial and commercial requirements for coal probably will only shift slowly because present burning equipment or production methods will not be replaced quickly. Therefore, current energy consumption patterns in industry are likely to remain fairly stable. Any changes that occur, however, are likely to be downward, as industry shifts the burden of energy production to public utilities.

A positive forecast can be made for coal production in the State due to new found stability that comes from increased consumption of coal by electric utilities. But, the heavy dependence on coking coal still means that fluctuations due to the business cycle will be reflected in coal production figures. In addition, cyclical response can be expected in industrial demand because most direct demand from this sector is from heavy industry.

Baring a technological breakthrough that reduces cost, and, thus, prices of anthracite significantly, it appears that the downward trend in demand for hard coal will persist. A recent Bureau of Mines forecast estimated a steady decline until 1985. Their 11.7 million tons production estimate for 1970 is 24 per cent below 1965 output. This drop will be accented by gradually changing production methods resulting in a greater than proportional reduction in employment opportunities in anthracite mining.

The affect of the market demand on production of bituminous coal in Pennsylvania will be a continuation of the present upward trend for bituminous and a reduction in cyclical swings as electric utilities account for a growing proportion of use, perhaps one-half, over the next decade.
Increased production should off-set gains in labor productivity resulting in a fairly stable employment picture; but there will be increased demand for skilled workers, especially mechanics to tend the sophisticated machines.

The current multi-million dollar plant scale test in the making of gasoline from coal as well as the purchase of Consolidation Coal Company by Continental Oil Company, hint of commercial manufacture of synthetic liquid fuel from coal within this decade. Unfortunately, eastern coal mines are not likely to benefit from such production because they are close to seaboard and consequently to cheap foreign crude which they cannot possibly compete with in a market unhampered by rigid government controls. The first commercial coal-to-gasoline plants will be built in the petroleum short, coal long midwest, for example, Illinois.

Pennsylvania mines will have to make their gains in the traditional markets. In these, the struggle with competitive fuels will be hard.

STRUCTURE OF PENNSYLVANIA COAL INDUSTRY

With about 2700 coal mines, Pennsylvania has more than a quarter of all the coal establishments in the country. The inclusion of over 1000 anthracite mines puts our state well above any other in total mines. You might contrast this with Illinois' production of over 52 million tons from just 108 mines.

The larger producers operate at more than one location. This is the reason that data show 450 fewer producers than mines. The
largest operator accounted for almost seven per cent of combined output in the State and the top 10 companies for one-third. The next series of charts shows that a few larger producers account for the bulk of output.

The first chart, Figure 5, shows both bituminous and anthracite production. It takes only one per cent of the anthracite companies to ship three fifths of output and two per cent of bituminous coal firms to ship the same proportion.

The next chart, Figure 6, for bituminous alone, plots number of producers rather than per cent as in Figure 5. The largest operator accounted for about eight per cent; the 10 largest for over 42 per cent. Deep and surface mines are plotted separately. After about the 30 largest, the balance of 810 mines only accounts for 10 per cent of the product. Surface bituminous coal mines show a much more even distribution of production though even here it takes 346 mines to account for the last 10 per cent of production.

Anthracite presents such a significant difference in origin of production that it is clear that it must be separated from bituminous in any study of the coal industry. Figure 7 for anthracite shows that strip mining now dominates this industry - just the reverse of facts in Pennsylvania bituminous coal. It is also noted that the slope of the curves for anthracite mining is much more regular than is the case for bituminous. This means that small mines are more important to anthracite. This chart (Figure 7) only accounts for 78 per cent of production as mining. Bank and river coal are omitted except in the plot of total Anthracite, the upper curve.
1963 Bituminous - Pennsylvania

% of Production

100
80
60
40
20
0

All bituminous

Deep only

Surface only

(840, 64.4%)
(416, 35.6%)

1239

Number of Producers

Figure 6
Figure 7

1963 Anthracite

- All anthracite
  - (1025, 100%)
- Strip only
  - (86, 40.8)
- Deep only
  - (850, 37.2%)

Number of Producers

% of Production
The next diagram (Figure 8) shows more clearly that while the big firms and large mines dominate, that the smaller mines still employ a significant number of people. This chart, for bituminous only, shows that truly, much of Pennsylvania production is from mines that can be characterized as "three men and a mule." The small mines, shown on the right, are much more unstable sources of income than are larger firms. The number has been dropping (slowly) in recent years and new inspection laws may accelerate this decline. Instability has a negative effect on an economy. In this case, it is magnified by marginal operators who go out of business when the economy slows down.

The larger firms with good long term reserves and financial strength to develop them add to the economy and have been entering long term contracts with utilities. This is a stabilizing factor because use of power does not decline significantly even in deep recessions, a fact that cannot be said of some of the other heavy industry in the State.

IMPACT

Figure 9, shows how personal income per capita receipts were distributed across the State. If you know those areas where coal activity is high, you will immediately infer that coal forms an important economic base for a number of the poorer counties. Greene with almost 32 per cent of personal income from mining and Indiana with over 12 per cent are outstanding examples of how coal can add income to an economy.

How do you measure impact of an industry on economy? Conceptually it is quite easy. First, add up the direct effects as was done at the
Production and Employment - Pennsylvania Bituminous Coal

<500,000 T/yr. = 56% of Production
49% of Employment

500,000 <50,000 T/yr. = 35% of Production
29% of Employment

> 50,000 T/yr. = 9% of Production
26% of Employment

Deep Mining 65% of Production & 76% of Employment

Surface Mining 35% of Production & 24% of Employment

Figure 8
PER CAPITA PERSONAL INCOME: 1963

Figure 9
beginning and then add up the indirect ones. Thus, add to direct items such as wage dollars, the effects of the miner spending his earnings, such as the miner's grocer and his appliance salesman spending in turn the miner's payment to them, and so on. This is called the multiplier effect by economists. If the expenditure of one dollar begets the expenditure through time of two more dollars for a total of three dollars, then it is said that you have an expenditure multiplier of three.

Work done by The Pennsylvania Regional Analysis Group at Penn State indicates that the multiplier for coal mining may be between two and three. You can think of this as the ripple effect of dollar of sales made by a coal company. Even using this multiplier concept in trying to gauge the importance of coal to Pennsylvania doesn't give very large numbers when compared to overall gross measures of the State's economy.

The device used to estimate the multiplier is an algorithm of an Input-Output Matrix. It is used to calculate the direct plus indirect effects of a dollar spent by an industry. It was by using this device that PRAG was able to estimate the multiplier given above.

The Table below shows how $100 of final demand for coal turns up in the national economy. The biggest gainer was "Wholesale and Retail Trade" as might be expected since not only does the mining company buy much of its needs from wholesalers but the miner buys consumer items from retailers. If this looks surprisingly small to you, just remember that this figure accounts only for the wholesale and retail margin and doesn't include the "value" of the goods sold.
### COAL'S MARKET BASKET*
(taken from national Input-output tables)

<table>
<thead>
<tr>
<th>VENDOR</th>
<th>$ per $100 coal sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholesale and Retail Trade (72)</td>
<td>$5.84</td>
</tr>
<tr>
<td>Mining Machinery (23)</td>
<td>4.75</td>
</tr>
<tr>
<td>Utilities (61)</td>
<td>4.27</td>
</tr>
<tr>
<td>Real Estate (70)</td>
<td>3.99</td>
</tr>
<tr>
<td>Iron and Steel Mfg. (38)</td>
<td>3.72</td>
</tr>
<tr>
<td>Petroleum (60 + 63)</td>
<td>3.58</td>
</tr>
<tr>
<td>Chemicals (58)</td>
<td>3.14</td>
</tr>
<tr>
<td>Transport and Warehousing (65)</td>
<td>2.66</td>
</tr>
<tr>
<td>Finance and Insurance (73)</td>
<td>2.28</td>
</tr>
<tr>
<td>Primary Non-Ferrous (36)</td>
<td>1.91</td>
</tr>
<tr>
<td>Business Services (75)</td>
<td>1.79</td>
</tr>
<tr>
<td>Lumber (47)</td>
<td>1.44</td>
</tr>
<tr>
<td>Rubber (50)</td>
<td>1.38</td>
</tr>
<tr>
<td>Other Fab. Metal Products (35)</td>
<td>1.38</td>
</tr>
<tr>
<td>Maintenance Construction (77)</td>
<td>1.03</td>
</tr>
<tr>
<td>Other 64 categories, less than</td>
<td>1.00 each</td>
</tr>
</tbody>
</table>

*Does not include value of transportation from mine to consumer.

You also might ask why food and clothing doesn't show up in the list since obviously miners buy them. The answer is that they are included in final demand in the national Input-Output chart and can't be easily extracted. Transportation and warehousing also probably look small. The answer is that Coal doesn't pay directly for this transportation, its customers do. Checking national Input-Output tables
shows that for every dollar that utilities spend on coal, they spend another dollar on transportation. Certainly, this isn't for all coal transportation, but the bulk of it is.

Prepared by:
J.J. Schanz, Jr.

PERSONNEL: J.J. Schanz, Jr., Principal Investigator, Professor of Mineral Economics
George K. Schenck, Instructor of Mineral Economics
INTERIM RESEARCH REPORT

Contract Number: CR-46

Title of Investigation: Investigation of Effective Measures to Combat Mine Disasters

SUMMARY OF PROGRESS AND PROJECTED PLANS

Research Results

A change of personnel has resulted with the retirement of Earl R. Maize July 31, 1966. Effective with the Fall Term on September 15, 1966, Dai Choi, half-time graduate assistant, joined the project. On November 1, Peter Okulich was added as a research aide. These personnel additions have accelerated the research activities greatly.

Ring cells with dial gages used for sensoring purposes have been investigated thoroughly. Measurement of ring deflection in the horizontal direction instead of vertically has eliminated the error in tracking due to the localized plastic deformation at the bolt holes. However, this was achieved at the sacrifice of sensitivity. To increase sensitivity a photoelastic strain gage sensing device is being investigated to replace the dial gage. Also, bonded electrical strain gages arranged in a bridge configuration are to be used for sensing purposes with the ring cell.

Also being explored is the use of a spherical cell. The ring cell permits adjustments due to misalignment of the drill hole from the perpendicular in one direction only. A spherical device would permit any adjustments in the 360° range.
Continued study to obtain a low-cost, reliable and sensitive load cell is progressing. Tests will continue in the laboratory to measure bleed-off and these are to be correlated with field observations.

Short Course

The short course scheduled for August 15-19, 1966 was cancelled. There was insufficient enrollment from industrial organizations alone within the state to justify offering the course. Last minute cancellations by the U.S. Bureau of Mines personnel due to changes in budget policies and the airline strike led to the cancellation. It will be offered again at some future date. A format change is being considered, however. The course will be extended to adequately cover the considerable material available. It will be unitized in such a manner though that production personnel may select only those parts in which they have a direct interest, for instance, subsidence, roof control, etc.

Prepared by:

R. Stefanko

PERSONNEL:  R. Stefanko, Principal Investigator, Professor of Mining Engineering
Dai Choi, Graduate Assistant
Peter Okulich, Research Aide
INTERIM RESEARCH REPORT

Contract Number: CR-61

Title of Investigation: A Landscape Architectural Approach to the Reclamation, Recreation and Development Potentials of Deep Anthracite Strip Pits

SUMMARY OF PROGRESS AND PROJECTED PLANS

During the past six months the actual work of research analysis has been completed. A scale model of the Big Creek Strip Pit was completed and delivered to Secretary Charmbury. In addition to the model two perspective sketches were prepared which illustrate the development of the area.

The writing of the report has been completed and is being reviewed by Professor Wilson.

Prepared by:

E. Lynn Miller

PERSONNEL: E. Lynn Miller, Principal Investigator, Assistant Professor of Landscape Architecture
Carl W. Wild, Consultant
Robert Gladstone, Consultant
INTERIM RESEARCH REPORT

Contract Number: CR-63

Title of Investigation: Evaporate Fog by Increasing the Absorption of Solar Energy with a Cloud of Finely-Ground Anthracite Coal

SUMMARY OF PROGRESS AND PROJECTED PLANS

An investigation of selected fog characteristics and control concepts, emphasizing the possible use of coal derivatives, was conducted. The results are summarized as follows:

1. Measurements of fog parameters such as drop size, liquid water content, condensation nucleus concentrations and visibility were made at the Philipsburg Mid-State Airport during the fall season. The results are in general agreement with structural fog models previously formulated. These models can thus be used in first approximation evaluations of various fog modification concepts.

2. Occasionally, exceptionally high concentrations of condensation nuclei at low supersaturations (0.02%) were observed that appeared to be associated with effluent from upwind pulp mills. Identification of the responsible compound(s) would be valuable in determining their suspected influence on valley haze and fog characteristics and in prescribing appropriate control measures.

3. An analytical review of fog (cloud) seeding with carbon particles to enhance solar absorption and promote droplet evaporation reaffirmed the feasibility of conducting such field tests. Experimental design criteria were established and a potentially more definitive experiment devised for testing the carbon-air heating hypothesis.
4. Several attempts were made to dispense milled anthracite coal over the tops of fog and stratus in order to test the hypothesis that enhanced solar absorption would promote droplet evaporation. However, the results of the tests were inconclusive. Great difficulty was experienced in trying to spread the material uniformly. While no large dissipation effect was obtained, observations indicated that the coal may have altered clouds in small, narrow zones.

5. Graphon (graphitized carbon black) particles were heat treated in an attempt to enhance (a) their water absorption properties and (b) their ice nucleating capability. The former objective was fulfilled but thus far the treated carbon particles remain relatively ineffective freezing nuclei.

6. The concept of desiccating fog with hygroscopic material was re-evaluated and sample calculations made of optimum particle sizes, concentrations, and mass requirements. The technique appears marginally useful. It would be more promising if a material could be found combining the attributes of high hygroscopicity, capability of being milled to micron sizes, low agglomeration tendency and low corrosiveness.

7. Modification of warm fog remains an unsolved problem. Any success obtainable in the immediate future may well involve the combination of a number of marginal control measures—each prescribed with exacting precision for a given fog situation and locale.

Prepared by:

C.L. Hosler
PERSONNEL:  C.L. Hosler, Principal Investigator, Professor of Meteorology  
George Imperial, Research Associate  
Larry Davis, Research Assistant  
Ronald Ruth, Graduate Assistant
INTERIM RESEARCH REPORT

Contract Number: CR-65

Title of Investigation: Research on Control of Water Quality in Coal Preparation Plant Effluents

SUMMARY OF PROGRESS AND PROJECTED PLANS

The short course was held June 27-July 1, 1966, as detailed in IPR-19. Remaining details are being completed, the major item being a revision of the extensive class and laboratory notes prepared for the course in a form suitable for release as a Special Report. All indications were that the course presentation was of interest and value and that similar future offerings are needed and would be well received.

Further study and modification of the industrial questionnaire has been in progress which has delayed its release. This questionnaire is the base for a state-wide survey of coal preparation plants to determine types of equipment and operating practices employed in controlling water quality.

Prepared by:

H.L. Lovell

PERSONNEL: H.L. Lovell, Principal Investigator, Associate Professor of Mineral Preparation
D.C. McLean, Principal Investigator, Associate Professor of Mineral Preparation
INTERIM RESEARCH REPORT

Contract Number: CR-66

Title of Investigation: The Effect of Acid Mine Drainage from Strip Mines on the Ground Water Reservoir Under Various Hydrogeologic Environments in the Clearfield Area of Pennsylvania and the Mutation of the Water as It Moves Through the Ground Water Reservoir

SUMMARY OF PROGRESS AND PROJECTED PLANS

Data gathered to date have made it possible to divide the approach to the problem into two separate parts. Part one is concerned with the conditions of acid formation which can be used to estimate the acid mine drainage potential of various rock strata; part two is concerned with the application of this knowledge to an evaluation of the effect of acid mine drainage on the ground water reservoir and the possible accompanying interactions.

The first part is being completed with a final acid leaching study currently in progress. The design of this final experiment has been guided by various concepts derived from the following developments.

The rocks of the two areas of study established for the purpose of comparing lithologies of a continental (Glen Richey Area) and marine (Clearfield Area) paleoenvironment were sampled and analyzed for total sulfur content and subjected to a leaching study. As discussed in the last interim report, the rocks of both areas had equal potential for producing acid mine drainage based on data obtained from leaching studies. Yet the absence of acid mine drainage in one of the areas,
the Glen Richey area, is noteworthy. Water sampled from the Glen Richey area was commonly neutral or slightly acidic, whereas water sampled from the Clearfield area was usually acidic where limestone was known to be absent. Although general water quality characteristics could be attached to both areas, for example, waters in the Clearfield area tend to be acidic, while waters in the Glen Richey area tend to be neutral, the parameters of water quality of both areas used for comparisons in this study were not strongly divergent. The values of sulfates, alkalinities and acidities tended to cluster about similar values making it difficult to accurately compare the water qualities and discern differences. For this reason it was decided to extend water quality measurements into areas representative of water quality extremes; i.e., areas where acid mine drainage was severe versus areas where water continued to be potable in spite of extensive mining. Accordingly, water samples were taken from the Krebs mine (located 1/2 mile due east of Krebs on the 7-1/2 minute quadrangle) and from a strip mine located approximately 6 miles southwest of Clarion, Pennsylvania; both areas are known to have extreme acid mine drainage problems. Water and rock samples from acid free strip mines were collected from mines in the areas of Grove City and Slippery Rock of the western part of Pennsylvania. The water samples were analyzed for alkalinity (as HCO$_3^-$), acidity (as H$^+$), pH, temperature, calcium (as Ca$^{++}$), sulfate (as SO$_4^{2-}$) and specific resistance.
The water samples collected from the Grove City and Slippery Rock areas were either neutral or very alkaline. The samples were taken from pools of standing water in mine floors, water bleeds from talus piles, and in two cases, ground water bleeds from high walls of two mines. The coal seam mined in these areas is the Clarion Seam (reported to be Brookville by the miners) and commonly was observed to contain a 1" to 3" layer of nodular pyritic material near the top of the seam. Total sulfur analyses have not yet been obtained for these rocks, but field observations suggest high values. Associated with the Clarion seam in this area is the Vanport Limestone, a relatively pure, 5-15 foot massive limestone found above the coal. The area has been glaciated, and in some cases, glacial deposits which are usually laden with calcium carbonate materials, are present at times in excess of 25 feet in thickness.

Since acid mine drainage contains chemical components equivalent to $\text{H}_2\text{SO}_4$, the sulfate and acidity values obtained from analyses can be plotted on a graph to establish a correlation between the sulfate content and the acidity. This is based on the assumption that the sulfate arises solely from the oxidation of pyrite. This is a valid assumption as sulfate bearing minerals (gypsum and anhydrite) are absent from the section. When the graph is constructed, using the chemical analyses of acid mine drainage, the sulfate content of a water sample can then be plotted on the graph and a probable acidity value for the sample can be extrapolated (Fig. 1). If the acidity of the sample, as measured by standard titration methods falls below the acidity extrapolated from
WATER SAMPLE ANALYSES PLOTTED BY $SO_4^{2-}$ CONTENT VERSUS $H^+$ CONTENT

Figure 1
the graph, neutralization may be indicated. If the sulfate content of
the water sample is low, then the possibility exists that the area from
which the sample was obtained was low in sulfur bearing materials or
contained sulfur compounds of an inert state. The graph is shown in
Figure 1 and was constructed from the chemical analyses of water
and acid mine drainage samples represented in Table 1.

Water sample SLR-2 has a sulfate content of 750 mg/l and from
Figure 1 should contain about 2 mg/l $H^+$ acidity. By the same extrapola-
tion the GRC samples should have acidities of approximately 0.5 mg/l
(as $H^+$). Instead the GRC and the SLR-2 samples are alkaline. This
suggests that neutralization under natural conditions has taken place.

Most of the other samples, however, have a very low sulfate
content, in spite of the observed abundance of pyrite nodules found in
the section. The fact that waters with a low sulfate content flow out
of mines which apparently contain abundant sulfide material, suggests
that the sulfide minerals found in these mines are stable and non-reactive.
This is further corroborated by the fact that the rock samples obtained
from these areas, and which contain visible abundances of sulfide
minerals, show not the slightest degree of oxidation.

An attempt to differentiate pyrite from marcasite by X-Ray
diffraction techniques has failed. This may be due to an apparent phase
transformation of marcasite to pyrite which results from grinding for
sample preparation. Consequently, all minerals X-rayed gave strong
pyrite peaks.
<table>
<thead>
<tr>
<th>Sample #</th>
<th>Location of sampling point</th>
<th>Source of water sample</th>
<th>pH</th>
<th>Temp. (°C)</th>
<th>Alkalinity as HCO₃⁻</th>
<th>Acidity as H⁺</th>
<th>Calcium as Ca²⁺</th>
<th>Sulfate as SO₄²⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT-15</td>
<td>Tributary to little Clearfield creek</td>
<td>Stream</td>
<td>6.48</td>
<td>-</td>
<td>46</td>
<td>0</td>
<td>-</td>
<td>185</td>
</tr>
<tr>
<td>RT-16</td>
<td>Tributary to little Clearfield creek</td>
<td>Stream</td>
<td>4.15</td>
<td>10</td>
<td>0.6</td>
<td>126</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>RM-35</td>
<td>Mine shaft in Glen Richey area</td>
<td>Spring from mine backfill</td>
<td>7.20</td>
<td>-</td>
<td>123</td>
<td>0</td>
<td>66</td>
<td>0</td>
</tr>
<tr>
<td>Ch-13S</td>
<td>Private well in Clearfield area</td>
<td>Spring</td>
<td>4.85</td>
<td>10</td>
<td>4</td>
<td>0.08</td>
<td>1</td>
<td>61</td>
</tr>
<tr>
<td>Ch-18</td>
<td>Private well in Clearfield area</td>
<td>Dug Well</td>
<td>4.75</td>
<td>9</td>
<td>3</td>
<td>0.08</td>
<td>0</td>
<td>72</td>
</tr>
<tr>
<td>CT-24</td>
<td>Tributary to Lick Run</td>
<td>Stream draining mined area</td>
<td>3.60</td>
<td>18</td>
<td>0</td>
<td>2.72</td>
<td>2</td>
<td>1120</td>
</tr>
<tr>
<td>CT-25</td>
<td>Tributary to West Br. of Susquehanna River</td>
<td>Stream No. of Kerr, Pa.</td>
<td>4.40</td>
<td>18</td>
<td>0</td>
<td>0.25</td>
<td>13</td>
<td>98</td>
</tr>
<tr>
<td>CM-6A</td>
<td>Strip mine in Clearfield area</td>
<td>Spring on floor of lower level</td>
<td>2.70</td>
<td>16.5</td>
<td>0</td>
<td>1.35</td>
<td>64</td>
<td>680</td>
</tr>
<tr>
<td>CM-6-6</td>
<td>Strip mine in Clearfield area</td>
<td>Pool on upper level</td>
<td>3.20</td>
<td>15</td>
<td>0</td>
<td>2.40</td>
<td>170</td>
<td>1270</td>
</tr>
<tr>
<td>CL-1</td>
<td>Strip mine 6 mi. SE of Clarion, Pa.</td>
<td>Pool on mine floor</td>
<td>2.35</td>
<td>13</td>
<td>0</td>
<td>8.70</td>
<td>350</td>
<td>4000</td>
</tr>
<tr>
<td>KM-1</td>
<td>Krebs mine</td>
<td>Mine wall bleed</td>
<td>3.15</td>
<td>12</td>
<td>0</td>
<td>4.05</td>
<td>108</td>
<td>2860</td>
</tr>
<tr>
<td>KM-2</td>
<td>Krebs mine</td>
<td>SE highwall bleed</td>
<td>2.90</td>
<td>16.5</td>
<td>0</td>
<td>2.75</td>
<td>93</td>
<td>1000</td>
</tr>
<tr>
<td>KM-3</td>
<td>Krebs mine</td>
<td>Drainage from talus</td>
<td>4.15</td>
<td>13</td>
<td>0</td>
<td>7.10</td>
<td>360</td>
<td>4800</td>
</tr>
<tr>
<td>KM-4</td>
<td>Krebs mine</td>
<td>Drainage from talus</td>
<td>3.95</td>
<td>17</td>
<td>0</td>
<td>8.65</td>
<td>150</td>
<td>5600</td>
</tr>
<tr>
<td>KM-5</td>
<td>Krebs mine</td>
<td>Stream from mine works</td>
<td>2.80</td>
<td>16.5</td>
<td>0</td>
<td>8.50</td>
<td>265</td>
<td>5000</td>
</tr>
<tr>
<td>SLR-1</td>
<td>Strip Mine 4 miles NW of Slippery Rock, Pa.</td>
<td>Pool of water near Highwall</td>
<td>7.05</td>
<td>12</td>
<td>224</td>
<td>0</td>
<td>140</td>
<td>98</td>
</tr>
<tr>
<td>SLR-2</td>
<td>Strip Mine 4 miles NW of Slippery Rock, Pa.</td>
<td>Mixture of pool and talus bleed</td>
<td>6.45</td>
<td>11.2</td>
<td>152</td>
<td>0</td>
<td>117</td>
<td>740</td>
</tr>
<tr>
<td>SLR-3</td>
<td>Strip Mine 4 miles NW of Slippery Rock, Pa.</td>
<td>Pool in talus pile</td>
<td>6.35</td>
<td>10.8</td>
<td>382</td>
<td>0</td>
<td>290</td>
<td>150</td>
</tr>
<tr>
<td>GRC-1</td>
<td>Strip mine 1 mile SE of Grove City, Pa.</td>
<td>Ground water bleed from high wall</td>
<td>8.00</td>
<td>11</td>
<td>112</td>
<td>0</td>
<td>50</td>
<td>125</td>
</tr>
<tr>
<td>GRC-2</td>
<td>Strip mine 1 mile SE of Grove City, Pa.</td>
<td>Pool parallel to Rt. 58</td>
<td>7.2</td>
<td>10.5</td>
<td>130</td>
<td>0</td>
<td>94</td>
<td>125</td>
</tr>
<tr>
<td>GRC-3</td>
<td>Strip mine 1 mile SE of Grove City, Pa.</td>
<td>Pool in rear of mine</td>
<td>7.45</td>
<td>11</td>
<td>170</td>
<td>0</td>
<td>68</td>
<td>100</td>
</tr>
<tr>
<td>HRG-1</td>
<td>Strip mine 8 miles NW of Slippery Rock, Pa.</td>
<td>Pool in mine floor</td>
<td>7.5</td>
<td>-</td>
<td>220</td>
<td>0</td>
<td>100</td>
<td>55</td>
</tr>
<tr>
<td>HRG-2</td>
<td>Strip mine 8 miles NW of Slippery Rock, Pa.</td>
<td>Pool in mine floor</td>
<td>7.15</td>
<td>-</td>
<td>240</td>
<td>0</td>
<td>81</td>
<td>60</td>
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The stability of some sulfide minerals may be explained by a calcium inhibitor, suggested by Temple and Koehler in their 1954 publication (West Virginia University, Eng. Exp. Sta. Bul. 25). In their leaching studies they noted some sulfur balls remained inert, while others were highly reactive. They traced this phenomenon to the presence of calcium in a sulfur ball which caused it to remain inert, whereas the sulfur balls without calcium oxidized and produced acid. Washing the sulfur ball with dilute hydrochloric acid solution subsequently caused the sulfur ball to oxidize and produce acid.

The apparently contradictory results which we obtained from our leaching studies when rocks obtained from an acid free area produced acid in the leaching experiment could now be explained by the fact that distilled water was used as the leaching solution and hence may have effectively removed the calcium inhibitor if it was present. This idea was further developed by the following field observations.

Field measurements show that in acid mine drainage problem areas the ground waters, in the absence of calcium carbonate, commonly have an acid pH (values vary from 4.5 to 5.4), whereas the ground waters in the problem free areas commonly have alkaline waters and pH values varying from 6.8 to 8.4. If the mechanism for inhibiting sulfide oxidation suggested by Temple and Koehler is present, the acid ground waters (the acidity as carbonic acid due entirely to the dissolved carbon dioxide) will be capable of removing the calcium from the sulfides under virgin conditions. This will cause the sulfides to undergo rapid decomposition upon being mined. If this inhibitor be present in an area
where alkaline ground waters are present, it will be preserved, as alkaline waters are incapable of further calcium solutioning. Upon mining the sulfide will remain inert until the calcium is leached by rain water. Hence a lag time may be afforded in these areas due to the time required for the rain to effectively leach the calcium from the rocks and permit the sulfides to oxidize. By this time, however, the miner may have already covered the sulfides with calcareous overburden from the next stripping operation.

Laboratory experimentation now in progress is directed toward investigating the existence of this postulated inhibitor and conditions surrounding the effectiveness of the reactions.

The problems as outlined above are restricted to the first part of this study and must be resolved prior to the initiation of the second stage which will involve detailed drilling and sampling of ground water. The experiments currently in progress will establish the acid water production potential of various rocks having varying total sulfur content and will consider the inhibitor suggested by Temple and Koehler. The nature of the mechanism, either as a true inhibitor or as a neutralization phenomenon will be established.

Upon completion of the first phase of this study (approximately 6-8 weeks) and according to the results of the experiments now in progress, three areas will be selected for the purpose of evaluating the effectiveness and validity of these laboratory reactions under field conditions. Water samples, which have been consistently taken
as the first part of this study progressed, will guide the choice of areas best suited for this purpose. These need not be restricted to the Clearfield and Glen Richey areas. Subsequently, a drilling program will be initiated to permit sampling of ground waters in a mined and unmined area for a two fold purpose; one, to substantiate the laboratory conclusions of conditions under which acid mine drainage will form, and two, to evaluate the effect of acid mine drainage on ground water through water sample analyses.

Prepared by:
R.R. Parizek

PERSONNEL: R.R. Parizek, Principal Investigator, Associate Professor of Geology
Frank T. Caruccio, Graduate Assistant
Contract Number: CR-67

Title of Investigation: Preliminary Investigation of the Design, Construction, and Operation of a Mine Water Treatment Plant

SUMMARY OF PROGRESS AND PROJECTED PLANS

Expenditures charged against this contract during the last six-month period have been associated with conferences and consultations engaged in, in the interests of expediting progress on the design of the mine water treatment plant programmed for construction at Hollywood, Pennsylvania. These conferences and consultations have resulted in a significant improvement in the treatment plant design by replacement of the thickener with a piece of equipment known as a Densator. This unit will reduce the sludge-handling problem, thereby influencing the economics of the entire plant operation.

As reported by H.L. Lovell in connection with Contract CR-70, conferences with Gannett, Fleming, Corddry and Carpenter have resulted in acquiring the services of this firm for the purpose of procuring preliminary engineering drawings and cost estimates. It is proposed that these be presented and discussed by University personnel at the next meeting of the Commonwealth Coal Research Board.
Contrary to the course of action proposed in Interim Progress Report IPR-19, it now is intended that the remaining contract funds will be spent primarily in the interests of procuring a Turbidimeter that is reputed to be capable of monitoring effluents such as those that would be produced in typical mine water treatment plants. Conferences have been held with manufacturers of these instruments and a purchase order issued for a suitable device. After receipt the turbidimeter will be built into a system containing the other components of the monitoring unit and laboratory tested. After this, the monitoring unit will be made available on a loan basis to Jones and Laughlin Steel Company for field testing at their treatment plant near California, Pennsylvania.

Prepared by:
W. Spackman

PERSONNEL: William Spackman, Principal Investigator, Professor of Paleobotany
Contract Number: CR-70

Title of Investigation: Treatment of Coal Mine Water to Meet Current Commonwealth Water Discharge Regulations

SUMMARY OF PROGRESS AND PROJECTED PLANS

1. Project Organization and Personnel - All project activities have proceeded under the organization and personnel as set forth in IPR-19. In addition, the assistance of numerous other University personnel has been made available including Mr. Roy Wilkinson, Jr., University Attorney; Mr. Walter H. Wiegand, Director of Physical Plant Planning and Construction and Mr. Thomas B. Kneen, Head of Division of Mechanical Design and Construction. Mr. Terry A. Stauffer, graduate assistant and Miss Sharon Arnold, part-time secretary have been added to the project staff.

2. Site Acquisition - Negotiations to acquire the land at Hollywood, Pennsylvania owned by the New Shawmut Mining Company continued through representatives of the Commonwealth's Department of Forest and Waters, Department of Mines and Mineral Industries, Department of Health and the University. Title to the land is to be transferred to the University. Appropriate surveys and legal documents have been prepared and final actions are being taken. A problem regarding the creation of pollution from refuse currently stored on or near the site appears to be resolved although the pollution apparently still exists.
The site contains approximately 41 acres and includes four water sources which will be available for study. The characteristics of these sources are given in Table I. Certain recommendations have been forwarded to the Department of Mines and Mineral Industries to aid in maintaining a flow from Procter No. 2 mine and to minimize the development of another seal blow-out. These are currently being studied for possible action.

Preliminary steps have been taken to acquire the permits required to operate the proposed plant.

3. Engineering Studies - Detailed surveys at the site have been completed and regular monitoring of the water sources continued on a monthly basis. Further data on the characteristics of the strata have been acquired. Cooperation from the Soil Conservation Service of the United States Department of Agriculture provided further information. Numerous laboratory studies and pilot plant tests with Operation Yellowboy trailer have been made and continue in progress, providing basic information necessary for plant design. An additional pilot plant - an Infilco Densator - has been rented and will be placed in operation shortly. Contacts have continued with various equipment manufacturers as regards various process and equipment requirements. Special interest has developed regarding the selection and use of a turbidimeter for continuously monitoring plant effluent. A unit has been ordered. It will be tested at the University, developed into a field system, and installed at the Thompson Bore Hole of Jones and Laughlin Steel Company for field testing as described in the accompanying report on Contract CR-67.
Table 1
Source Stream Data

### A. Flow (gpd) and Water Temperatures (°C)

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<tr>
<th>Date</th>
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<th>Procter No. 2</th>
<th>Procter No. 1</th>
<th>Tyler Run</th>
<th>Bennett's Branch(2)</th>
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<td>212,300</td>
<td>9,300(26°)</td>
<td>200,000(20°)</td>
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</table>

(1) Before blowout
(2) During our observations the flow in Bennett's Branch has always exceeded 500,000 gpd, however, it has shown wide variation.

### B. Basic Analyses*

(all expressed as ppm except pH)

<table>
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<tr>
<th>Sample Date</th>
<th>Procter No. 2</th>
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<th>Bennett's Branch</th>
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<tr>
<td></td>
<td>pH</td>
<td>Acidity</td>
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<td>Fe&lt;sup&gt;+&lt;/sup&gt;</td>
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<tr>
<td>6/17/66</td>
<td>3.30</td>
<td>6720</td>
<td>2150</td>
<td>--</td>
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<tr>
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<td>3.81</td>
<td>5343</td>
<td>1311</td>
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<td>2.85</td>
<td>5985</td>
<td>1516</td>
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Western Branch
2.90 751 106 106
2.89 1271 109 103
2.60 709 99 99
2.18 752 112 105
3.18 709 99 99
3.22 408 4 4
3.91 439 16 16
3.80 39 88 --
3.05 241 39 39
2.80 466 74 74
3.12 892 157 154
3.68 169 38 38

* Suspended solids never determined but negligible - Bennett's Branch turbid with silt at times
4. **Plant Design Proposals** - A proposal for the plant design was presented to the Pennsylvania Coal Research Board on October 5, 1966. It was based upon the treatment of 500,000 gpd (with volume capability to at least 1,000,000 gpd) of water containing 8000 ppm acidity and 4000 ppm iron. The proposed plant was to be extremely versatile and gave a wide range of capabilities with respect to various neutralization processes. These included the use of several reagents and treatment methods ranging from the minimum alkali addition-sludge settling system, a microbiological operation, to the inclusion of a thickener and vacuum filter. The cost estimate was $734,869.00.

The Board subsequently requested an amended proposal for consideration at their November 4, 1966, meeting. This request involved the following:

1. The initial proposed cost exceeded expectations and available funds, accordingly a phased program was requested.
2. Various aspects of the plant need not necessarily comply with the specific Sanitary Water Board Guidelines.
3. Consideration should be given to an alternative design involving omission of the thickener and filter units.
4. Studies on the emptying of the sedimentation lagoon should be emphasized.
5. The possibility of smaller equipment should be seriously considered where technically feasible.
Accordingly an amended proposal was presented to meet these requests. In addition a new piece of equipment was recommended (the Infilco Densator) to take advantage of a recent technical development which would result in a substantially reduced sludge volume. The implications of this development, if it can be successfully applied, can be far reaching in the mine drainage problem. This proposed unit would function also as a thickener. The proposal modification included, among other changes, a different influent water quality for design: acidity - 100 ppm and iron - 100 ppm. The proposed costs totaled $729,020.00 and consisted of $450,000.00 initial costs, $232,951.00 extended costs and $46,069.00 additional costs.

The Coal Research Board acted to: 1) accept the flow sheet and concepts presented; 2) request the University to obtain detailed engineering drawings from a consulting engineering firm and to acquire bids and/or estimates for equipment required for the capital construction; 3) inform the University of its intent for the allocation of the major portion of its 1966-67 budget for construction of the proposed plant; and 4) note that these actions may delay the project progress.

The University responded immediately to these actions and has arranged for the firm of Gannett, Fleming, Corddry and Carpenter, Inc. to prepare the requested independent plans and estimates. This engineering firm estimates that four months will be required to complete the required studies. Their preliminary report will be presented to the Coal Research Board at a special meeting on January 11, 1967.
In the interim, the Board of Trustees of The Pennsylvania State University acted to: 1) accept the land at proposed site subject to certain stipulations and 2) approve the firm of Gannett, Fleming, Corddry and Carpenter, Inc., for preparing plant design drawings.

Prepared by:

H.L. Lovell

PERSONNEL:  H.L. Lovell, Principal Investigator, Associate Professor of Mineral Preparation
Robert Reese, Registered Professional Engineer
Robert I. Lachman, Research Assistant
W.L. Duguay, Graduate Assistant
Terry E. Stauffer, Graduate Assistant
Elaine Martinec, Analyst
Charles O. Wilson, Laboratory Technician
SUMMARY OF PROGRESS AND PROJECTED PLANS

A. Objectives of Investigation:

To analyze the physical and chemical characteristics of microsites on bituminous spoil banks in order to determine the reasons for success or failure of trees and shrubs test-planted on these sites.

B. Present Status of the Investigation:

Eighteen species of trees and game-food shrubs were planted in the spring of 1966 in replicated plots on extremely acid spoils (pH below 3.0), and on spoils (pH above 4.0) where plantings have generally been successful. Frequent survival checks were made throughout the 1966 growing season to determine time of mortality. This data will be correlated with air temperature, surface and soil temperature, and precipitation data collected at the sites. Chemical analyses of spoil samples from each plot are now being conducted. Survival and micro-climatic data will be measured through the second growing season (1967).

Preliminary results indicate high mortality, apparently due to acidity, but also indicate considerable mortality from high temperatures.
and low soil-moisture conditions during the first growing season.

There were great differences in mortality among the eighteen species.

Prepared by:

W.W. Ward

PERSONNEL:  W.W. Ward and R.J. Hutnik, Principal Investigators, Professor and Associate Professor of Forestry, respectively
M.L. Horn, Graduate Student
SECTION II

FISCAL REPORTS
INTERIM FINANCIAL REPORT

To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  Investigation of the Technical Aspects of Deep Well Disposal of Mine Water

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date  $40,000.00

Less Costs Incurred:

Reporting Period
Salaries  $3,604.00
Wages  00.00
Other Expense  648.40
Special Equipment  00.00
Total  $4,252.40
Previous Periods  $31,565.52

$35,817.92

Cash Balance on Hand  $4,182.08

Submitted by:
William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

| Total Sum Allocated | $40,000.00 | Contract Number | CR-39 
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To: Hon. H. Beecher Charmbury, Secretary  
Department of Mines and Mineral Industries  
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  Strip Mining and Land Restoration 

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date  
$40,000.00

Less Costs Incurred:

Report Period

| Salaries   | $3,335.00 |
| Wages      | 85.64     |
| Other Expense | 701.63  |
| Special Equipment | 00.00    |
| Total      | $4,122.27 |

Previous Periods  
$31,219.08

Cash Balance on Hand  
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Submitted by:

William Spackman  
Director of Coal Research
INTERIM FINANCIAL REPORT

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To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  Optimization of Coal Mine Systems for Low Cost Mining

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date $36,500.00

Less Costs Incurred:

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$32,121.73

Cash Balance on Hand $4,378.27

Submitted by:

William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

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To: Hon. H. Beecher Charmbury, Secretary  
Department of Mines and Mineral Industries  
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  Study of High-Moisture Pulverized Coal  
Flames with Supplementary Study of Time-to-Ignition Temperature of  
Coal Dusts and Their Dependence on Moisture Content

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date  $33,500.00

Less Costs Incurred:

Report Period

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$33,500.00

Cash Balance on Hand  $00.00

Submitted by:
William Spackman  
Director of Coal Research
INTERIM FINANCIAL REPORT

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To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  The Economic Importance of the Coal Industry to Pennsylvania

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date  $17,000.00

Less Costs Incurred:

Report Period

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Previous Periods  $15,759.61

Cash Balance on Hand  $ 1,034.64

Submitted by:

William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

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Contract Number  CR-46
Report Number  6
Date  12/15/66

To: Hon. H. Beecher Charmbury, Secretary
   Department of Mines and Mineral Industries
   Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  Investigation of Effective Measures to
Combat Mine Disasters

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date  $50,000.00

Less Costs Incurred:

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Previous Periods  $34,759.14

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Cash Balance on Hand  $11,447.17

Submitted by:
William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

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To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  A Landscape Architectural Approach to
the Reclamation, Recreation and Development Potentials of Deep Anthracite Strip Pits

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date  $9,500.00

Less Costs Incurred:

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$6,755.12

Cash Balance on Hand  $2,744.88

Submitted by:
William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
<th>Description</th>
<th>Amount</th>
<th>Description</th>
<th>Amount</th>
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<td>$14,220.00</td>
<td>Contract Number</td>
<td>CR-63</td>
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<td>$14,220.00</td>
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<td>12/15/66</td>
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To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  Evaporate Fog by Increasing the Absorption of Solar Energy with a Cloud of Finely-Ground Anthracite Coal

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

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<tr>
<th>Description</th>
<th>Amount</th>
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<tr>
<td>Monies Received to Date</td>
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<tr>
<td>Less Costs Incurred:</td>
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<td>Previous Periods</td>
<td>$11,014.83</td>
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$14,220.00

Cash Balance on Hand          | $00.00

Submitted by:

William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

Total Sum Allocated $9,700.00
Received to Date $9,700.00
Expended to Date $7,162.78
Unexpended to Date $2,537.22

To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION Research on Control of Water Quality in Coal Preparation Plant Effluent

PERIOD COVERED BY REPORT June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date $9,700.00

Less Costs Incurred:

Report Period
Salaries $1,020.00
Wages 491.88
Other Expense 987.15
Special Equipment 67.00
Total $2,566.03
Previous Periods $4,596.75

$7,162.78

Cash Balance on Hand $2,537.22

Submitted by:
William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tr>
<td>Expended to Date</td>
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<tr>
<td>Date</td>
<td>12/15/66</td>
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</table>

To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  The Effect of Acid Mine Drainage from Strip Mines on the Ground Water Reservoir Under Various Hydrogeologic Environments in the Clearfield Area of Pennsylvania and the Mutation of the Water as It Moves Through the Ground Water Reservoir

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date  $14,400.00

Less Costs Incurred:

Report Period

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Previous Periods  $4,280.58

$7,054.47

Cash Balance on Hand  $7,345.53

Submitted by:
William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

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<thead>
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<th>Description</th>
<th>Amount</th>
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<td>12/15/66</td>
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To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION  Preliminary Investigation of the Design,
Construction and Operation of a Mine Water Treatment Plant

PERIOD COVERED BY REPORT  June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<td>Monies Received to Date</td>
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|                          | $1,813.26  |
| Cash Balance on Hand     | $1,186.74  |

Submitted by:
William Spackman
Director of Coal Research
INTERIM FINANCIAL REPORT

To: Hon. H. Beecher Charmbury, Secretary
Department of Mines and Mineral Industries
Commonwealth of Pennsylvania

TITLE OF INVESTIGATION: Treatment of Coal Mine Water to Meet
Current Commonwealth Water Discharge Regulations

PERIOD COVERED BY REPORT: June 16, 1966 to December 15, 1966

FINANCIAL STATEMENT:

Monies Received to Date: $190,000.00

Less Costs Incurred:

Report Period:

- Salaries: $9,942.50
- Wages: 1,992.03
- Other Expense: 47,289.78
- Special Equipment: 216.33
- Total: $59,440.64

Previous Periods: $1,542.99

Total: $60,983.63

Cash Balance on Hand: $129,016.37

Submitted by:
William Spackman
Director of Coal Research
# INTERIM FINANCIAL REPORT

<table>
<thead>
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<td>Unexpended to Date</td>
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To: Hon. H. Beecher Charmbury, Secretary  
Department of Mines and Mineral Industries  
Commonwealth of Pennsylvania

**TITLE OF INVESTIGATION**  Revegetation of Spoil Banks Produced by Surface Mining

**PERIOD COVERED BY REPORT**  June 16, 1966 to December 15, 1966

**FINANCIAL STATEMENT:**

Monies Received to Date  
$5,000.00

Less Costs Incurred:

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Previous Periods  
$00.00

$1,800.00

Cash Balance on Hand  
$3,200.00

Submitted by:  
William Spackman  
Director of Coal Research
# FINANCIAL SUMMARY

**December 15, 1966**

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<th>Contract Number</th>
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