92d Congress }
1st Session }

COMMITTEE PRINT

THE ISSUES RELATED TO SURFACE MINING

A SUMMARY REVIEW, WITH SELECTED READINGS

PREPARED AT THE REQUEST OF

HENRY M. JACKSON, Chairman

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS
UNITED STATES SENATE

PURSUANT TO

S. Res. 45

A NATIONAL FUELS AND ENERGY POLICY STUDY

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MEMORANDUM OF THE CHAIRMAN

To members and ex officio members of the Senate Committee on Interior and Insular Affairs, pursuant to Senate Resolution 45, a national fuels and energy policy study

The decisions and the management philosophy underlying the uses we make of the Nation's limited land and mineral resource base—the endowment of present and future generations—have come to be viewed as a key element in determining the quality of the life of our Nation.

Important progress has been made in many areas in recent years as a result of new Federal initiatives in the area of environmental management, including the balancing and review process established by the National Environmental Policy Act of 1970. Concomitant with the goals declared in the National Environmental Policy Act are the goals of the National Mining and Minerals Policy Act of 1970 which states that the national interest is served by fostering and encouraging the development of an economically sound and stable domestic mining industry. The Senate Interior Committee has played an important role in awakening public interest in land use policy as the key institutional device for shaping the future, and in recognizing the goals of the National Mining and Minerals Policy Act as a part of that future.

The series of hearings chaired by Senator Frank E. Moss, Chairman of the Subcommittee on Mining, Materials, and Fuels, on the pending legislative measures to control and regulate surface mining have served to focus national attention upon an important and integral part of our total land use considerations.

The pending surface mining measures raise many important issues. Some relate to the sufficiency of the Nation's energy resource base and industrial system to provide environmentally clean energy in the form the public needs. Others concern problems of acid mine drainage, treatment of highwalls, the handling of refuse and overburden materials which are a source of pollution, and the bleak and barren landscapes which are too often left unreclaimed in the wake of surface mine operations. Too often overlooked and therefore usually not considered in discussions of surface mining regulation is the environmental impact of water pollution from underground mining, acid mine drainage, subsidence and ugly tailing piles. Of even more serious concern is the tragic and appallingly high loss of life and the intolerable accident rates associated with underground coal mining—the major alternative to surface coal mining practices.

Many other issues associated with surface mine legislation are also of major policy significance. These include:

Important questions as to Federal-State relationships and responsibilities;

Who should pay the costs to correct past abuse;

What Federal agency should administer the program;

The timetable for implementation of Federal regulations;

The consideration of sanctions for noncompliance;

The adequacy of surface mine reclamation knowledge, techniques, and management practices; and

The imposition of uniform Federal and/or State severance taxes.

As a nation, we can no longer accept the social and environmental costs imposed by some past surface mining practices. These costs, estimated in 1967 at $1.2 billion, are real and pose a serious national problem. Their resolution will require a national policy that is balanced yet firm; that recognizes the widely different circumstances and problems involved in different kinds of mining operations *and* in differing regions across the land; that protects private as well as public lands from abuse; and that is capable of incorporating new technological concepts to improve environmental standards so that the social and environmental costs of surface mining are mitigated.

Mr. George H. Siehl of the Environmental Policy Division of the Congressional Research Service, Library of Congress, at my request has prepared a report summarizing some of the major issues related to surface mining legislation and a compilation of excerpts from the current literature and the testimony from the hearings. This material will be of significant assistance to the committee and others in analyzing the issues presented in the pending bills.

I have directed, therefore, that Mr. Siehl's paper be reproduced as a committee print so that it will be readily available to members of the committee and other interested parties.

HENRY M. JACKSON,
Chairman.

LETTER OF TRANSMITTAL

THE LIBRARY OF CONGRESS,
CONGRESSIONAL RESEARCH SERVICE,
Washington, D.C., December 27, 1971.

Hon. HENRY JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: I am pleased to transmit herewith a report "The Issues Related to Surface Mining" prepared at your request by Mr. George H. Siehl, analyst in our Environmental Policy Division. We have drawn these issues from a review of the extensive literature on the topic, and from hearings on surface mining proposals which were held by your committee on November 16 and 17, and December 2, 1971.

Also included is a selection of recent readings which illustrate in some detail the issues which have been identified.

Sincerely yours,

LESTER S. JAYSON, *Director.*

THE ISSUES RELATED TO SURFACE MINING

A SUMMARY REVIEW, WITH SELECTED READINGS

Compiled by

GEORGE H. SIEHL
Environmental Policy Division
Congressional Research Service
Library of Congress

at the Request of

HENRY M. JACKSON, Chairman
Committee on Interior and Insular Affairs
United States Senate

December, 1971

INTRODUCTION

Key Issues in Surface Mining

FROM THE LITERATURE

For a period of 30 years the Congress has had before it legislative proposals bearing on the recovery of various minerals by surface mining. A history of these bills was contained in a Committee Print issued earlier this year by this Committee.[1]

Surface mining refers to the process of removing the soil, rock and other material which covers the mineral, e.g. strip mining, open cast mining, placer or hydraulic mining, quarrying, and dredging.

A related method, used in the recovery of coal, is auger mining, a process in which large drills are used to bore horizontially into coal seams on hillsides.

An Interior Department study, "Surface Mining and Our Environment", has identified these advantages of surface mining methods:

> It makes possible the recovery of deposits which, for physical reasons, cannot be mined underground; provides safer working conditions; usually results in a more complete recovery of the deposit; and, most significantly it is generally cheaper in terms of cost-per-unit of production.

Surface mining is of great importance in our domestic mining industry, as illustrated by recent remarks of Interior Secretary Morton to the Interstate Mining Compact Commission in which he noted:

> Surface mining in 1969 accounted for 94 percent of all domestic production of crude metallic and nonmetallic ores: 2.45 billion tons compared with 165 million tons from underground mines.
>
> Approximately 38 percent of all coal in 1969 came from surface mines. Preliminary data for 1970 indicates that this figure has risen sharply to 44 percent.
>
> On a comparison basis, surface mines in 1969 produced 218 million tons and 269 million tons in 1970. Underground mines produced 347 million tons in 1969 compared with 338 million tons in 1970. Only the sharp increase in surface-mined coal enabled the industry to meet demand last year.

A more detailed picture is presented by the tables in the reader section of this Committee Print which show the production of various commodities by surface mining. Tables are included under the heading on Natural Resource and Energy Requirements.

Another study has recently noted these characteristics of coal surface mining operations:

> In strip mining, output per man-day is roughly 100 percent higher than in underground mining, average recovery is 60 percent higher, and operating costs are 25–30 percent lower.

This report, "Stripping Coal Resources of the United States" by Paul Averitt of the U.S. Geological Survey shows the increased efficiency of recovery made possible by strip mining methods. A Penn-

[1] Legislative Proposals Concerning Surface Mining of Coal. 92nd Congress. 1st Session, Committee on Interior and Insular Affairs, United States Senate. September 1, 1971.

sylvania anthracite field, for instance, saw only one-third recovery by underground mining years ago. In the 1920's and 1930's strip mining with small shovels increased the recovery. Now partly mined coal is being recovered by surface mining methods in pits as much as 400 feet deep.

Averitt indicates that by 1980 the pits may reach a depth of 1,000 feet.

Despite the magnitude and value of surface mining operations some Members of Congress and other concerned citizens feel the adverse environmental effects of surface mining are so severe in the case of coal that they seek a total ban on all coal strip mining. Other bills have sought to ensure a nationwide system of State, Federal or a combination of State and Federal control of surface mining which would, among other things, require the restoration of lands to be disturbed by surface mining. Some of the proposed bills provide reclamation of lands already disturbed.

It was estimated that some 3.2 million acres had been disturbed by surface mining as of January 1, 1965. Of this total, some "two-thirds of the acreage (about 2.0 million) still require some remedial attention", according to the 1967 Interior Department report.

One serious deficiency in working with the problem of land reclamation is the lack of adequate current statistics on the amount of land disturbed and restored since the 1965 information was published. The Bureau of Mines, which compiles national mineral industry statistics has released the following figures only for 1969 and only for coal, although it is understood that later figures are being gathered and will be made available:

SALIENT STATISTICS ON SURFACE MINING OF COAL IN THE UNITED STATES, IN 1969[1]

State	Production: Number of mines	Production: Quantity (thousand short tons)	Surface mined land: Acreage disturbed	Surface mined land: Acreage reclaimed	Percent of disturbed land reclaimed during year
Alabama	65	8,169	(2)	(2)	(2)
Alaska[3]	3	667	15	---	---
Arkansas	6	167	(3)	(3)	(2)
Colorado	9	1,915	(3)	(3)	(3)
Illinois	37	34,640	6,711	5,479	81.6
Indiana	32	17,976	3,335	3,118	93.5
Iowa	11	534	120	40	33.3
Kansas	4	1,313	1,176	250	21.3
Kentucky:					
Eastern	262	17,082	12,200	9,600	78.7
Western	51	27,632			
Maryland	38	1,045	261	459	175.9
Missouri[3]	8	3,299	(2)	(2)	(2)
Montana	5	995	31	33	106.5
New Mexico[3]	3	3,636	250	100	40.0
North Dakota	20	4,704	330	140	42.4
Ohio	276	32,616	10,629	7,902	74.3
Oklahoma	8	1,722	1,674	1,441	86.1
Pennsylvania:					
Bituminous	602	22,592	11,774	9,298	79.0
Anthracite	174	4,579	534	539	100.9
Tennessee	73	3,609	(2)	(2)	(2)
Virginia	158	5,182	2,258	2,331	103.2
Washington	2	5	(2)	(2)	(2)
West Virginia	340	19,388	15,711	17,117	108.9
Wyoming	8	4,481	154	51	33.1
Total[4]	2,195	217,952	67,163	57,898	86.2

[1] Data on acreage disturbed and acreage reclaimed compiled from Bureau of Mines form O.M.B. No. 42–S70014.
[2] Data not reported.
[3] No State regulation on surface mining.
[4] Data may not add to totals shown because of rounding.

On the unreclaimed surface mined site there is destruction of the vegetative cover; the overburden is strewn upon adjacent lands; and surface and subsurface drainage patterns are altered. The 1967 Interior report notes these additional offsite damages:

> Stream and water-impoundment pollution from erosion and acid mine water; isolation of areas by steep highwalls; and, the impairment of natural beauty by the creation of unsightly spoil banks, rubbish dumps, and abandoned equipment.

An important loss from unreclaimed lands is the fish and wildlife which the affected area would have supported in its natural condition.

Only seven commodities have been identified as being responsible for 95 percent of the 5,000 square miles which have been disturbed by surface mining. They are:

	Percent
Coal	41
Sand and gravel	26
Stone 8 percent, gold 6 percent, clay 3 percent, phosphate 6 percent, iron 5 percent	28
All others	05

These figures explain, perhaps, the prominence given to coal in the public discussion of problems related to surface mining. A contributing factor must also be the fact that coal mining is conducted largely in the East where it is visible to a larger portion of the population than is the case with Western mines which are primarily for metallic ores.

Although the prime arguments over legislation to regulate surface mining are economic and environmental, there are a number of additional points of controversy. These include the need for continuing supplies of minerals, particularly coal because of the current concern over energy supplies; and the effectiveness of reclamation procedures. The question of who shall administer regulation programs, and the safety of mine workers are also of concern. Briefly, the contentions over these matters are as follows.

The energy crisis

The Senate Interior Committee has been particularly cognizant of the mounting public concern over the continued availability of adequate energy supplies. Recent evidences of action in this matter are the establishment of a National Fuels and Energy Policy Study pursuant to Senate Resolution 45 of the 92nd Congress, action by the Committee on S. 1846, to develop an accelerated program of coal gasification, and a review of the Department of Interior's prototype leasing program for oil shale.

Estimates of major energy sources in the period beyond the year 2000 indicate that fossil sources will decline in importance. Until that time, however, fossil fuels must be considered our primary energy source. Of those fossil fuels—coal, oil and gas—coal is the most abundant and the most accessible. The major use of coal is in the generation of electricity.

The 1970 edition of Mineral Facts and Problems published by the Bureau of Mines notes:

> Increasingly, environmental and social considerations can be expected to constrain the supply and limit the use of direct fuels to those that are nonpollutant. Land use and ecological considerations may restrict strippable coal supply.

Environmentalists have advocated constraint in the use of energy generally, and strip mined coal in particular, on the theory that our current level of electrical power use is needlessly high. Power companies have also been criticized for extensive advertising to generate additional consumer demand for power. Major portions of the U.S. coal reserves are recoverable only by surface mining techniques. Satisfaction of electric power demands without access to these coal deposits would add a new and significant dimension to the energy crisis.

Our need for non-fuel minerals has been presented as largely a choice between surface mining for domestic reserves or dependence on foreign sources of supply. Interior Secretary Morton in his remarks to the Interstate Mining Commission declared:

It is the surface mining industry that, in the future, will provide a strong domestic mineral supply base and prevent our dependence on foreign sources of mineral raw materials from becoming dangerously large or prohibitively expensive.

Reclamation feasibility

The capability adequately to restore surface mined lands using available technology is a matter which is still under debate. While industry has returned to productive use some thousands of acres of mined land, opponents claim that, in the main, these are simply "showcase" projects which are not representative of the vast majority of reclamation efforts.

State-by-State statistics and examples of reclamation efforts by the coal industry in 1970 are contained in the reader portion of this document under the heading "Reclamation."

Although existing State laws require land rehabilitation, opponents of surface mining have claimed that the requirements are not rigid enough to provide environmental protection, or that there is little or no enforcement of the provisions.

Federal or State regulation

A major question concerning the regulation of surface mining has been whether the Federal or State government should establish and operate the program.

State regulation has been favored by the mining industry on the grounds that local unique conditions could be more easily recognized and built into the regulatory program. An overall Federal program, it was claimed, would be too inflexible and would work a disadvantage on some surface mining operations.

Proponents of a Federal program criticize the lack of strong regulations and enforcement under State management. They cite as an additional argument that, with uniform nationwide standards and requirements, unscrupulous surface mine operators would not be able to move from State to State, in effect, "shopping" for the lowest standards of environmental protection.

Wayne Davis wrote in his article "The Stripmining of America":

As the acceleration of stripmining proceeds, attempts to regulate it are frustrated. Although Kentucky has a fairly good mining reclamation law and some honest, conscientious people in the Division of Reclamation, law enforcement has broken down. An employee of the Division told me that during the summer of 1970 permits were issued to over 100 new operators. Since anyone who can borrow enough to get a bulldozer into operation can go into business and get rich now, there is a flood of new people into stripmining. The enforcement officer said that some of these inexperienced operators could not operate within the law even if trying to do so and spills of spoil onto public highways and into the streams are the result.

Davis added:

* * * we must have federal regulations of mining practices. Any local efforts to regulate this or any other industry encounter the standard and somewhat justified reply that regulation would put them at a disadvantage with their competitors in other states.

Edmund Faltermayer has examined the strip mine reclamation requirements and operations in Pennsylvania, and in *Life* magazine expressed a strongly contrary opinion. After commenting on the several State and Federal proposals to ban strip mining of coal he writes:

* * * It costs $1.50 a ton less, on the average, to strip coal than to send men into the bowels of the earth for it. That cost advantage is so great that strip-mining companes can afford to do some pretty fancy regrooming if they are made to do it. I know this is so, because I've been to Pennsylvania, a state which rigorously enforces its reclamation law, the toughest in the land. A lot of Pennsylvania companies are now going beyond what the law requires—replacing topsoil, for example. "They've really got religion on reclamation now," says William E Guckert, who runs the states' enforcement program. "But," he quickly adds, "they didn't get religion until we put the screws to them."

Cynics will greet with disbelief the news that there is a state government anywhere that puts the screws to the strip-mining industry. How it happened is worth telling. With more scarred acreage than any other state. Pennsylvania also has the country's biggest constituency of outdoorsmen to notice all the ruined terrain—1.1 million licensed hunters and 800,000 fishermen—and they know how to lobby.

Both of these articles appear in their entirety in the later pages of this committee print.

Several of the pending bills combine Federal and State roles in regulating surface mining. The Federal responsibility lies in formulating general guidelines within which the States are to develop and enforce reclamation programs. In the event a State does not do so, the Federal Government is empowered to develop and or administer a program deemed satisfactory by the Secretary of the Interior.

Worker safety

An important social issue which had been discussed with regard to the relative merits of underground and surface mining is the health and safety of the miners.

Mr. Harry Perry, Senior Specialist for the Congressional Research Service, has stated:

* * * The fatality and injury rate in underground mines is much higher than for strip mines. In 1970 the fatality rate in underground mines was 1.17 per million man hours of exposure while it was only .64 for strip mines. If all coal stripping were banned and the fatality rates remained as they now are the conversion to all underground mining would indicate statistically 90 additional men killed in mining for 1970.

Strip mine opponents have contended that rigorous enforcement of the 1969 Mine Health and Safety Act would do much to reduce the hazards of underground mining.

The Issues From the Hearings

The hearings held by this Committee on November 16, 17 and December 2, 1971 developed a useful record on surface mine regulation. Witnesses provided new documentation of previously identified issues. In addressing themselves to the various legislative proposals before the Committee, witnesses raised additional questions and points of view.

In order to review and analyze the issues, representative statements from the hearings have been selected and grouped in this section. First, those issues identified earlier in this document are listed. Following these are the points newly identified during the hearings.

Coal, once again, was the commodity most discussed. The extent of that discussion is reflected in the accompanying excerpts.

Surface mining was defended on economic grounds. Cannelton Coal Company president Paul Morton noted the efficiency of surface mining when he testified:

> I sincerely believe that the surface mining method of extracting our Nation's coal resources is more nearly in accord with rational conservation of natural resource policy than is the deep mining for coal. By surface mining we are presently able to make a total recovery of the resource while this is not possible through deep mining. For example, in my own operations, Cannelton Coal can and will recover all 14 million tons of coal reserves presently held in fee and covered by our present 2,000-acre permit. Through the best in underground methods, we are able to extract less than 4 million tons from that same reserve. Hence, more than two-thirds of our coal would be non-recoverable if not surface mined.

Representative Kenneth Hechler of West Virginia cited the environmental costs which stand in contrast to efficiency:

> Watertables are destroyed, depriving the earth of its channels of nourishment. The delicate surface fabric of life-supporting earth is cast to the bottom. Deep strata of rock and shale are pulverized and exposed to the elements, where they will leach acids and toxic minerals into the surrounding streams for generations. Mountains, now unstable, crack, slip and slide. Rains wash mud, sand and toxic substances down into the streams and rivers, filling their channels and poisoning their waters.

These two basic positions—economics versus environment—were heard from many witnesses who detailed various aspects of the controversy.

Underground mining

A useful corollary to the environmental damages of surface mining was contained in the testimony of several witnesses on underground mining.

Russell Train, Chairman of the Council on Environmental Quality, noted the extent of subsidence:

> * * * land undermined by underground mining alone probably exceeds 7 million acres—with 2 million acres already suffering some subsidence and another two-thirds of a million acres expected to subside by the year 2000. The Bureau of Mines estimates that new underground mining will affect 4 million more acres of land in the meantime. Our actions now can prevent those 4 million acres from becoming a burden on future generations.

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Train added, "environmental consequences of underground mining, such as subsidence and acid mine drainage, can be very serious without adequate controls".

He was speaking in support of the administration proposal, S. 993 and S. 1176, which along with a number of other pending measures would impose environmental controls on underground mines as well as surface mines.

John R. Quarles Jr. of the Environmental Protection Agency cited the extent of damages from mining operations, then added, "a major portion of the damages which I have just mentioned results from inadequately planned and unregulated underground mining and mineral processing".

Energy needs and coal

The conservationist point of view on the widely discussed energy crisis, and the need for coal to resolve it, is typified by this testimony of the Wilderness Society representative, A. T. Wright:

> We doubt that there is an energy crisis of serious enough proportions which demands that coal be strip mined at its present rate or, indeed that it be strip mined at all. The experts tell us that we have adequate coal reserves for the indefinite future. We are not forced to resort to stripping. Why, then, must coal be stripped at all in view of the staggering social and environmental costs which attend it? * * * Deep mining on an almost exclusive basis seems to be the only sane answer to the catastrophic alternative of strip mining.

Cannelton Coal's Morton offered a starkly different view:

> Deep mining simply does not provide the Nation with a viable alternative to surface mining.

National Coal Association President Carl Bagge said:

> It is not realistic to expect that surface mined coal could be replaced by production from underground mines. While there are ample underground reserves, to produce the 264 million tons of surface coal mined last year would require 132 additional underground coal mines of 2 million tons annual capacity, a capital investment of $3.2 to $3.7 billion, three to five years before full production could be anticipated and an additional 78 thousand trained underground miners.

Later, pointing out the contribution of surface-mined coal to the national energy supply, Bagge added, ". . . it is reasonable to assume that about one-fourth of the total electric energy generated in 1970 was produced from surface mined coal".

Senator Howard H. Baker testified also on this point:

> . . . the power grids of the nation, especially those of the Southeast, are dependent to a remarkable degree on the production of coal from surface mines and this dependence cannot be withdrawn suddenly without unacceptable economic and social consequences.

Wright in his statement questioned the existence of any real overall energy crisis, testifying:

> Aside from the fact that the crisis, if indeed there is one, has been induced by high pressure sales tactics and overpromotion, a part of the picture has to be the 52 million tons of coal exported annually.

Extensive testimony on the matter of promotion of the use of electrical energy was presented in this committee's hearings on power generation and associated problems in the Southwest.

Reclamation feasibility

Opponents of surface mining contend that the technology is not available to provide for the adequate reclamation of lands following mining. Much of their effort to ban such mining has been based on that contention.

Hollis Dole, Assistant Secretary for Mineral Resources of the Department of Interior discussed at some length the means available to counter adverse environmental effects of both surface and underground mining. "Reclamation of mined areas," he said, "not only reduces pollution, but returns land to subsequent productive use."

Dole further stated:

> The growing conviction that environmental damage caused by mining operations can be controlled and minimized through adequate safeguards and proper surveillance has led in recent years to the formulation of new environmental protection measures by several Federal Agencies having land management responsibilities. Mineral operations on these lands now must be conducted in accordance with the best available practices, and the lands disturbed reclaimed to a condition compatible with current standards.

Interestingly, the witness who followed Dole was John Quarles of the Environmental Protection Agency who said:

> We do not have adequate technology to deal with all of the environmental problems that are created by mining and mineral processing activities.

A. T. Wright of the Wilderness Society stated:

> . . . reclamation is at best a myth and at worst a hoax if we delude ourselves into believing that we can re-establish anything but a shaky monoculture on strip mined areas.

It seems fair to state that the prompt restoration of surface mined land to its original natural state is impossible. The restoration of the same land to some useful state is more likely and in some situations could make the mined land more valuable. Representatives of both the coal and stone industries testified that the use of surface mined land after mining should be left to the decision of the operator-owner, or local government. Thus, they oppose Federal statutory language requiring restoration of mined land to the original contour, or the filling of all cuts.

Federal or State administration

The 1971 hearings revealed a significant change in the position of the mining industry from that expressed in the 1968 hearings.

On page 97 of the printed hearings on "Surface Mining Reclamation", 90th Congress, 2nd Session, Mr. Joseph Abdnor, representing the American Mining Congress testified:

> Based on the mining industry's awareness of the economic factors involved, its experience in the diversity of the problem and the engineering techniques of land restoration, and its analysis of the problem on a national basis, the American Mining Congress is opposed to the legislation before you today.

He further noted on page 98 of the 1968 hearings:

> We do not believe Federal legislation is called for; we oppose it as unnecessary, undesirable, and impractical.
>
> It is unnecessary because no plausible case exists for global Federal regulation producing a conflict of jurisdiction over the myriad local conditions which apply to the reclamation of surface-mined lands.

In the 1971 hearings, Abdnor once again represented the American Mining Congress. His recent testimony illustrates the change in the mining industry's approach:

> Let me say at the outset that the American Mining Congress endorses the concept embodied in a number of the legislative proposals pending before this Com-

mittee—namely, that it is appropriate for the federal government to have and exercise the authority to establish guidelines for the regulation of surface mining. While urging that the states have a responsible role, we recognize that when federal guidelines are thus set, it is incumbent on a state to satisfy those federal guidelines; and if it does not, then the federal government will come into a state and do the job itself.

In 1968, conservationists found acceptable the proposition of Federal guidelines for the States to use in the development and administration of their own programs—the approach now supported by a large segment of the mining industry.

The conservationist position has also undergone a shift. Based on their observations of State programs to regulate surface mining and reclamation, conservationists find State control unsatisfactory, in many instances. As a result, their request is now for a Federally administered program.

Assistant EPA Administrator John Quarles criticized the existing situation, noting:

> Many of the State statutes are inadequate and ambiguous; some do not admit of equitable enforcement. State enforcement has been hampered by lack of funds and personnel. In addition, most of the State laws . . . are too limited in coverage to provide a comprehensive remedy for the problem.

United Mine Workers of America representative Joseph Brennan, speaking in support of S. 2777, said:

> S. 2777 contains a provision for State control over stripping under certain circumscribed conditions. We have some misgivings on this section because of many State failures in the past to adequately control stripping or to effectively enforce proper statutes.

Other critics of the State programs were more outspoken. Peter Borrelli of the Sierra Club testified:

> There are two basic reasons for the failure of regulation. One is lack of enforcement. The feeble regulatory efforts of West Virginia and Kentucky are just no match for the immense political and economic power of the coal industry. . . . Pennsylvania can at least balance the scale with some real enforcement, but blatant violations of the law abound.
>
> The second reason for the failure of regulation is that regulations in all three states prescribe procedures to be followed, rather than results to be achieved.

Norman R. Williams, former official in the West Virginia surface mining regulatory program concluded, "the surface mining industry in Appalachia is not amenable to social control". He charged that in West Virginia:

> . . . the entire regulatory apparatus of the State is geared to protect the surface mine operator's profits as against protecting the environment and downstream residents.

In contrast, two active State reclamation officials, William Guckert of Pennsylvania and Sanford Carby of Georgia testified in support of an overall Federal program but for a State role. Guckert, for instance called for Federal legislation which "should set the standards, requirements and penalties, but the responsibility for enforcement should be with the individual States".

S. James Campbell of the National Crushed Stone Association cited the historic role of State and local government in determining land use patterns. He said:

> Blanket federal rules respecting reclamation would conflict with and undermine efforts of state and local authority to provide rational growth and land development.

Administering Federal agency

There was a strong difference of opinion apparent in the hearings as to which agency should lead the Federal effort in establishing guidelines and administering the program.

Department of Interior Assistant Secretary Hollis Dole testified:

The Department of the Interior, whose function is the formulation and administration of programs relating to management, conservation, and development of our natural resources, is the logical agency to administer the proposed act.

His position was supported by industry spokesmen and others who acknowledged the expertise of the Department of the Interior.

Carl Bagge stated that Interior was best qualified to administer the Federal program, particularly in light of the fact that, "the Mining and Minerals Policy Act of 1970 charges the Secretary of Interior with the responsibility of carrying out the policy of that Act".

Joseph Brennan testified for the United Mine Workers that, "the Department of Interior is the logical place for enforcement . . .". He added:

On the other hand, there is a great deal of knowledge about the impact of strip mining and the damage done to the environment by strip mining outside the Department of Interior. To bring this knowledge to the fore, S. 2777 provides for the use . . . of experts from other governmental agencies. It also establishes a strip mining advisory commission, with membership appointed by three somewhat diverse governmental departments.

The Secretary of Interior would appoint three members . . .

The Secretary of Agriculture would appoint three members . . .

Finally, the responsibility for the Federal anti-pollution law rests with the Administrator of the Environmental Protection Agency . . . [who would also appoint three members of the advisory commission].

In general, conservation and environmental groups favored vesting primary Federal authority in the Environmental Protection Agency.

Malcomb Baldwin, testifying for the Conservation Foundation, said:

We believe that the Environmental Protection Agency, which is responsible for enforcing most of the nation's Federal environmental protection laws, is in the best position to enforce strip mine legislation. This separation of enforcement duties from the Department of the Interior's development and management functions is consistent with the theory behind the Administration's environmental reorganization proposals. Conflicts of interest historically apparent within the Department of the Interior can be resolved by giving EPA enforcement authority over coal strip mining.

Among others sharing this position were the Black Mesa Defense Fund, and the Sierra Club. Senators Cooper and Baker advocated EPA as the lead agency for the Federal effort. Senator Cooper noted:

Senator Baker and I have concluded that the proper agency for control would be the Environmental Protection Agency, cooperating with the Department of the Interior's Bureau of Mines, and with the Forest Service and Soil Conservation Service of the Department of Agriculture, and others.

The case for the Department of Agriculture as lead agency was made by David Unger, of the National Association of Conservation Districts:

The Federal responsibility for dealing with the impacts of mining on the land surface should be exercised by the Department of Agriculture. USDA is the recognized authority in dealing with erosin, land reclamation, and land conservation. Working in cooperation with our conservation districts, the Department has built up a network of technical, financial, and educational arrangements which are already being utilized in mined-land reclamation and which would be available for an accelerated and expanded program.

Virtually all of the research being conducted on reclamation of mined lands is being done by USDA and cooperating Agricultural Experiment Stations. . . .

The Soil Conservation Service of the Department of Agriculture has nearly 40 years of experience in the scientific planning of land reclamation and conservation work . . .

SCS has available a corps of nearly 8,000 trained technicians across the country who are experienced in the application of technology to land problems of this kind.

Additional issues

Several points, not previously discussed in this Committee Print, appeared in the hearings a number of times. These are the special characteristics of some mineral operations; the problem of previously mined lands including questions of ownership; a severance tax on surface mined minerals; a timetable for the implementation of surface mining regulation; and other suggested additions or deletions with regard to the then pending legislation. The contentions on these points are outlined in the following sections.

Special characteristics of some mineral operations

Rather broad support was made for the point that surface mining for different minerals creates different problems—and that any Federal reclamation law should recognize those differences.

Malcomb Baldwin of the Conservation Foundation said:

However, many of the bills now being considered would legislate for all forms of surface mining. We believe these bills to be inadequate, because they do not recognize the problems peculiar to each form of strip mining.

Georgia reclamation official, Sanford Darby, noted:

I know from experience in writing the Georgia rules and from administering and enforcing the provisions of this law many of the problems involved. I can assure you that if you delegate complete responsibility to the Secretary of the Interior or to any one specific government official the responsibility of developing regulations which will apply to the entire United States, he is going to have an almost impossible task to accomplish.

S. James Campbell, of the National Crushed Stone Association, said:

With regard to the requirements of several of the bills this Committee is now considering, I would call to your attention the unique character of our industry. Quarries have to be located in or near urban areas because of the high cost of transporting heavy stone materials. Consequently, our industry is already subject to heavy local regulation through zoning and area growth plans. Again, a quarrying operation disturbs very little land—the average quarry encompasses less than 30 acres. Because almost 85% of the materials excavated from a quarry is sold, there is virtually nothing left for land fill. Moreover, typical types of quarries have a life expectancy of about 81 years.

With the exception of being located near urban centers, these same arguments are also applicable to the mining of iron ore. Tom Binger said of his company's experience in Minnesota:

It is the numerous inactive mines and lean ore stockpiles that can be relied upon to provide the demands of the increased steel production in times of national emergency. If all the pits in Minnesota had been "reclaimed" and the lean ore piles dumped back in the open pits, I do not believe the production requirements of World War II or the Korean War could have been so easily fulfilled.

. . . My company's operations have always involved the adoption of new techniques to gain mineral values from mines that have thought to have been exhausted of economic ore by a previous operator. Had the previous operator contaminated the mine by the reintroduction of surface materials or had he not carefully segregated the lean ore materials brought to the surface in his operations, it seems certain to me that most of the iron ore we have been able to produce would not have been possible.

Previously mined lands

There are about two million acres of land which have been disturbed by surface mining but never reclaimed. Provisions for treatment of these "orphan lands" are included in some—but not all—of the pending bills.

Senator Clifford Hansen said of S. 1160, which he introduced:

> The Subcommittee has devoted much time and effort to several bills pending in the Congress concerning strip mining and underground mining and the restoration and reclamation of mined lands. I am deeply concerned however, that these bills do not provide for restoration and rehabilitation of areas which have been mined in the past and have been long since abandoned.

The bill would provide nationwide application of a program presently limited to Appalachia whereby the Secretary of Interior makes grants to seal and fill voids in abandoned coal mines. Abandoned oil and gas wells would also be covered by S. 1160.

Assistant Interior Secretary Dole testified in opposition:

> * * * preventing the annual additions of new problems is relatively more important than initiating broad new programs to ameliorate the affected lands of the past. We must bring under control today's and tomorrow's potential damages to the environment before we can make reasonable headway against those of yesterday.
>
> * * * Our second reservation concerning S. 1160 is centered quite simply on the basis of cost. It is truly a very substantial expense which will be involved in repairing past mining damages. It is not one that can be imposed readily on its perpetrators, as too many of the former mine operators and landowners no longer control or own the mined property. And because our knowledge of what really needs to be done is incomplete, the potential for costly mistakes is large.

Senator Jennings Randolph testified that in West Virginia:

> The principal remaining concern is acid mine drainage from abandoned and orphaned surface mined lands.

The Conservation Foundation, referring to coal, stated.:

> We recommend a joint State-Federal program, in which initially the states should catalogue and establish reclamation plans and priorities for these lands and the Federal government should provide the funds and special expertise. Then the states and/or the Federal government should proceed selectively to reclaim or rehabilitate.
>
> We recognize that there are problems of windfall profits to private owners benefitting from the enhanced value of their lands. However, liens could be applied by states, to assure that an owner of reclaimed land would repay the state for any increment in value resulting from reclamation, at least up to and including the resulting increment in fair market value of the land. We recommend that new legislation require a thorough study of the "revolving fund" mechanism whereby public acquisition and resale of subsequently reclaimed land can fund the purchase of more such land.

Severance tax on surface mined minerals

Senator Howard Baker testified:

> We should consider the establishment of a severance tax on all coal and on other fuels at the Federal level to insure uniformity and make the proceeds thereof available to the states or locality if they elect so that the benefits of this resource can accrue to the area in which it is located.

In later questioning, he indicated that he would make such a tax applicable to all surface mined minerals, not only fuels.

Norman Williams also supported a tax on coal to facilitate reclamation:

* * * a Reclamation Trust Fund should be established, based on a per-ton tax of all coal mined, the money to be devoted exclusively to purchasing and restoring lands inadequately reclaimed from surface mining or deep mining of coal, and also for funding workshops and other organized efforts to train citizens in monitoring techniques.

Peter Borrelli, of the Sierra Club, offered as one method by which the "federal government might affect partial prohibition" of surface mining of coal:

A tax of $2.50 per ton, on strip-mined coal to remove the competitive advantage of strip mining over deep mining. The tax could be used for federally administered reclamation.

A timetable for surface mining regulation

The administration surface mining proposal allows two years for the States to develop requirements for mining operations and reclamation. Another proposal, S. 1498, would abolish surface mining for coal within six months of enactment. The timing of controls for surface mining thus remains an active question.

Administration spokesmen defended the two year time allowance to the States on the grounds that some State legislatures met only every two years, and thus would need the time allowed by the administration proposal.

Senator John Sherman Cooper proposed a more compressed schedule:

This procedure, establishing a system of primary State regulations, backed up if necessary and enforced by the EPA, would require 16 or 18 months to develop—6 months from enactment for the EPA to issue comprehensive guidelines and criteria to the States, 6 months for the State to develop its plan based upon the Federal criteria and guidelines, and then 4 to 6 months for the action of the EPA in approving or amending State plans.

Noting the problems that unregulated mining could cause during even the 18 month period, Senator Cooper added:

I therefore propose that during this interim period, surface mining be conducted only under Federal authority, with the approval of the EPA.

Our proposal would establish an interim Federal program, under Federal authority of the Environmental Protection Administration. Any person currently operating a surface mine, or proposing to initiate operations at a new site, would be required to file a plan with the EPA describing the method of operation and the restoration program. The Administrator of EPA would have to approve the plan if the operator is to continue operations, or initiate new operations. The Administrator would approve the plan only if he were assured that restoration is adequately provided for. Six months after enactment no person could operate a surface mine except in compliance with the interim Federal controls and EPA approval.

A similarly compressed timetable was proposed by Baldwin of the Conservation Foundation, who said:

* * * we recommend that Federal law should give the states a regulatory role, but that it should allow them not more than six months to develop Federally-approved laws, regulations, and implementation procedures. Failing such approval, Federal standards and enforcement should apply.

Given the general condition of state law and the urgency of radical changes, it may well be that the foregoing propsal might result in direct Federal control over coal strip mining in many states, through Federal permits, regulations, and inspection programs. Such a direct Federal role would find some precedent in Federal enforcement of the Coal Mine Health and Safety Law.

As part of the Federal program, Baldwin also recommended that, "all contour stripping cease within six months of the date of enactment of the Act."

Other proposed additions and deletions

The hearings elicited numerous suggestions as to additions, deletions and changes in language of the several bills. Several witnesses, such as HELP and the League of Women Voters of Scranton, Pennsylvania, and the National Coal Association provided detailed reviews of the pending legislation.

Among the suggestions offered were these:

The American Mining Congress expressed concern that any legislation approved by the Committee, "include an appeals procedure, including the right to judicial review by the courts". The Mining Congress also declared, "that criminal sanctions in a federal surface mining statute would be most inappropriate".

The National Coal Association said that, with regard to any federal guidelines, or regulations, "public notice and the right to comment should be required".

The deletion of control of underground mining was proposed by E.R. Phelps, President of Peabody Coal Company, who said:

> The coal industry believes the legislation should not include the environmental regulation of underground mining.

R.W. Hatch added in this regard:

> * * * no practical technology has yet been developed to control subsidence in underground coal mining, so there is no way that that part of the statute could be enforced.

The Crushed Stone Association offered this suggestion:

> We propose that such legislation define the term "reclamation" to specify that flexible land reuse is the will of Congress. The failure to make this clear will, we submit, invite "guidelines" ordering a return to as near original condition as possible irrespective of possible alternative uses that would result in a higher use of such land.

The Association also offered a suggestion that was repeated by other mineral industry witnesses:

> That any Federal guidelines or state standards should be required to be consonant with the Mining and Minerals Policy Act of 1970.

These are, of course, but a few of the many suggestions offered during three full days of testimony. The selection is not meant to be encyclopedic, but only to provide an indication of the concerns expressed. While it is hoped that this review of the hearings is balanced, overall, the full hearing record must be examined as the final source on what transpired.

TABLE 1.—COMPARISON OF SELECTED PROVISIONS OF 92D CONGRESS BILLS TO REGULATE SURFACE MINING

Bill No.	Sponsor	Lands, affected minerals	State-Federal relationship agency involved	Bond required	Source of funding
S–77, introduced Jan. 25, 1971.	Nelson, Percy, Stevenson	All lands, all minerals, surface only retroactive and future mining.	1. Establishes a national advisory committee. 2. Secretary of Agriculture and Interior develop Federal standards and issuing mining permits and/or 3. Approve State standards and requirements as effective as Federal standards.	None	1. Establishes "Mined Lands Reclamation Revolving Fund" from (a) appropriations, (b) sale or lease of Federal lands, (c) fines and forfeitures, (d) other operation sources of money.
S–630, introduced Feb. 5, 1971, H.R. 60.	Jackson	All lands, all minerals, surface only, future mining only	1. State plan submitted to Secretary of Interior for approval within 2 years. 2. If not, Secretary issues regulations and permits for particular States/or grant a 1 year extension.	None	1. Establishes Mined Lands Reclamation Fund from (a) appropriations, (b) permit fees, (c) other charges and penalties. 2. Federal cost of State Program, not to exceed 50 percent.
S–993, S–1176, introduced Mar. 10, 1971, H.R. 4704, 4967. 5689, 6580, 7422,	Administration bill: Jackson, Allott, Cooper, Case.	All lands (except Federal and Indian) all solid minerals, surface and subsurface future mining only.	1. State plan submitted to Secretary of Interior for approval within 2 years. 2. If not, Secretary issues regulations and permits for particular States/or grant a 1 year extension. 3. Establishes an advisory committee.	None	1. Appropriations authorizing Federal Government to finance 80 percent of State 1st year cost.
S–1498, introduced Apr. 5, 1971, H.R. 4556, 4557, 6484, 6485, 7675, 7695, 8174, 8386.	Nelson, M Govern, Kennedy, Humphrey, Case, Harris.	All lands, coal only. Surface only except subsurface National Forests retroactive and prohibits future mining.	1. EPA promulgates regulations. 2. EPA to publish regulations for underground coal mines after which States submit implemention plans for approval. 3. If not, EPA sets forth implementation plan for State. 4. Federal pays 90 percent of costs of acquisition and reclamation.	Bond for each mine.	1. Executive order empowering Federal assistance by agencies through grant, loan, or contract.
S–2455, introduced Aug. 5, 1971, amended Nov. 12, 1971.	Moss	All lands, all minerals, surface only retroactive and future mining.	1. Secretary of Interior consulting with, EPA and Secretary of Agriculture to promulgate standards and/or; 2. Approve State standards comparable to Federal standards within 180 days.	Bond amount to be determined by Secretary of Interior.	1. Establishes strip mining land restoration fund from (a) fees and fines (b) appropriations.
S–2727	Jackson, Allott	Federal only, all locatable minerals, surface and subsurface.	1. Administered by Department of Interior. 2. Subject to all applicable State and Federal laws.	Bond, yes	1. Fines. 2. Rental fee. 3. Royalty fee.
S–2777, introduced Oct. 29, 1971.	(H.R. 10758) Gravel	All lands, all minerals, surface only retroactive and future.	1. Establishes strip mining advisory commission. 2. Secretary of Interior shall develop and promulgate standards and/or; 3. Delegate authority to State to enforce State law consistent with provisions of act.	Not less than $1,000/acre $10,000/ operation determined by Interior.	1. Strip mine reclamation fund with funds from (a) appropriations (b) fines and fees (c) sale, lease, or rental of reclaimed land.

S-3000	Cooper-Bennett	All lands, coal only, surface only	1. EPA administered—promulgate standards within 4 months. 2. State submits plan to EPA within 8 months. 3. Federal Government takes control during interim period. 4. No surface mining without license 270 days after enactment.	Yes	1. Appropriation. 2. Fines.
S-1160, Mar. 9, 1971	Hansen	All lands, all minerals, surface and subsurface retroactive only.	Secretary of Interior to make grants on a matching basis to State.	None	Appropriations.
S-1240	Church, L. Jordan, Mansfield, Metcalf, Moss.	Public lands designated by Secretary of Interior, all minerals surface only.	Secretary designates those lands on which mechanical equipment is prohibited in mining activity.	do	

SELECTED COMMENTS FROM THE HEARINGS

Bill No.	National Coal Association comment	U.M.W. comment	Environmental groups	Agency comment	Specialized mining industry comment
S-77, introduced Jan. 25, 1971.	Administration by 2 sections would result in confusion.			Not supporting (1) Joint control, (2) Government pays 75 percent of cost to rehabilitate land previously damaged.	Sand and gravel, iron ore, crushed stone, copper—open pit.
S-630, introduced Feb. 5, 1971, H.R. 60.	Favors this approach, recommends that, (1) Public notice be required. (2) That all parties have the right to comment on regulations. (3) Advisory committee at Federal and State level.			Not supported, (1) encourages State regulations of surface mining only will Federal goal as backup.	None of proposed regulations. Appropriate to long-term operation, little spoil, no land fit.
S-993, S-1176, introduced Mar. 10, 1971, H.R. 4704, 4967, 5689, 6580, 7422.	Favors this approach, recommends: (1) Right of operator to appeal to Department of Interior if State denies permit. (2) States be required to grant operator a hearing if his operations are prohibited.		Sierra Club sees little improvement except marginal in some States not now having legislation.	Will allow the necessary development of our mineral resources and insure protection of our environment.	
S-1498, introduced Apr. 5, 1971, H.R. 4556, 4557, 6484, 6485, 7675, 7695, 8174, 8306.	Unrealistic and irresponsible reduces production 44 percent and ignores the fact that the technology for reclamation has improved.	Against this approach	Sierra Club supports generally	Not supported.	
S-2455, introduced Aug. 5, 1971, amended Nov. 12, 1971.	Costly and no advantage mine operators would be responsible first to State, then Federal Government, then back to State.		LWV support reclamation provisions with amendments.	Limited to surface only. Not broad enough.	
S-2777, introduced Oct. 29, 1971.	Attempt to impose uniform standards regardless of existing conditions would not be desirable.	Full support: (1) Tight Federal control should satisfy citizen revolt against all strip mining. (2) Best assurance that the ecology will be preserved.	LWV support judicial review provision.		
S-1160, Mar. 9, 1971				Would not regulate future mining limited to reclaiming mined lands.	
S-1240				Too narrow limited to control of heavy equipment use on public lands.	

GENERAL

[From New York Times, Aug. 22, 1971]

Coal Rush Is on as Strip Mining Spreads into West

(By Ben A. Franklin)

Washington, Aug. 21—A new stage in the development of the American West is beginning on the arid plains and badlands that flank both slopes of the Rocky Mountains.

On thousands of square miles of vacant land west of the Mississippi—much of it in Federal ownership or in Government land grants to Indian tribes and railroads—a feverish coal rush is on.

The scramble is for coal leases and rights that will open an enormous and virtually untapped reserve of cheap Western fuel to strip mining.

On a scale far larger than anything seen in the East, where acreage totaling half the area of New Jersey has been peeled off for coal near enough to the surface to be strip mined, portions of six Western states—Arizona, Colorado, Montana, New Mexico, North Dakota and Wyoming—face a topographic and environmental upheaval.

It is being brought on by the nation's apparently insatiable demand for energy, by the air pollution crisis in urban centers, by new technology in the conversion of coal to clean fuels, and by the economies of bulldozing rather than tunneling for coal that are available in the West.

In resolving the energy and air pollution problems, however vast areas of isolated open spaces in the West may be drastically altered.

The visual impact of strip mining is invariably stunning. On flat or rolling terrain, mammoth power shovels crawl day and night through great trenches, lifting, wheeling and depositing, the unwanted strata above the coal seam into thousands of uninterrupted acres of geometrically perfect windrows of spoil banks.

In mountain coalfields where one, two or as many as five seams may lie horizontally through timbered slopes far above the valley bottom, the contour strip mines are notched in continuous, sinuous strips around the mountainsides. Trees and earth and rock are cast down the mountain flanks to expose the strippable edge of the coal bed.

The legacy of upheaval remains. Silt fills streams for thousands of miles. Sulphur-bearing coal, left in place and exposed to the elements, yields a long-lasting trickle of sulphuric acid which chemically burns streams and kills aquatic life. From the air over a "hot" acidic strip mine, pools of rainwater glow in weird shades of red and orange.

The debate over strip mining has been gathering since the late nineteen-fifties, when larger and larger earth-moving machinery made its growth economically feasible and gave it a cost advantage over underground mining. With a passion that coal men tend to see as mysticism, conservationists say that stripping destroys the very roots of men's souls—the land. The mining industry sees it with similarly strong conviction as the best way to tap a vital national resource which, as one strip mining executive put it recently, "God put there for man's use—it's a sin to waste it."

According to one Government geologist here, the six states and others in the West—Oklahoma, Texas and even a patch of Washington State—"are on the brink of, not years, but generations of strip mining for coal that will make the excavation for the Panama Canal look like a furrow in my backyard vegetable garden."

The first wave has begun. In 1970, for the first time in the 100-year history of coal mining in America, a Western mine—the Navajo strip mine of the Utah Construction and Mining Company near Farmington, N.M.—became the largest single producer in the country. Its output from Indian coal lands was more than six million tons for the Four Corners Electric Power Complex, an environmentally controversial steam-electric station serving New Mexico, Arizona, Nevada and Southern California.

Near Centralia, Wash., 30 miles south of Olympia and just beyond the foothills of Mount Rainer, a 5,000-acre, 135-million ton deposit of coal that was only nibbled at by tunneling from 1870 into the nineteen-fifties for pre-diesel locomotive fuel for the Northern Pacific and Union Pacific Railroads, is being turned into one of the biggest strip mines in the country. The planned rate of production is five million tons a year for a 700,000 kilowatt generating station of the Pacific Power and Light Company and the Washington Waterpower Company.

Pacific Power and Light also owns rights to an estimated 1.6 billion tons of strip mine reserves in Wyoming and Montana. The company expects to rank among the top fine coal producers in the country by 1977 with production of 23 million tons a year. Its president has said that the company will go slow on expensive investment in nuclear power stations because "we've got coal running out our ears."

Even Texas lignite—lignite is the lowest rank of coal in energy per ton and it has never generated more than an asterisk in Government coal production statistics—is having a sudden boom.

Three electric utilities—Texas Power and Light, Dallas Power and Light and Texas Electrical Service, Inc.—announced two months ago that they would begin a 35-year strip mine operation on 17,500 acres of lignite beds in Freestone County, near Fairfield, to fuel the new Big Brown steam-electric station east of Waco. Other lignite-fired plants are scheduled for Rusk and Titus Counties.

Western coal is low in sulphur—a boon to electric utilities caught between soaring power demand and new air pollution regulations that forbid the burning of sulphur-contaminated fuel. Accordingly, also for the first time last year, some low-sulphur western coal was hauled by rail as far east as Chicago.

But according to Government coal men, an immense strip mine explosion west of the Mississippi River that, by comparison, will make this excavation for electric power stations look like a mere desert gulch, is coming in the nineteen eighties for a giant new coal consuming industry, gasification.

Officials forecasts here say that 20 years from now perhaps 300 million tons of coal a year—half of last year's total United States production—will be processed at huge, refinery-like plants, surrounded by massive strip mines in the Western coal fields. The product will be quadrillions of cubic feet of pipeline quality, pollution-free gas. The Government and the mining and gas industries are now committed to this basic change.

VAST COAL BEDS IN WEST

Coal gasification will replace the country's dwindling supply of natural gas from wells, now estimated to be only about a 15-year reserve. Consumed in power plant and industrial boilers in the East, the gas will reduce air pollution. And pumped through pipelines that might otherwise be empty, it will save the pipeline industry from collapse.

Millions, perhaps billions, of dollars are thus finally ripening in coal beds under Western sagebrush, where the mineral has lain for geologic time, 130 million years.

The speculative market in Western strip mine leases to dig it, and in permits to explore for more, has suddenly become a bonanza.

In the 12 months that ended in July, 1970, the increase in prospecting permits issued by the Interior Department's Bureau of Land Management for coal exploration on Federal land—national forests, grassland, desert and range—shot up by 50 percent to the greatest number in history, covering 733,576 acres. That is the area of all New York City and Long Island, with Westchester and Rockland counties thrown in.

Prospecting permits on Indian reservations, issued separately by the Bureau of Indian Affairs, went from none to exploration rights covering 500,000 more acres. Such permits are convertible to firm mineral leases if coal is found.

COAL-FIRED TURBINES

Nearly one million acres of public and Indian coal land in the West is already leased. Leases by private owners, chiefly by the transcontinental, land-grant railroads, are unknown but may cover an equal area.

The forces behind the sudden migration of coal mining to the West are complex, and the reasons for them are probably as irresistible as money.

First, despite the wide acceptance during the nineteen-sixties of visionary forecasts for nuclear electric power, half the nation's electricity is still generated by coal-fired steam turbines.

Dr. Glenn T. Seaborg, the retiring chairman, of the Atomic Energy Commission, recently conceded that the poor record of the A.E.C.'s vaunted nuclear-electric program means that coal will fuel an even greater portion of the enlarged generating capacity required for the next three decades.

Other important factors are mining costs and mining volume.

Strip mine production of coal in the country as a whole has advanced very rapidly in the last few years, from about one-third of the annual tonnage in 1968 to 40 or 42 per cent last year. According to the United States Bureau of Mines, the cost advantage over deep mined coal is on the order of three to one.

Productivity per worker runs as high as five to one in favor of strip mining, and is going higher under the Federal Coal Mine Health and Safety Act of 1969, which requires deep mines to take expensive steps to curb the high rate of death and injury underground.

Moreover, particularly for gasification, huge guaranteed volumes of cheap, strip-mined coal are essential.

77 PERCENT OF RESERVE

The Bureau of Mines has just cautiously disclosed in an unpublished compendium that beneath 13 states west of the Mississippi River there lies 77 percent of the country's total of economically strippable coal reserves of 45 billion tons. The Western coal is in seams 12 times thicker, on the average, than in the East. And 25.5 billion tons of it is low-sulphur coal.

Wyoming and Montana, together, contain 21 billion tons of the entire Western reserve of low-sulphur coal. Wyoming's low-sulphur reserve, alone, is eight times West Virginia's and Kentucky's put together.

The Government has apparently pre-empted most of one of Colorado's major strip mine fields by building the Air Force Academy on top of it at Colorado Springs. But Colorado still contains nearly half a billion tons of the highest grade of low-sulphur strip mine coal.

And still undisturbed beneath the wheat and grasslands of western North Dakota wait 50 billion tons of lignite—the leanest rank of coal, but equivalent in total energy to all the better grades of coal left to be mined in the four largest producing states, West Virginia, Kentucky, Pennsylvania and Illinois.

The Bureau of Mines has recently disclosed that Pennsylvania and Illinois have no low-sulphur stripping coal left at all. The reserve in West Virginia is only about 1.2 billion tons, one twenty-fifth of the national reserve.

For a hundred years the traditional coal field regions of the United States have been there—in the Appalachian east and south and across southern Indiana and Illinois, tapering off into Missouri, Kansas and eastern Oklahoma.

Billions of tons of coal and billions of dollars of investment in immovable tools and tunnels remain in these traditional coal areas, and depletion of total coal reserves is not the most important factor in the move to the West.

But although the Eastern and Midwestern fields now supply 94 per cent of the 600 million ton-a-year coal production, they contain only 17 per cent of the remaining reserve of strippable low-sulphur coal.

ENERGY SYSTEM SHIFTING

It is this arcane statistic, the 83 per cent of shallow, strippable, low-sulphur coal beneath the Western states, that is starting what the United States Geological Survey calls "a massive change" in the whole national fuel and energy system.

Until the air pollution crisis of the nineteen sixties and seventies the West's low-sulphur coal was as worthless as a coyote. Coal is the cheapest of fossil fuels and, accordingly, freight is a large part in its cost to consumers. Longhaul reserves were not cost-competitive.

But now that many urban pollution abatement laws forbid the burning of coal or oil containing more than 1 per cent sulphur by weight—and the Federal Environmental Protection Agency has said the limit may have to be pushed to 0.7 per cent—the ancient economic maxims of coal, a $3-billion a year industry, are caving in.

Already, in a break with transportation tradition, the historic flow of coal from Appalachian mines to Lake Erie port to docks at Superior, Wis., or Duluth, Minn., has begun to turn around.

For example, Burlington Northern, Inc., the merged railway system—and also one of the largest private owners of Western coal reserves through 19th century Federal land grants—has been loading low sulphur coal from the Peabody Coal Company's Big Sky strip mine at Colstrip in eastern Montana. The coal goes by train to the docks at Superior and is shipped lake steamer to Tasonit Harbor, Mich., a movement that would have been economically unthinkable a few years ago.

It is the prospect, however, of prodigious volumes of stripmined coal to supply gasification plants that lies behind the frantic scramble by coal, petroleum and pipeline interests—and by land brokers and speculators who expect to profit at their expense—to assemble leases and rights to large tracts of Western coal for future stripping.

The scope of this Western stripping for gasification—large both on a plant-by-plant basis and also in the area to be affected by big new surface mines—is suggested by what the American Gas Association calls its "very confidential" study of potential gasification sites.

Apparently for fear of stimulating price gouging in mineral leases and arousing conservationist opposition, the association will not discuss the study beyond acknowledging its existence. Association officials will not even say which states have been identified as gasification sites, much less which counties.

But it is known that the association report pinpoints 176 prospective plant locations—each to require a $200-million to $300-million investment in strip mine and coal processing facilities—and industry officials say variously that "a large majority" or "nearly all" of them lie west of the Mississippi.

A Government geologist who has seen the association study says that 156 of the 176 sites—all but 20—are in "the Rocky Mountain West." Enough of them are to be developed by 1985, the study suggests, so that gasification by then will materialize as a $1-billion-a-year industry on the West's open spaces.

According to Interior Department reports, coal for future gasification is spurring recent transactions like these:

In response to a United States Bureau of Land Management invitation to bid on 6,560 acres of Federally owned coal land in Campbell County near Gillette, Wyo.—the bureau delicately described the 10-square-mile area as "susceptible to stripping"—the Cordero Mining Company won the coal leases with a record high price of $505 an acre. In recent years, some Federal coal leases have gone for under $1 an acre. Cordero is a subsidiary of the Sun Oil Company.

On the same day last December, the Mobil Oil Company bid $441 an acre for leases on 4,000 acres of bureau land adjoining the Cordero site. The United States Geological Survey had estimated its worth at $35 an acre.

LEASE PRICES SOAR

Bureau lease prices have advanced so rapidly that a short time earlier a successful bid of $257.50 an acre by a land-buying affiliate of the Ashland Oil Company—$1.9 million for coal rights to 7,600 acres, or 13 square miles, of Carbon County near Hanna, Wyo.—was being called a "precedent-shattering high price." The $257.50 precedent lasted two weeks, when Cordero doubled it.

But particularly on Indian reservations, there have also been what one official of the Bureau of Indian Affairs here calls "some damn lucky breaks" for Eastern coal companies bidding for leases of tribal coal reserves.

Last September, Westmoreland Resources, Inc., a year-old Western strip mining partnership of the Philadelphia-based Westmoreland Coal Company, Penn Virginia, Inc., the Kewanee Oil Company, the Morrison-Knudson Company, and the Kemmerer Coal Company of Wyoming, had to bid an average of only $7.87 an acre for 32,300 acres of coal rights held by the Crow Indian reservation in the Sarpy Creek area of Treasure and Big Horn Counties, Mont.

Within months, the syndicate had sold options to buy 300 million of its 900 million tons of Montana coal reserves to the Colorado Interstate Gas Company, the pipeline division of the Colorado Interstate Corporation. The company is a major pipeline company and may be one of the first to erect a coal gasification plant, presumably near Hardin, Mont.

OTHER VAST RESERVES

Other vast coal reserves in the West are owned by the railroads. Government land grants to the railroads, which were originally meant to encourage and finance the construction of track to the West but which have remained dormant and unsalable for 100 years, are suddenly valuable.

The Union Pacific, for example, has become a profitable lessor of its 10-billion-ton to 12-billion-ton reserve of coal on land given the company by the Federal Government under the railroad land grants of the last century.

But by far the greatest acreage of coal leaseholds is being acquired on speculation for later sale to the coal gasification industry.

An unpublished "working paper" prepared at the Interior Department shows that the 10 largest holders of Federal coal leases control 49 percent of the 773,000 acres of public domain turned over to mining interests or land speculators as of July 1, 1970, and that very little of their acreage is being mined. Some of the inactive leases have been held at little cost since the nineteen-twenties but most are about five years old.

The 10 largest lease holders, in order of the acreage of their coal rights, are listed as the Peabody Coal Company; the Atlantic Richfield Company; the Garland Coal and Mining Company; the Pacific Power & Light Company; the Consolidation Coal Company; the Resources Company; the Kemmerer Coal Company; the Utah Construction and Mining Company; Richard D. Bass, a Dallas geologist and land investor, and the Kerr McGee Corporation.

DRASTIC CHANGE SEEN

The Interior study says that, of all the Federal coal acreage under lease, those 10 lease holders control 97 percent of the leases in Montana and North Dakota, 91 percent in New Mexico and Oklahoma, 79 percent in Utah, 75 percent in Colorado and 77 percent in Wyoming. Peabody and Atlantic Richfield together hold one-third of all the federally leased coal land in Montana and North Dakota.

Federal coal leases, many at bargain rates, are not the only incentives that the Government has provided for the development of Western coal.

On Aug. 4, the Interior Department signed an agreement with the gas industry that will add $80-million in Federal funds to $40-million from gas and pipeline companies for a four-year acceleration of existing work on small-scale but working pilot coal gasification plants. Some $176-million more in Federal money has been set aside for the next step—construction of a full-scale demonstration plant.

Meanwhile, the coal industry is working hard to picture the environmental prospect for the West as benign, if not uplifting.

Carl E. Bagge, a former member of the Federal Power Commission who now heads the National Coal Association, an influential Washington-based industry group, has been making an unusual number of trips into the West to preview the "new prosperity" in Western coal and to inveigh in speeches against "reckless," "radical," "emotional" conservationist attacks on strip mining.

Mr. Bagge has been pointing out in his Western travels that the strip mining industry genuinely means to do better there than in the ravaged coal fields of the East, and that the tempo of Western nature is slower—there is less timber, less rainfall, less visual discontinuity in stripping buttes and badlands than Appalachian hickory forests or Indiana cornfields.

One coal industry suggestion, put forward earlier this year at a session of the Rocky Mountain Mineral Law Institute, was that tourists might have some interest in visiting the scarred and barren "badlands" created by strip mining.

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SULFUR CONTENT OF STRIPPABLE COAL RESERVES

	Grade [1]	Millions of tons by sulfur content			
		Low	Medium	High	Total
Wyoming	B	13,377	65	529	13,971
Montana	B, C	6,133	764	0	6,897
New Mexico	B	2,474	0	0	2,474
North Dakota	C	1,678	397	0	2,075
West Virginia	A	1,138	669	311	2,118
Texas	C	625	684	0	1,309
Kentucky (east)	A	532	189	60	781
Colorado	A	476	24	0	500
Arizona	B	387	0	0	387
South Dakota	C	160	0	0	160
Virginia	A	154	99	6	258
Washington	B	135	0	0	135
Alabama	A	33	74	27	134
Arkansas	A, C	28	118	28	174
California	B	25	0	0	25
Oklahoma	A	10	44	57	111
Utah	A	6	136	8	150
Tennessee	A	5	43	26	74
Michigan	A	0	0	1	1
Maryland	A	0	8	13	21
Ohio	A	0	126	907	1,033
Iowa	A	0	0	180	180
Kansas	A	0	0	375	375
Pennsylvania	A	0	225	527	752
Kentucky (west)	A	0	0	977	977
Indiana	A	0	293	803	1,096
Missouri	A	0	0	1,160	1,160
Illinois	A	0	80	3,167	3,247
Total		31.787	4,036	9,161	44,986

[1] A—Bituminous; B—Subbituminous; C—Lignite.
Source: The New York Times, Aug. 22, 1971.

Note: The westward movement of stripmining has resulted from low-sulfur reserves west of the Mississippi that promise less pollution in fuels to meet the energy crisis.

Pro and Con in a Bitter Debate

WASHINGTON, Aug. 21—Behind the argument over strip mining there lies a maze of complex public issues and private interests that the combatants on both sides agree touch on the most serious environmental questions in the country today.

On one side is the nation's seemingly infinite demand for electrical energy and, at the same time, for clean air. On the other is its equally urgent desire to preserve the national environment.

Coal, the cheapest of fossil fuels, now provides the energy for more than half the country's electric power production. Although it has been a major source of particulate and sulphur-dioxide pollution, the Atomic Energy Commission is now saying that coal will continue to dominate the utility market for three more decades.

Thus, as power demands increase, so will coal mining. The cheapest coal—and the safest coal to mine in human terms—is strip mined coal.

Much of the vast Western coal reserves can be mined in no other way. It is too shallow for underground tunneling, or in seams that are too thick or structurally unsound.

One of the chief attractions of the Western coal is that it is low enough in mineral and chemical contaminants to meet the strictest air pollution standards when it is burned.

It is also the only coal abundant enough, in concentrated beds, to supply the new coal gasification industry, another source, when it is fully developed, of nonpolluting fuel.

The assault on strip mining has brought a fierce response from the coal and electric utility industries, and even from some Government officials.

"Unwilling or unable to face up to the facts of life" is the characterization given the conservationists by Aubrey J. Wagner, the board chairman of the giant, Government-owned Tennessee Valley Authority, the nation's largest single power producer and the largest consumer of strip-mined coal.

In testimony before the Tennessee Legislature last April, Mr. Wagner said that environmentalist critics who seek to abolish strip mining outright or to impose prohibitive reclamation standards "fail to recognize that coal is essential if the electric power needs of the nation are to be met."

"Nor do they understand that coal cannot be obtained in the near term without resort to strip mining," he continued, "and, further, that resort to deep-mined coal instead, even in the long term, creates problems of environmental deterioration and human safety. They would outlaw strip mining even in the face of the fact that such action would create a power shortage in which industrial activity would be severely curtailed, unemployment would increase, commerce would stagnate, and home life would be disrupted."

Conservationists call the "trade off" idea—that a measure of strip-mine damage is acceptable to guarantee the nation's power supply—a rationalization in advance for a permanent defacement of the land.

Moreover, many conservationists seriously question the industry's assertion that it is averting an electric power crisis by strip mining more and more coal.

"We waste electric power as if it were cheap and easy to get," Ed Chaney, a National Wildlife Federation lawyer, said in an interview. "But if you look at what strip mining has done to West Virginia or Southern Illinois and Indiana, you see that it wasn't cheap after all."

"If we ever see, as a people, what strip mining is doing to our country," Mr. Chaney said, "I'm sure we would insist on some other answer, and less use of electricity may be a temporary solution while we find other means of generating power."

[From the Christian Science Monitor, Sept. 23, 1971]

Strip Coal on Way in Montana

Billing, Mont.—Montana Power Company has picked the small southeastern Montana community of Colstrip, 100 miles east of Billings and the site of extensive strip mining of coal for many years, to locate a 350,000-kw., coal-fired power-generating station. It is a possible first step in turning the area into the electric-power generation center for the entire northern Rocky Mountain area.

Cost of Colstrip Unit No. 1, as the plant is being called, is $60 million, exclusive of transmission facilities. George W. O'Connor, president of Montana Power, says preliminary construction began in August, and the plant is scheduled for completion by July 1, 1975. The first of two 230,000-volt transmission lines, which will carry power from the plant site to the company's load and switching center in Billings, is under construction.

The plant, which Mr. O'Connor said "can be developed ultimately to produce 3,000,000 or more kws. of power," is the first minemouth generating station to be constructed in Montana and may be the forerunner of a much more extensive development of eastern Montana's vast coal fields.

RECENT UPROAR

News of the new Montana plant comes on the heels of a recent uproar over coal-fired power plants in New Mexico, Arizona, Utah, and Nevada. The plants there have triggered heavy opposition from environmentalists and caused Secretary of the Interior Rogers C. B. Morton, to clamp a moratorium on new plants on the Colorado Plateau pending a study of their impact on the environment.

Eastern Montana coal is prized for power-generating plants in a pollution-conscious nation because of its low sulfur content and because it lies near the surface, readily available for strip mining. Much of it also is in a sparsely settled sagebrush-covered area of plains or low rolling hills, where reclamation of disturbed land is neither difficult nor costly.

Numerous coal or power companies are interested in the area.

A new coal mine recently was opened near Decker in the southeastern corner of Montana, an area other mines formerly had operated. It will supply 22 million tons of coal over a six-year period to Commonwealth Edison Company of Chicago, beginning early in 1972.

Another likely development area is in the vast Sarpy Creek coal field about 80 miles northeast of Billings, where four major coal companies have acquired holdings. Sarpy Creek reportedly has more than 6 billion tons of subbituminous coal with less than 1 percent sulfur content.

Planned developments stirred some opposition in the recent session of the Montana Legislature. Some lawmakers opposed "mine-mouth energy" plants that would use Montana coal to produce electrical energy for transmittal out of state. They would prefer industrial firms to locate plants in Montana to use locally produced power.

The Montana power plant at Colstrip will use coal being produced at the site by the company's wholly owned subsidiary, Western Energy Company.

But other coal companies also are interested in the area. In February, Peabody Coal Company bid $56 per acre to win a 4,306-acre federal coal lease near Colstrip. Edwin Zaidlicz, state director of the United States Bureau of Land Management, said "spirited bidding . . . indicates a new era for Montana's valuable coal resource."

In April, bids totaled $2,348,290 for prospecting permits on the Northern Cheyenne Indian Reservation, south of Colstrip. The propsecting area covers 367,429 acres in 18 tracts. Low bidders for various tracts, with 13 companies submitting bids, included Meadowlark Farms of Indianapolis, Ind.; Consolidation Coal Company of Pittsburgh; Belco Petroleum Corporation and some Montana firms.

ACTION CENTER

Consolidation Coal Company also is interested in some huge coal fields at Roundup, 50 miles north of Billings, where it plans extensive strip mining in an area that formerly produced coal from underground mines. The community of Roundup welcomes the development, but landowners in the Bull Mountains, a scenic area, oppose the company on ecological grounds. Consolidation, however, claims it can successfully reclaim any strip-mined area satisfactorily, even if not restoring it to its original condition.

Westmoreland Resources Group of Colorado has purchased coal prospecting and water rights from the Crow Indian tribe, whose reservation in southeastern Montana also has vast coal deposits.

While action has centered within 50 miles or so of the Colstrip area, most of eastern Montana has vast beds of readily accessible coal. Coal production in the area doubled last year, and will increase another 65 to 75 percent by 1973, according to C. R. Binger, vice-president for resource and development of Burlington Northern.

The 1971 session of the state Legislature recognized the likely development of eastern Montana coal fields in the near future, and took steps both to obtain revenue from it and to protect the region from the evils of strip mining that have been evident elsewhere.

A tax bill signed into law this year has sliding rates of from 4 to 12 cents a ton, depending upon heating content of the coal, and averaging about 10 cents per ton. The state also adopted laws requiring reclamation of strip-mined lands, and new federal strip-mining regulations are being enforced for the first time in the new developments at Colstrip.

[From the Sierra Club Bulletin, February 1971]

THE STRIPMINING OF AMERICA

(By Wayne Davis*)

Kentucky is being destroyed by stripmining. Not slowly and surely, but rapidly and at an ever accelerating rate. And the disease that affects Kentucky soon may spread to more than half our other states.

Most Sierrans are aware of the problem of acid mine drainage. Sulfur impurities in coal, when excavated and exposed to the air, invite invasion by bacteria which manufacture sulfuric acid. The result is streams with a pH so low that nothing survives but bacteria, the damage is permanent; some sickly red streams run dead a hundred years after mining operations have ceased, with little prospect of improvement in sight.

The extent of the problem is enormous. Keith O. Schwab, of the Federal Water Quality Administration in Cincinnati, has data showing 12,000 miles of degraded streams from mine acid drainage in the Appalachian states. "We can ill afford to lose more streams to mining pollution," he said, "but this is exactly what is happening."

Acid mine drainage has been with us as long as we have been mining coal. It comes from deep mines and surface mines. It has long been accepted by most local

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people as a price they must pay for an economy which removes the coal and burns it up as quickly as possible. Progress means removing the wealth, destroying it, and leaving the land and streams permanently impoverished.

Acid mine drainage, considered one of the most vicious of industry by-products, is trivial however compared to the massive onrush of destruction caused by the incredibly rapid move to surface mining.

In surface mining heavy machinery removes the soil, including trees, grass and everything else on the surface, to expose the coal seam beneath. In the steep hill country of Eastern Kentucky, this means pushing massive amounts of spoil down the mountainside. Even the largest trees are broken and pushed over. The magnitude of the devastation is difficult to imagine for anyone who has not seen it. Man's ever accelerating technology, now rushing forward faster than the speed of thought, has designed machinery which will move 100 cubic yards of dirt with a single bite. Such shovels, standing as high as a 12 story building, are used around the clock, as is the smaller equipment at many of the mountain stripping sites. With profits running as high as 50 percent annual return on the dollar invested and the minimum price of Eastern Kentucky coal having doubled over a 6 month period last year, the rush is on while the getting is good. Western Sierrans who watched the timber barons' frenzied efforts to cut as many big trees as they could before Congress established a national park will understand the rape of Kentucky. As stripping grows and as people become more informed, the opposition forces encompass an ever larger segment of the public.

When rain falls upon a strip mine site massive quantities of mud wash into the streams. A study by the U.S. Forest Service in Kentucky showed streams carried as much as 46,000 ppm of suspended sediment, compared to a maximum of 150 ppm in adjacent forested watersheds. Stream bed burdens of as much as 66,500 cubic feet of sediment per square mile of watershed were observed in the stripped areas. In addition to the stream beds the woodland flood plains were also made a muddy mess from silt. Subsequent rains not only brought down more silt but moved part of the previous loads on downstream, affecting more of our watercourses.

Bethlehem Steel Corporation has mined the high quality low sulfur coal needed for processing steel from deep mines in Eastern Kentucky for many years without arousing the displeasure of conservationists. However, their decision in 1969 to strip 40,000 acres in several counties changed them from an acceptable responsible corporation into the number one target and rallying point for the anti-stripping forces. Stripmining not only puts permanent scars on the mountainsides, but it also kills the streams, which are public property.

Silt kills streams by destroying the nature of the bed. Many aquatic invertebrates upon which fish feed live beneath stones in the gravel-covered bottom of a stream. A fine load of silt from the clay-banks above glues down the stones, making them inaccessible and preventing the free movement of oxygen-carrying water among the gravel and beneath the stones.

The effect upon spawning of fish is similar. Most species of game fish lay eggs in the gravel of the stream bottom. If a fine layer of silt washes off the strip mine spoils and covers the eggs, they are deprived of sufficient oxygen for development and fail to hatch. Thus the stripminers rob the public of a valued resource.

Although land destruction occurs, acid mine drainage and silt are the best known effects of stripmining, a less known but equally dangerous factor may be the raising of the mineral ion concentration of the water effecting its usability by man and his industries. The U.S. Public Health Service sets standards for drinking water quality and the various industries have their own tolerance levels depending upon the purpose of the water they use.

The U.S. Forest Service has done studies on the effects of stripmining on water quality in Eastern Kentucky. In a report they point out that although the U.S. Public Health Service's Maximum Permissible Level for sulfates in water is 250 ppm, on severely disturbed watersheds in Eastern Kentucky they found concentrations ranging up to 2100 ppm. Whereas the tolerance level for manganese is 0.05 ppm, concentrations of up to 74 ppm were found, and for iron, whose recommended maximum level is 0.3 ppm, concentrations ranged up to 88 ppm.

Why the tremendous increase in stripmining activity? Many reasons have coalesced to result in today's frenzy.

The use of electrical power, pushed along by Madison Avenue's request that we live better electrically, have been growing at 7 percent per year, a rate which doubles consumption every 10 years. Coal is a major energy source for power generators.

Even with nuclear reactor power generators increasing at a rate that doubles their numbers every 2.4 years, with this rate expected to continue at least through 1980, the demand for power is increasing so fast that coal powered generators also are being built.

The scarcity of natural gas, which caused gas companies in the East to deny service to many new industrial customers in 1970, and the ever increasing dependency of this country on foreign oil sources, has increased the interest in coal, one resource which is still in abundant supply.

The new mine safety law has helped push operators out of deep mining into the stripmining business. Stripping produces three times as much coal per man as an underground operation and requires less machinery and investment. It is safer for the workers and more profitable to the operators. The result has been that the strip mine has risen from 29 percent of the production 10 years ago to 36 percent today. In the steep Appalachian hills of 9 states strip mine benches now extend for 20,000 miles. Since only 4.6 billion of the estimated 108 billion tons of strippable coal have been harvested, one can see what the future holds.

As the acceleration of stripmining proceeds, attempts to regulate it are frustrated. Although Kentucky has a fairly good mining reclamation law and some honest, conscientious people in the Division of Reclamation, law enforcement has broken down. An employee of the Division told me that during the summer of 1970 permits were issued to over 100 new operators. Since anyone who can borrow enough to get a bulldozer into operation can go into business and get rich now, there is a flood of new people into stripmining. The enforcement officer said that some of these inexperienced operators could not operate within the law even if trying to do so and spills of spoil onto public highways and into the streams are the result.

The business is so lucrative that an operator has been quoted as saying that if we will leave him alone for just two years he doesn't care if we outlaw stripmining, for by that time he would be rich enough to retire.

Operators are getting rich and selling out to the big corporations. The giants of oil and steel, smelling the killing at hand, have been rushing into the fray like a pack of sharks to a bleeding swimmer. The major stripmining operations are subsidiaries of such corporations as Gulf Oil, Humble Oil, U.S. Steel and Bethlehem Steel. TVA is also heavily involved.

If you think coal mining is only a problem for Kentucky and such well known coal states as West Virginia, Pennsylvania and Illinois, you are in for a surprise. A total of 26 states have strippable reserves of coal. We easterners will not even be in the running when the big time arrives, because the states with the largest reserves of strippable coal are North Dakota, Montana and Wyoming. If we draw a line from Pennsylvania to the coal-laden northwestern tip of Georgia, every state west of the line except Wisconsin, Minnesota and Hawaii has some coal deposits. With the industry's trend toward building power plants where the coal is, the destruction of parts of your state may be even now on the shallow horizon.

Stripmining as a big business has moved into Ohio. Ben A. Franklin of the *New York Times* reports that 5 billion tons of low grade fuel, long considered too marginal for mass mining, lie near the surface in Ohio, and the boom is on from Cincinnati to the east-central border to recover it. In 346,000 acre Belmont County alone 200,000 acres have been sold, leased or optioned to the strippers. Two giant electric shovels, each 12 stories high, scoop up farms, barns, silos, churches and roads to uncover the coal, piling the rubble into strip mine spoil banks. Franklin quotes Ohio Congressman Wayne Hays, whose home is in Belmont County, as saying "They're turning this beautiful place into a desert," but Ford Sampson, head of the Ohio Coal Association is credited with the line, "Are we going to cut off the electric power because some guy has a sentimental feeling about an acre of coal?"

Perhaps a better example of what we are up against is illustrated by the opinion of James D. Riley, a vice president of Consolidation Coal Company, who spoke to the American Mining Congress in Pittsburgh in 1969. To the thunderous applause of the assembled strip miners, Mr. Riley declared that the conservationists who demand a better job of land reclamation are "stupid idiots, socialists and commies who don't know what they are talking about. I think it is our bounden duty to knock them down and subject them to the ridicule they deserve."

What can be done? First we must insist that Americans take their heads out of the sand and recognize the fact that power demand cannot continue to rise as it has been. Nothing—whether the power demand, the production of coal, the number of people, the number of cars, or the gross national product—can continue indefinitely to rise at an exponential rate in a finite world. The sooner we face reality on this, the sooner we can begin to attack the problems.

So the next time the power tycoons tell you they must double power capacity by 1980 you should reply, "Nonsense—long before 1980 we must plan and put into practice a program to level off power consumption at something like present levels or less."

Second we must have federal regulations of mining practices. Any local efforts to regulate this or any other industry encounter the standard and somewhat justified reply that regulation would put them at a disadvantage with their competitors in other states.

Dr. Robert Kuehne says that in Kentucky we could not have designed a better system to ruin the maximum number of streams in a shorter period. Instead of mining watersheds that are already destroyed until all the coal is gone, the economic system assures that we skip around in such a way as to kill all our streams in the coal country.

The Committee on Resources and Man of the National Academy of Sciences-National Research Council has pointed out that the culmination of oil production in this country is now at hand and the culmination of natural gas will arrive at the end of this decade. We are now dependent upon foreign sources for 20 percent of our oil supplies, and by the end of this decade this is expected to rise to 40–45 percent. Although coal reserves are much greater, we should not continue to treat them as the common enemy to be destroyed with all speed by the system found to be so effective in getting rid of our oil and gas.

We simply cannot afford to continue the present pattern of exploitation of the fossil fuels.

[From Coal Age, March 1971]

The Surface Mining Issue: A Reasoned Response

(*Efforts to abolish surface mining in West Virginia are now under way in the current session of the legislature. As must be expected, the surface mining industry opposes, categorically and unequivocally, any proposed legislation that seeks to put it out of business and place its employees on the rolls of the unemployed. The following is a statement issued by the West Virginia Surface Mine Association to inform all West Virginians, and indeed the Nation, the vital roll that surface mining plays in serving mankind in terms of economics, employment and energy needs.*)

We in the industry know that surface mining is an emotional issue to many people. But we also know that emotionalism, unsupported by fact and sound judgment, creates more problems than it solves. For this reason, we are making every effort to respond objectively and logically to this unprecedented challenge to our industry's existence.

In the emotional fervor of environmental concern, we can understand how well-intentioned citizens—especially those who have had little exposure to the positive values of surface mining—might be unduly influenced by overzealous critics of the industry. But this in no way changes the facts.

By any yardstick of reason, the proposal to outlaw surface mining can only be interpreted as ill-advised and unrealistic. It is unsound because it ignores the serious and damaging consequences to the economy of both West Virginia and the nation. At best, it is an extremist solution to what is essentially an aesthetic problem.

INFLUENCE OF HISTORY

To better understand the facts at issue, it is essential to remember that the surface mining industry of today operates on a far more scientific and knowledgeable basis than it did 20 or 30 years ago.

Surface mining received its first major impetus during the national energy crisis of World War II. At that time the urgent demands of war overrode any immediate concern for restoring or reclaiming disturbed land. In those years the science of reclaiming mined land was still in its infancy. As a result, land abuse was fairly common, and, unfortunately, a tradition was established that endured far too long.

But the fact that should be made clear here is that the mistakes and malpractices of the past are history, and only history. They bear no relationship whatever to the manner in which surface mining is conducted today.

RESPONSIBLE SURFACE MINING CAN BE DONE UNDER EXISTING LAW

In 1967, West Virginia enacted one of the most stringent surface mining and reclamation laws in the Nation. It not only prevents repetition of irresponsible practices but also makes provision for reclaiming the "orphaned banks" inherited from the past.

Properly enforced, the existing law is fully adequate to protect our land and our heritage. What's more, it is enforceable, and it is being enforced. As a result, surface mining in West Virginia today not only can be but is being done responsibly—with prompt and full reclamation of all land disturbed in the process. In fact, since the passage of the 1967 law, we have been reclaiming more land than we mine. And given time, we will catch up to our history.

As surface mine operators, we take seriously our environmental obligations to the people of West Virginia. We fully support adherence to proper surface mining and reclamation methods. And we endorse rigid enforcement of West Virginia's surface mining and reclamation law.

NATIONAL ENERGY CRISIS

Right now there is as serious a shortage of coal as this Nation has ever known. Those unaware of the severity of this crisis may complacently claim that surface mining should be abolished. But it is extremely doubtful that the Nation could do without the energy derived from surface-mined coal.

Demand for electric power, for example, is expected to double by 1980, requiring twice the volume of coal being used today or 1.1 billion tons a year. Add to this another 150 million tons for conversion to gas and other uses, and we have a demand 12% greater than today.

A ban on surface mining would shrink coal supplies to a catastrophic degree and force prices to rise even higher. At home this would mean severe power shortages and higher costs to the consumer at a time when we are all concerned about inflation. It would also indirectly jeopardize the country's coal exports at a time every effort is being made to improve our balance of trade.

These are some of the national implications that a ban on surface-mined coal would have. The direct consequences to the economy of West Virginia would be even more drastic. Let's look at some of them.

LOSS OF 26.9 MILLION TONS OF COAL PRODUCTION

In 1970 West Virginia produced 26,987,598 tons of surface-mined coal with a total market value of more than $188 million. Production and distribution statistics of surface-mined coal for the years 1968, 1969 and 1970 are given in Table I.

If shipped at one time, this much coal would require a train of 359,835 coal cars, stretching out over 3,067 mi—or almost the distance from Miami, Fla., to San Francisco, Calif.

This same quantity of coal could provide a city of 80,000 population, consisting of 24,000 family units, with enough electrical power to last 580 yr. This projection applies to residential use only, Nevertheless, even if business and industrial power usage were added, this much coal would still furnish power to a city of this size for 104 yr.

Should surface mining be abolished, it is improbable that this production loss could be made up entirely by deep mining methods. A surface mine is twice as productive as a deep mine, requires far less capital investment, and can be placed into production quickly. By comparison, a minimum of 3 to 4 yr would be needed to develop the number of deep mines that would be required to produce this vast amount of coal. Moreover, surface mining recovers deposits of coal that cannot be mined any other way. For the most part, this coal is found near the outcrop of the mountains and other areas where rock strata is too weak to support a safe roof for deep mining.

TABLE I—SURFACE MINE COAL PRODUCTION AND DISTRIBUTION STATISTICS

	1968	1969	1970 [1]
Employees	3,460	3,651	5,571
Production (tons)	16,703,461	18,867,500	26,987,598
Shipped by: [2]			
Rail (tons)	13,211,214	14,496,070	20,729,380
Truck (tons)	2,189,448	2,675,524	3,825,999
Barge (tons)	1,102,947	1,501,556	2,047,224

[1] 1970 production figure is actual; other figures are projected.
[2] Excludes local trade and stocked.

TABLE II.—RECAPITULATION OF ECONOMIC CONTRIBUTION TO WEST VIRGINIA BY SURFACE MINING AND DIRECTLY RELATED INDUSTRIES FOR 1968

Industrial contributor	Number of employees	Wages	Taxes (other than Federal corporate income taxes)	Supplies and services	Total contribution
Surface mines	3,460	$20,392,000	$3,111,000	$32,505,000	$56,008,000
Railroads	549	4,755,000	417,000	677,000	5,848,000
Barge lines	46	379,000	6,000	712,000	1,096,000
Trucking	91	901,000	131,000	662,000	1,694,000
Equipment manufacturers	16	95,000	7,000	25,000	126,000
Total	4,162	26,522,000	3,672,000	34,581,000	64,772,000

Source: National Coal Association study dated July 14, 1970.

TABLE III.—1970 PROJECTIONS [1] OF STATISTICS IN TABLE II RECAPITULATION OF ECONOMIC CONTRIBUTION BY SURFACE MINING AND DIRECTLY RELATED INDUSTRIES TO WEST VIRGINIA

Industrial contributor	Number of employees	Wages	Taxes (other than Federal corporate income taxes)	Supplies and services	Total contribution
Surface mines	5,571	$32,831,120	$5,008,710	$52,333,050	$90,172,880
Railroads	884	7,655,550	671,370	1,089,970	9,415,280
Barge lines	74	610,190	9,660	1,146,320	1,764,560
Trucking	147	1,450,610	210,910	1,065,820	2,727,340
Equipment manufacturers	26	152,950	11,270	40,250	202,860
Total	6,702	42,700,420	5,911,920	55,675,410	104,282,920

[1] Projections made by applying a growth factor of 1.61 to 1968 statistics given in table II.

ECONOMIC IMPACT OF SURFACE MINING TO WEST VIRGINIA'S ECONOMY

On July 14, 1970, the National Coal Association, Washington, D.C., released an in-depth study of the impact made during 1968 on the economy of West Virginia by the surface mining, coal hauling and mine equipment industries.

While documented statistics for 1970 are not now available, we have been able to project current impact by applying a growth factor of 1.61 to the 1968 figures. This growth factor is determined from the increase in surface-mined coal tonnage for the year 1970 (26.9 million tons) over 1968 (16.7 million tons). If anything, such projections will be conservative since wages and the cost of supplies and services have risen considerably in the past 2 yr.

A tabulation of the NCA statistics for 1968 is given in Table II and projections for 1970, in Table III.

$104 MILLION IN WAGES, TAXES, SERVICES AND SUPPLIES

Projections for 1970 based on the 1968 study show that the mining and transportation of surface-mined coal and the manufacture of mining equipment created 6,702 jobs with a total annual payroll of $42.7 million and contributed to the economy a total of $5.9 million in taxes (business and occupation tax, workmen's compensation, county property, and corporate net income), as well as expenditures of $55.6 million in supplies and services, including gasoline, oil, repairs and purchases of equipment. Total projected contribution to the economy from surface mining and directly related industries comes to a total of $104 million for 1970.

The projected breakdown for the surface mining industry, alone, shows that 5,571 jobs were created (including production workers, supervisors, and on-site office workers) with an annual payroll of $32,831,120. In addition, an estimated $5,008,710 were paid in taxes and $52,333,050 expended for services and supplies. The 1969 statistics for surface mine tonnage and employees, by county, are given in Table IV.

TABLE IV.—1969 STATISTICS FOR SURFACE MINE TONNAGE AND EMPLOYEES, BY COUNTY

	Production tons	Number of employees		Production tons	Number of employees
Barbour	1,576,927	196	Mercer	207,321	41
Boone	2,202,078	317	Mineral	80,167	14
Brooke	212,807	41	Mingo	285,623	104
Fayette	1,492,436	210	Monongalia	386,695	71
Gilmer	51,445	15	Nicholas	450,424	174
Grant	502,131	111	Preston	1,207,498	189
Greenbrier	6,875	5	Raleigh	1,906,059	572
Hancock	3,217	4	Randolph	78,510	47
Harrison	900,747	170	Taylor	129,239	30
Kanawha	1,855,381	369	Tucker	570,052	79
Lewis	519,326	144	Upshur	216,426	35
Logan	1,411,324	252	Webster	35,630	25
Marion	110,460	22	Wyoming	1,056,856	152
McDowell	1,411,826	262			

Source: 1969 Directory of Mines, State of West Virginia Department of Mines.

$128 MILLION IMPACT ON NON-RELATED BUSINESSES

Beyond this direct contribution to the economy by the surface mining, coal hauling and mine equipment industries, there is a second cycle of monetary expansion among non-related businesses.

Economists have determined that to measure accurately the effect wages have on the economy, the wages should be multiplied some three times, as every dollar spent will generate three other dollars in trade as it circulates through commerical channels. (It should be noted that a multiplier of three is very conservative. In many areas a factor of five or seven is commonly used.)

In 1970, the annual payroll for surface mining and directly related industries is estimated at $42.7 million. Using a multiplier of three, this means that another $128.1 million of business will be generated in year-round purchases of consumer items, such as food, clothing, housing, automobiles and other items. It also means that local businessmen, in turn, must hire clerks, salesmen, and other employees to satisfy the demands generated by surface mining and directly related payrolls.

With these facts at hand, a crystal ball is not needed to realize that economic losses to West Virginia would be staggering if the surface mining industry were abolished. Even more frightening is what a surface mining ban would do to the people of West Virginia who depend upon the industry for their support.

LOSS OF 6,702 JOBS

Should the forces seeking to ban surface mining in West Virginia succeed, an estimated 6,702 men would be forced out of work. The figures, by industry, break down as follows:

Surfacing mining, 5,571
Railroads, 884
Barge lines, 74
Trucking, 147
Mining equipment,* 26

*This estimate is extremely low. A recent check with five of the largest equipment suppliers in West Virginia showed that 401 jobs would be lost in those firms by the abolition of surface mining.

Most of these men have families. Based on 1960 Census figures, the average family in West Virginia consists of 3.51 people. This means that over 23,500 people in the state of West Virginia depend exclusively upon surface mining for their livelihoods. What will happen to these men and their families if surfacing mining is abolished? Some, undoubtedly, could be absorbed by other local industry at lower wages, But in areas where the unemployment rate is already high, many would be forced to go on welfare.

Another factor of no small concern is what happens to the surface mine operator if the industry is put out of business. Some of the larger operators might be able to survive by taking their equipment to another state and try to start over. But others could well be forced into bankruptcy.

LOSS OF $5.9 MILLION IN TAX REVENUE

If surface mining were abolished, the state of West Virginia would lose an estimated $5,911,920 in tax revenues. This is direct loss from the business and occupation, workmen's compensation, county property and corporate net income taxes. Additional tax revenues would be lost in the form of local or state sales taxes and diminished taxes from other businesses affected by the abolition of the surface mining industry.

TOTAL LOSS WOULD EXCEED $232 MILLION

When the $104.2 million direct contribution of the surface mining and directly related industries is added to the additional $128.1 million of business generated in nonrelated consumer industries, total loss to West Virginia's economy would exceed $232 million.

It is inconceivable to those of us in the industry that the state of West Virginia would be willing to sacrifice economic considerations of this magnitude for the sake of resolving an aesthetic problem. And except for the highwall that remains after land has been surfaced mined, the aesthetic problem is being resolved through effective reclamation practices.

The surface mining industry, as it evolved, has faced many difficult problems. But we have done, and are doing, much to solve them. As surface mine operators, we have two responsible jobs to perform: to supply the Nation with its demand for more coal and to return surface-mined land to beneficial use. We intend to do both jobs well. But we will need the help of the legislature and all clear-thinking citizens in the state to defeat the move to abolish our industry.

[From the Coal Age, June 1971]

CRASH CAMPAIGN—TELEVISION COMMERCIALS HELP DEFEAT SURFACE MINE ABOLITION PUSH IN W. VA.

(Roy Alexander, president The Alexander Co. New York Public Relations Firm)

Just after Christmas 1970, West Virginia's Secretary of State, John D. (Jay) Rockefeller IV announced a campaign to ban the surface mining of coal "completely and forever" throughout the Mountain State.

Key West Virginia lawmakers pledged their support when the legislature convened in late January, 1971. The state s most influential politicians jumped on the popular ecological bandwagon.

Influential newspapers—most notably, *The Charleston Gazette*—backed Jay Rockefeller completely. Letters poured in praising Rockefeller.

By early February, the juggernaut was rolling.

The future for surface mining in West Virginia looked bleak.

Yet 2 months later, the tide had turned. The Rockefeller forces found it hard to get legislative support. People started writing legislators asking them to vote against surface mine abolition. Protesting throngs marched on the state capitol. Pro-industry letters inundated newspapers. Citizen groups rose up to defend surface mining as necessary to bread and board. Rockefeller back-pedaled, calling for a "gradual phase out" instead of complete abolition.

When the legislature adjourned in March, 1971, it had passed a bill limiting surface mining growth in non-mining counties. And it imposed stricter reclamation rules (which the industry agreed to).

But the massive abolition movement had been soundly defeated.

What happened? The cutting edge was a series of television commercials. These commercials were rushed into production. They were on the air via eight West Virginia stations by early February. They influenced legislators directly and via voter-to-legislator impressions.

"In terms of sheer effectiveness—swaying undecideds, making out-and-out opponents think twice, getting our argument across—the commercials turned the tide in our favor," says O. V. (Dick) Vande Linde, executive director of the West Virginia Surface Mine Association.

How did this rush job come about?

THE CRISIS MEETING

West Virginia Surface Mine Association, when formed in 1966, pledged itself to strong and enforceable reclamation laws and self-policing of members to enforce reclamation standards. And with more than 50% of its budget devoted to reclamation research, the WVSMA was making orderly progress.

The association, however, was not equipped to take on enraged public opinion fostered by the Rockefeller campaign. The association started 1971 with no public relations or advertising budget. When Rockefeller lobbed his bombshell, WVSMA's Vande Linde sounded the tocsin.

"We need a special assessment to fight this abolition movement," Vande Linde told members. "And we need it now."

But he was working with a small base. Only 25% of the state's surface mine operators are WVSMA members. A total of $50,000 over the association's regular budget was raised. This extremely modest budget would allow scattered newspaper advertising. But higher-priced television commercials—calling for production costs plus time costs—did not appear possible.

About that time Oak Leaf Coal Co. joined the association, and things began to change. In January, Robert D. Esseks, president of Sherwood Diversified Services—parent firm to Oak Leaf—attended a public relations action committee meeting held by WVSMA. Esseks immediately saw the need for dollar-stretching of association funds.

"Sherwood operates a commercial film division," he told the group. "We volunteer to produce television commercials and donate them to the association. With production costs out of the way, the Surface Mine Association could afford to buy TV time throughout the state."

The association committee—led by vigorous and vocal support of Don Streletzky of Bethlehem Steel and Hazlett Cochran of Consolidation Coal—was all systems go.

"We certainly appreciate it," association president Gil Frederick told Esseks.

The beleaguered industry was beginning to fight back.

MAKING THE COMMERCIALS

Oak Leaf Coal immediately engaged the services of a television film crew headed by John Nicholas. And Esseks assigned Sherwood's public relations firm—The Alexander Co.—to handle advance work for the film crew and manage the details.

That was Saturday.

On the following Monday, The Alexander Co.'s Bob Arnold arrived in West Virginia to advance the job. Using leads from Vande Linde, he talked to approximately 50 people throughout the state—seeking suitable candidates for filming.

"By this time, our strategy was clear," Arnold said. "We didn't want self-seeking industry members standing up before the camera pushing their viewpoint. We wanted a cross-section of people talking how the abolition of surface mining would affect their lifestyles and livelihood. And that's what we got."

Many volunteered. "My only problem was paring down the number of willing participants," Arnold relates.

By late Friday night, Arnold had set the film crew's itinerary. He had 19 persons ready for camera. Included among them were: a welder, two truck drivers, a service station owner, a restaurant owner, grocery store clerk, machine shop owner.

Helicopters from Hummingbird Air Service had been donated by Phil Nutter, also a surface mine operator and association member.

On Saturday morning the film crew went out in three helicopters. The four-man crew (camerman, sound man, director, and assistant) set up equipment, conducted an interview and then moved to another location in 20 to 30 min. The crew put 12 interviews on film that day.

Sunday, nature intervened. Snow. Helicopters were grounded.

To salvage the day, Vande Linde phoned Mrs. William Strange, president of a state-wide miners' wives protest group.

"Send them over to my house," she said. "I'll get people over here to be filmed."

When film crew director John Nicholas rang Mrs. Strange's bell, at least 100 eager souls were waiting to talk about surface mining. By day-end, 19 subjects were in the can.

CLOSING THE RING

On Monday (January 18) the film crew flew back to New York with raw film footage. Sherwood's editorial and optical houses started editing and finishing. Within a week, Sherwood's Esseks was presenting a reel of finished commercial tapes to the association public relations committee. WVSMA president Gil Frederick gave the final green light.

Eight different commercials started appearing on West Virginia television the first week in February—less than three weeks after Oak Leaf had joined the association.

Citizens would turn on television sets and hear:

Jack Burdete.—"This thing makes me mad. They want to take my job away because I'm polluting. Heck, you can't raise a conversation in these hills let alone a crop."

Tipple operator J. L. Perkins.—"I've never followed politics much before. But when people start talking about taking my job away, it's a serious matter. I'm going to follow politics very seriously now."

Gus Glavaris, Logan restaurant owner.—"Almost everyone who eats in my restaurant is supported directly or indirectly by surface mining. Logan, W. Va., would wilt and die without the industry."

Further, material did double duty. Fahlgren & Associates, WVSMA's advertising agency, developed newspaper ads from the commercial material. Radio commercials were cut out of the TV sound tracks.

Reaction to commercials was swift. Government officials received irate letters. Miners protest groups converged en masse on Charleston to buttonhole legislators. As pressure increased, a legislator approached Vande Linde.

"We aren't going to pass an abolition bill," he said. "Your commercials are stirring people up too much."

He urged Vande Linde to halt the advertising campaign.

The campaign's success befuddled opponents. Some leveled wild charges. A letter in a Charleston newspaper questioned the ethics of the ad campaign. It suggested the industry—represented by a "big man in a big car, smoking a big cigar"—paid persons to appear on commercials.

"Far from it," says Esseks. "If we had paid anybody, the commercials wouldn't have been as good. We approached the commercials in documentary style. Honesty and believability is the secret of successful viewpoint advertising."

PLANNING FOR FUTURE

What did it cost? Sherwood spent about $40,000 in fielding the crew, handling the advance work, and editing and finishing the commercials. The association spent another $40,000 in broadcast time and print space.

"For our part, we feel the funds were a good investment," Esseks said. "When a company happens to have a facility that can help its industry in a crisis—as we did with our film division—it should step forward and be counted."

Of course, winning a battle isn't winning the war—as WVSMA officials readily admit. Plans for next year are already underway.

"We know we've got a fight on our hands in 1972," Vande Linde said. "This time we want to start earlier and be better prepared. But this year, it was certainly vital to lay the facts on the public via television commercials. Since we couldn't have done it without volunteer help, we certainly give major credit to Oak Leaf Coal Co. and Sherwood this time around."

[From Mining Congress Journal, September 1970]

"Whatever one may think of the logic of the nature or environmental moralists, their growing political muscle cannot be ignored by industry. And the extractive minerals industry is recognizing that . . . it is fighting for its domestic life"

Ecoethics, Environmental Politics and Miner-Devils

By EARL COOK
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Adapted from a paper presented to the Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, at Denver, February 16, 1970.

IN DISCUSSION, there is often a polite and tacit assumption of agreement on the meanings of terms like ethics, morality, sin and environmental quality. But there is substantial evidence that no general agreement exists on the precise meaning of any of these terms, and discussions based on an assumed agreement usually range from fruitless to divisive. In order, then, to stimulate useful discussion, or even to communicate ideas more or less accurately, I must start by giving my own operational definitions of ethics, morality, sin, and environmental quality.

An *ethic* is a cultural template that limits our freedom of action and directs our efforts in the struggle for existence. Technology and our control of energy (including energy stored as money) tell us what we *can* do. An ethic tells us what we *may* do, among all the things we can do, and of the things we may do, which are better to do than others. An ethic describes or implies a set of cultural goals, as well as action modes for achieving those goals. The cultural goal of the Christian ethic is the establishment of the Kingdom of God on earth; the indicated action mode, however, depends on the means or strategy chosen to achieve that goal, and Christian action modes have ranged from ruthless conversion of the pagan and aggressive extermination of the infidel to kindly persuasion, meek example and hopeful prayer.

Morality is harmony between personal or group actions and a planned or prescribed strategy for reaching the cultural goals defined by an ethic; in other words, morality is a measure of ethical conduct. Often lost sight of, however, is the fact that morality is not measured in terms of the ethical goal but in terms of the action mode chosen to achieve that goal. Christians, for illustration, have found it much more difficult to agree on the appropriate means, in other words on what is moral, than on the desired end.

To facilitate the measurement of morality, codes of good and bad conduct are established by each group that espouses a particular strategy for reaching an ethical goal. The Ten Commandments, all codes of honor, and professional codes of ethics are conduct codes designed for easy measurement of morality. Perhaps because man loves to label and categorize his fellow man, such codes tend to acquire an importance that sometimes obscures the goals they were designed to advance.

In this operational context, *sin* is the commission of an action contrary to a conduct code. Although the subscriber to that code will assume that the sinful action is equally contrary to the ethical goal of his group, the outsider who sees another way of reaching that goal may not agree.

Although a religious ethic was used to illustrate these definitions, the same principles apply to ethics and moral-conduct codes which attempt to deal with man's willful relations with his environment, in other words, which attempt to define ecoethics and environmental morality.

Except that the term so commonly is used without definition, it would seem unnecessary to say that *environmental quality* is an exceedingly fluid concept, meaning essentially "my external environment as rated or graded in terms of things I like and things I don't like." Only by health and hazard measurements can such environmental grading be made anything like uniform. Many, if not most, individual grades given to specific environments are based on complex mixes of health, esthetic, political, religious and even mystical criteria.

Aristotle saw ethics as branch of politics

Aristotle considered ethics a branch of politics, for, he said, "it is the duty of the politician to create for the citizen the best possible opportunity for living the good life,"[1] and determination of the good life to Aristotle was a matter of ethics because it was a matter of determining cultural goals. He called the church the ethical arm of the state, and for hundreds of years of Western civilization the church *was* the ethical (and moral) arm of the state. During this time, the state or its prince had little difficulty in determining good (ethical goals), however much difficulty there might be in acting in accordance with that good (morality).

It was not until well along in the development of our present technological civilization that the church as the ethical arm of the state began to atrophy and to be variously replaced by military castes, "old school" alumni establishments, or by the leaders of new secular religions like communism and capitalism. For a time, each Western nation had one of these groups as either the official or unofficial ethical arm of the state. Then came the Great Depression which, with the dictatorships and wars that followed it, shattered the dream of universal affluence as well as the ideal of the perfectibility of man, and left Western man divided and doubtful about the old ethical systems.

No ethical arm in modern nation

A modern nation has no ethical arm, although it will have ethically derived moral constraints built into its political-legal and social systems. Its political leaders move cautiously, trying to develop new devices for sensing what its people consider good and what they consider bad. They move cautiously because they face sustained and growing questioning of goals and values. They move cautiously because opinions differ and conflict, because many people are uncertain or unclear about their own values and goals. They move cautiously because values seem to be changing rapidly, especially among the young. And they move cautiously because there is great difficulty in determining what the people want, let alone what may create for them, in Aristotle's words, "the best possible opportunity for living the good life."

The difficulties of determining ethical attitudes of the public are well illustrated on the environment scene. One can define such attitudes and study their historical development more easily than he can measure them.

Three identifiable ethical positions on environment

I identify three major ethical positions in today's discussions and controversies about environmental problems: the *development* ethic, the *preservation* ethic, and the *equilibrium* ethic. By the definitions I use, these are ethical positions because they imply cultural goals and state action modes or strategies for achieving those goals. Each of these *ecoethics* has its own appropriate code of conduct against which individual, political, or corporate morality may be measured. It hardly seems necessary to point out that an action which may be moral in terms of one ecoethic can be a sin in the context of one or both of the others.

Development ethic suggests action

The development ethic is the modern version of the dominion or conquest ethic, an important element of Judeo-Christian teleology which holds that man and nature are separate and that man has dominion over nature.[2] "Be fruitful and multiply," man was told (Genesis 1:28), "and fill the earth and subdue it; and have dominion over the fish of the sea and over the birds of the air and over every living thing that moves upon the earth." In this world view, good comes from the management and mastery of nature, and it comes from action, not from contemplation or from esthetic sensitivity.

The development ethic is reinforced by the work ethic which holds that work is good, and that any sort of non-work, except the rest needed to restore strength, is bad. Under the work ethic, contemplation is shunned, action is sought, continuous change is regarded as progress, bigger and faster are better, and economic and population growth are good.

The work ethic, which also finds Biblical sanction (II Thessalonians 3:10, "If anyone will not work, let him not eat"), got its great impetus from St. Benedict who taught that idleness is the enemy of the soul and who founded a great working order that at one time counted some 40,000 monasteries under its rule. The Puritans brought the work ethic to America: Cotton Mather denounced any "frolick" and proclaimed "what is not useful is vicious." The Puritan philosophy has dominated American business and was expressed very clearly by Henry Ford when he said, "I do not believe a man can ever leave his business. He ought to think of it by day and dream of it by night."

Release of human energy characterizes development ethic

The development (work-conquest) ethic is still the dominant template controlling the release of human energy in America. In regard to nature it means that a dammed and diverted stream is good whereas a wild river is "lawless;" that any natural resource, once perceived, must be developed else the perceptor is un-American and probably sinful. The resource developer believes he is one of the vertebrae in the backbone of the country. He points with pride to the new capital he has produced, to the economic multiplier effects of his activity, to the contribution he is making to regional economic health and to the national security.

The pure conquest-of-nature ethic, once flaunted by Americans, is now, like the iceberg of simile, largely submerged. But the satisfaction of Americans in putting men on the Moon, and their willingness to pay for that "adventure in national pride," shows that it still exists. The dambuilder, the bridgebuilder, and the miner all feel the joy of conquest, as do the mountain climber and the astronaut. In regard to what is generally called "nature," however, it is dreadfully unfashionable to express. Eric Hoffer, the articulate retired longshoreman, is one of the few with the courage to be unfashionable in this regard; Hoffer combines a vigorous defense of man's "war with nature" with an aggression-displacement hypothesis:[3]

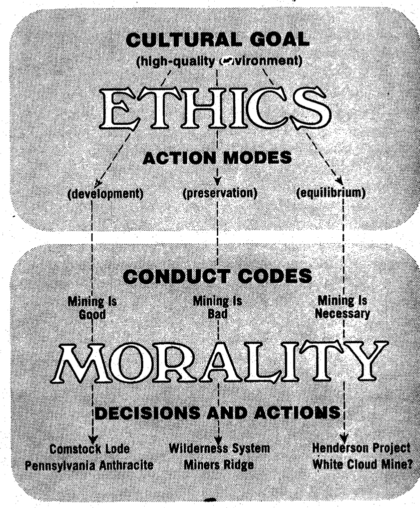
". . . the overcoming of nature, so crucial in the ascent of man, can be a most effective agency of humanization in the decades ahead—if for no other reason than that it may divert aggressive impulses and wild energies from social strife."

Preservation ethic has several frameworks

The preservation ethic forbids the further alteration by man of natural areas deemed to have special esthetic, recreational, scientific, therapeutic, or ecologic values. It may also require us to take steps to preserve an endangered vertebrate species other than man. Because this action (inaction?) mode fits several different ethical frames, I shall attempt to define the several ethical reasons for preservation in terms of hypothetical "pure" types of preservationist.

First, the *mystic* preservationist, who believes that nature is good in and of itself. If he doesn't actually regard man as bad, he certainly regards man's alterations of natural areas as bad, for he speaks of rape, desecration, and despoiling in describing roads, pipelines, dams, and mine dumps. He seems to prefer mountains and pines to plains and sagebrush, and he advocates restricting the quantity (and in some cases, the quality) of visitors to preserved areas. The mystic preservationist may defend, as did St. Francis, another species' "right to existence." Nature mysticism in Judeo-Christian thought, long contrapuntal but subordinate to the nature-conquest theme, may have had its origins in religious retreats into the wilderness for spiritual renewal.[4]

The *nature-therapy* preservationist believes that nature is not just good in itself, but that it is good for man, both physically and psychologically. He stresses a built-in genetic need of modern man to get close to and commune with nature, a need which has yet to be demonstrated except by the dogmatic declarations of its exponents.



Flowsheet illustrates operational concepts of ethics and morality as applied to mining in the United States

The *esthetic* preservationist also believes that certain natural areas are good for man, because of esthetic satisfactions which may be derived from visiting them. He would preserve an area because it's beautiful, not just because it's wild.

The *scientific* or curator preservationist wants to preserve examples of unusual or endangered species in their native habitat, to preserve diverse ecosystems in an undisturbed state, and even to preserve unique geologic formations from flooding or destruction because he feels man can learn more from natural than from captive individuals, from undisturbed than from altered systems, from natural variety than from humanized sameness. He may also believe that biological diversity strengthens the ecosystem on which man depends.

Significant as a political force is the *recreation* conservationist who wants natural areas preserved (but not pristine) so that he may hunt, fish, hike, picnic, or enjoy peace and quiet in them.

City dwellers supporters of preservation concept

The preservation ethic gets a great deal of its force from a reaction to crowded and unpleasant cities. Dislike of cities is old. Two thousand years ago, the Roman scholar Varro declared cities unnatural and corrupting, and Seneca described the evils of a civilization "too dependent on its machines, its energy-control devices and its creature comforts." These Romans envisioned a pastoral ideal, where the fertility of soils would be maintained by proper care and the guardians of the soil would be happy, virtuous men. Their good nature was a man-made garden, not a wilderness.

Some 1700 years later, the environmental pollution and urban stresses of the Industrial Revolution brought about a more violent reaction to cities; the garden or pastoral ideal was replaced with wild nature. For the first time, only about 200 years ago, mountains and forests became esthetically good. As late as 1770, Samuel Johnson had referred to mountains as "rather uncouth objects" and called the Alps "high and hideous." But to Rousseau, Wordsworth, Byron, Goethe, and other leaders of the Romantic movement, they were beautiful and good. They could serve not only as retreats from urban life, but as arenas of challenge where man unaided by machines could test himself against nature, and either renew his sense of fitness or end up in the English cemetery for fallen climbers at Zermatt.

In America, the anti-urban reaction was represented by men so different as Thomas Jefferson and Henry Thoreau. Jefferson believed that agriculture makes for individual character and national health and he wrote that "Those who labor in the earth [he didn't mean miners] are the chosen people of God . . . The mobs of great cities," he claimed, "add just so much to the support of pure government, as sores do to the strength of the human body."[5] Thoreau saw life of his time as a conflict between industrialism and simplicity, between the exploitation of nature and living in harmony with nature; he chose simplicity and harmony.

But most Americans accepted progress only in terms of rapid conquest and exploitation of the environment. In the America of the 1850's, a statement like this in a newspaper article surprised no one: "How great, how glorious is man, the conqueror of nature—and the immortal co-worker with God."[6] European emigrants came to America with visions not only of freedom, but of wealth. They turned Jefferson's dream into a nightmare as they plowed and dug and cut and blasted and built their way across the Louisiana Purchase, which he had negotiated in order to keep America a nation of virtuous farmers.

Conservation movement has seen shift in values

The westward crunch left behind in the northeastern United States a defeated landscape of deforested hills, depleted soils, rivers lined with textile mills and iron works, and cities already crowded, dirty, and unhealthy. From this wreckage were to come both the forerunners and the leaders of the American conservation movement: James Fenimore Cooper, a novelist of the man-nature ethical struggle; Thoreau, Emerson, and the other transcendentalists; George Perkins Marsh, prophet of the ecological approach to balanced utilization; Francis Parkman, author of "The Oregon Trail" and mourner of a lost West; the Hudson River School of landscape artists; and finally, Gifford Pinchot and Theodore Roosevelt, who transformed an ecoethic into political reality.

The history of the American conservation movement is one of shifting ethical values, both inside and outside the group calling themselves conservationists. The closing of the American frontier marked the rise of the first phase of conservation. Moved by a fear of coming scarcity of natural resources on which the nation's "progress" and security depended, Pinchot, Theodore Roosevelt and others developed a conservation ethic that reflected enlightened self-interest and patriotic concern.

As defined by Pinchot, conservation was not an effort to achieve a balance with nature, but was an effort to attain the most efficient use of nature's resources in a manner that would assure each citizen "his fair share of benefit from those resources." There was, perhaps for the first time in a widely accepted nature ethic, a strong element of concern for posterity; Van Hise, one of the conservation leaders, wrote: "He who thinks not of himself primarily, but of his race and of its future is the new patriot."[7]

Equilibrium ethic abandons growth-oriented economy

George Perkins Marsh, New England lawyer, author, and minor diplomat, was the first to recognize and document the longterm adverse effects of man's alterations of the environment and to advocate planning for ecological equilibrium. His book, called "Man and Nature," published in 1864, was so far ahead of its time that Marsh might properly be called the grandfather, rather than the father, of the equilibrium ethic.

The equilibrium ethic would require us, on a global scale, to work towards achieving a stable equilibrium between man and his environment short of disaster. It implies ultimate stabilization of population and abandonment of a growth-oriented economy. Although we still seem a long way from widespread belief in the necessity for such an equilibrium, the Environmental Quality Act of 1969 states that it should be public policy to "achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities."

Because the idea of any equilibrium in human population, in economics, or in resource use is so foreign to our growth-oriented society, adoption of this ethic as a frame for political decision will require a veritable revolution in human thought. George Marsh was well aware of this more than a century ago when he wrote, "A political and moral reformation in the world is needed if technology is to aid conservation."

Aldo Leopold in 1949, at the close of the first 50 years of the American conservation movement, complained that "conservation as preached and practiced has only been enlightened self interest" and urged the development of a land ethic that would embody the concept of equilibrium between man and the land.

The modern equilibrium ethic took a long time to emerge, because it springs from the relatively recent awareness of man as part of a world ecosystem, and as a major perturber of that system in ways that produce unwanted and potentially lethal consequences.

Although in recent years many voices have joined the equilibrium chorus, the nation's aspirations and economic planning remain rather firmly geared to growth. The equilibrium voices were all but drowned

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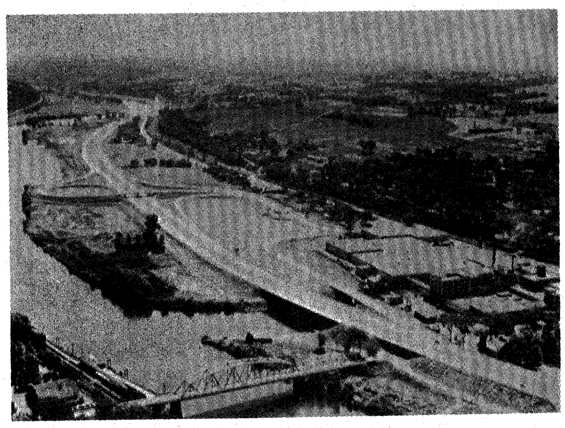

Many people argue that the developer should be able to prove his proposal has a clearly positive benefit-cost ratio before he is permitted to alter the environment by building a dam or a highway or tunneling into an ore body. Up to now, the burden of proof has been on the opponent to the proposed alteration but that is changing

in the wails of the "undercounted" when the preliminary results of the 1970 U.S. Census were released!

Environmental politics growing greatly

Problems of the environment, whether they threaten man's health, impair his enjoyment, or offend his sensitivity, increasingly are being debated in the political arena and argued in the courts. "The status of the environment," writes Robert Cahn, member of the President's new Council on Environmental Quality, "is a major political issue."[8]

Time magazine suggests that "The environment may well be the gut issue that can unify a polarized nation in the 1970's." Senator Gaylord Nelson, who credits his own conservation activities with his distinction as the only Democrat in the 20th Century to be re-elected as Governor of Wisconsin, has called for a constitutional amendment stating that "every person has an inalienable right to a decent community."

Young people recently mounted a crusade for the environment, featuring a nationwide environmental teach-in on April 22. In California the Student Environment Confederation will exert pressure on candidates in this year's state elections to run with environmental programs. More than 30 major environmental bills have been passed by Congress in the past four years and many more are in the hopper.

We have come a long way from the day in 1875 when President Grant, urged by his Army friends like Phil Sheridan who publicly advocated extermination of the buffalo as the best way to handle the Indian problem, vetoed the first measure ever passed by the U. S. Congress to protect a species of wildlife. We have come a long way from the day in 1902 when Uncle Joe Cannon,[9] the powerful Speaker of the House, asserted that Congress "was not going to appropriate one damned cent for scenery" and even from the day a few years ago when the late Robert S. Kerr of Oklahoma[10] on the Senate floor warned his colleagues to stop wasting time on "esthetics."

Burdens of proof shifting to developer

Most significant in all the controversy and discussion that swirls about questions of environmental pollution and degradation is the clear evidence of a burden-of-proof shift in the public attitude.

Up to now the initiative has been with the developer, the person proposing to modify the environment, and the burden of proof has been on the person who, objecting to the proposed alteration of the environment, has wanted to prevent or restrict it. In the political forum, the opponent has had to persuade decision makers that the cost to the nation of the proposed development would exceed its benefits. In the courts, he has had to demonstrate a clear and present physical or financial threat to himself in order to deter development.

Now both frames are changing. Extending the new philosophy of drug approval (that they be demonstrably beneficial) to the environment, many people now argue that the burden should be on the developer to prove that his proposal has a clearly positive benefit-cost ratio for the nation, in terms of environmental and ecological impacts as well as market values, before he should be permitted to alter the environment by building a dam, carving a highway, spraying pesticides, or tunneling into an ore body. Further, the courts have recognized the right of a citizen to maintain a suit on the grounds of esthetic deterioration of the environment and have awarded damages for noise pollution by aircraft, unrelated either to direct overflight or physical damage, both of which used to be required to sustain such a suit. The courts have even been asked to define a Constitutional right to "an environment free of improvident pollution."

"Today's politics of the environment are developing against a background of a new wave of reaction against the excesses of cities and the bad fruits of technology. The leaders of this reaction invest nature with both esthetic and moral qualities. There is a resurgent nature moralism that prescribes "right conduct" toward nature and which scorns multiple use as enjoyed rape"

Shift enormously important to natural resource industries

The importance to a natural-resource industry of this burden-of-proof shift is enormous. With the burden of proof on the preservationist, for example, a virgin area may be deflowered (from his point of view) before he can arouse enough political support for annulment. With the burden of proof on the miner, however, an area of economic mineralization might lie untouched for years.

Movement of environmental problems into the political arena demonstrates an unwillingness any longer to let experts in the government make environmental decisions and an impatience with existing mechanisms for resolution of the problems. Consequently, we see more and more public confrontations on specific environmental issues, where the public attempts to bypass the experts in government and to deal directly with the industry involved, through political or legal action or both, and by a variety of mechanisms: through established conservation groups; by means of ad hoc task forces with names like Get Oil Out, Organization for an Unblemished Shoreline, and Group Against Smelter Pollution; through quasi-governmental environmental councils and advisory committees; and by establishing special-technique groups like the Environmental Defense Fund and student groups for public awakening like the Nature Conspiracy.

Tendency is for people to create straw devils

Many people appear to require a focus of indignation before they can incite themselves to political action. We will work hard to prevent a bad man from being elected, but we ignore appeals to help a good man when his opponent is not an identifiable devil. We are worried about our international misadventures, our domestic unrest, and the deterioration of our environment. Since we haven't willed or wished for any of these things, they cannot be our fault; if not our fault, they must be the fault of someone else, either someone who wishes us ill or whose perverted values and goals blind him to the evil he does. So, we create *straw devils,* in order to focus our indignation, to incite ourselves to remedial action, and to fix the blame away from ourselves.

Our international misfortunes then result from Communist ill will or industrial-military power lust, rather than our own mistakes. Our domestic unrest then stems from Eastern liberal propaganda or authoritarian repression, rather than our faults of intelligence and charity in dealing with racial and moral problems. Our environmental deterioration is then due to the greed of resource exploiters and industrial polluters rather than to our own reluctance to curb our voracious appetite for energy and material things, our strong disinclination to pay the costs of pollution abatement, and our insistence on the freedom to "family-plan" ourselves right out of what we regard as a tolerable existence.

Miners make good straw devils

The miner seems to make a peculiarly satisfactory straw devil. Miners have long been regarded by both nature preservationists and tillers of the soil as destroyers of nature and therefore evil men.

The miner-devil concept may be rooted in the basic fear of dark places, the mythology of the underworld, and the theology that—at least until Copernicus—placed Heaven in the sky and Hell within the earth. But there were more substantive reasons: more than

400 years ago Agricola wrote that farmers blamed miners for destroying fertile fields, cutting down woods and groves, driving away wildlife, poisoning streams, and corrupting mankind by the production of gold and silver. Incidentally, in refuting most of the arguments against mining, Agricola made an astoundingly modern proposition: that "birds, edible beasts, and fish" be purchased and stocked in mountainous regions with the profits from the mining and metals industry.[11]

Mining accords with development ethic

To the nature mystic, miners personify the evilness of man as against the goodness of nature. They scar, despoil, desecrate, rape. Mining accords with the conquest or development ethic and during the winning of the American West was highly regarded; it conflicts with the preservation ethic, and as the desire to preserve natural portions of our environment grows stronger, mining tends to be viewed as both morally and ecologically wrong.

To some authors, mining degrades the miner as well as the environment; Lewis Mumford, for example, in "Technics and Civilization," holds that the habitual destruction and devastation of mining "brutalizes" the miner and says there is indeed "something devilish and sinister about the whole business" of mining.[12] In the nature righteousness of a John Muir or an Aldo Leopold, there is no room for miners, except as devils. And it is as devils that miners appear, not only in sermons from the sierras of environmental piety, but in the pages of sub-objective periodicals like *Harpers*, the *Atlantic*, and the *Christian Science Monitor*.

Whatever one may think of the logic (or even the morals) of the nature or environmental moralists, their growing political muscle cannot be ignored by industry. And the extractive minerals industry is recognizing that its actions are being reviewed in political arenas that range from garden clubs and neighborhood bars to the public press and the U. S. Senate; that its plans and decisions no longer can be confined to a neat framework of economics, engineering, and the law; that it has both inherent and acquired disadvantages in the public arena; that it no longer has such a great advantage of initiative as it once enjoyed; and that it is fighting for its domestic life.

Nature moralism scorns multiple use

Today's politics of the environment are developing against a background of a new wave of reaction against the excesses of cities and the bad fruits of technology. The leaders of this reaction invest nature with both esthetic and moral qualities. There is a resurgent nature moralism that prescribes "right conduct" toward nature and which scorns multiple use as enjoyed rape.

In America, nature moralism descends from Thoreau and Emerson through Liberty Hyde Bailey, the Cornell dean of agriculture who urged his fellowmen to develop a sense of "earth righteousness;" through John Muir who at his death was called "the most rapt of all prophets of our out-of-door gospel;" and through Aldo Leopold who wrote that "a thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise." Tonight the campfires of the nature moralists dot many hillsides, and a measure of their growing confidence is their willingness of some of them to take on both Christianity and capitalism in their crusades.

As with Rousseau, who claimed that the victims of the Lisbon earthquake of 1755 deserved their fate for not living in the forests and fields where they would have been saved both morally and physically, there is a feeling that cities are evil and are built on the greed of the industrial establishment that fosters and requires cities. Very few people today dare to agree publicly with Eric Hoffer when he says that "It's in the city that man becomes human; no noble ideas were ever conceived outside the city,"[13] or, for that matter, with John Wesley Powell, conqueror of the Colorado canyons, who wrote "When a man loses faith in himself, and worships nature . . . he lapses into stagnation, where mutual or moral miasma is bred . . . ."[14]

Nature seen as mistreated by man

Man's struggle with nature for subsistence was very real to Americans of the 1930's, the time of the Great Depression and the Dust Bowl, of the New Deal and the Civilian Conservation Corps. In only 30 years, however, most Americans—because of the urban implosion and their rapidly rising standard of living—have become separated from direct knowledge of the physical sources of their food, clothing, shelter, fuel, and conveniences, and are shielded from any sense of struggle with nature for the elements of existence.

We now see statements that nature has always been essentially benign or friendly to man, and that in return he has horribly mistreated her. One is reminded of the long argument between those who saw the physical world as a divinely designed abode for man and those who, like Alfonso X of Castile and Leon, retorted, "Had I been present at the creation, I would have given some useful hints for the better ordering of the universe."

Can't reason with preservationists

The miner and the oil man, as obvious conquerors of nature, now face two kinds of adversary: the preservationists, many of whom live in cities where they enjoy the fruits of the drill while declaiming against its use; and the equilibrists, who would weigh all exploitation decisions in terms of total costs and benefits to the nation (or to mankind) and who would give the benefit of any doubt to the environment rather than to the exploiter.

The preservationists are implacable foes, who regard mining and miners as evil and whose environmental values are not commensurable; in other words they refuse to transmute their values into interests and to negotiate with those who have other interests. The equilibrists are reasoning critics who demand only that the inclusive cost-benefit ratio of any proposed development project be demonstrably positive; within limits of health, their environmental values are commensurable.

The preservationists cannot be reasoned with. The equilibrists can, for they agree with Aldo Leopold who said years ago, "We shall hardly relinquish the steam shovel, but we need gentler and more objective criteria for its use."[15] With the preservationists, the old democratic rules of compromise, accommodation, and exchange of interests will not work, and it is no use to hope for a negotiated settlement. With the equilibrists, incommensurable values still can become real-life commensurables by the democratic process. Consequently, the mining industry should attempt to distinguish and keep separate these two groups, and to deal with each in a different way. With the "implacables," the appropriate mode is political warfare. With the "defenders," the appropriate mode is political accommodation.

Whereas in political warfare, one tries to isolate the opponent from his potential allies, to induce him to attack straw targets and accept Pyrrhic victory, to incite him to fatal excesses of choler or malice (which may not work in a political environment where choler and malice appear to be regarded as virtues), or simply to outlast him, in political accommodation one tries to negotiate the most favorable settlement of a specific issue without unduly prejudicing one's future options.

Hard choices facing minerals industry

It is in this matter of prejudicing future options that the minerals industry faces its most critical political problems. Behind the numerous confrontations on specific issues lies a growing demand that the rules of the game be changed, a demand for new decision mechanisms which will allow the public and its representatives to compare alternative plans for developing a resource, be it a river valley, an oil field, or a mineral deposit, in terms of all the costs and benefits, both market and nonmarket; which will allow nondevelopment as an alternative; which will regard preserving options for the future as a benefit, and maintaining environmental quality as a practical goal; and which will allow the exploitation decision to be made on a best-alternative basis.

Some such mechanism may emerge from the smoke and flame of contemporary resource controversies. At the very least, formidable constraints will be placed on the initiative and options of the resource exploiter. The minerals industry is faced with some hard choices. Should it broadly defend, with financial tooth and legal claw, its present "rights" under the law? Should it negotiate on an ad hoc basis, only at those places and times where it feels forced to do so, hoping to preserve the present frame of the industry while allowing a few alterations of the picture? Or should it participate in devising and implementing rather sweeping changes in the fundamental legal and economic framework of the domestic industry in the hope of staying in the new game, even though the rules may be different? I don't know the answer.*

[**Author's note: The report of the Public Land Law Review Commission was released after this paper was prepared. The recommendations of the Commission for changes in the mining laws appear to be an attempt to tidy up the playing field and return more of the receipts to the owners of the stadium without any fundamental change in the game itself. Mining on the public lands would still represent what the lawyers call "a self-initiated right." E.C.*]

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[12] Mumford, Lewis. *Technics and Civilization,* New York: Harcourt, Brace and World, 1934.

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NATURAL RESOURCES AND ENERGY REQUIREMENTS

[From the Minerals Yearbook, vols. I-II, U.S. Department of the Interior, 1969]

TECHNOLOGIC TRENDS IN THE MINERAL INDUSTRIES (METALS AND NONMETALS EXCEPT FUELS)

(By John L. Morning [1]

A banner year was enjoyed by the mining industry as value of metals and nonmetals reached $8.96 billion. To accomplish this, nearly 4 billion tons of material was handled, including 2.6 billion tons of crude ore.

In the battle for lower unit costs, wheel tractor scrapers have found wider application owing to improved design, which has added versatility and increased production capability of these units.[2]

The development of larger size front-end loaders during the past 10 years has resulted in a change in their use from strictly stockpile loading to competition with electric shovels for primary pit loading applications.[3] Also, during the past 10 years there has been an improvement in the cost performance of off-highway haulage trucks with the increase in truck size from 22- to 40-ton capacity in 1960 to the present-day 85 to 120 tons and larger.[4]

A comparison of various construction and mining earth-moving equipment made by various manufacturers was published.[5] Tractor shovels ranged to 22-ton carrying capacity; self-propelled scrapers to 72 tons; and off-highway haulers to 200-ton maximum carrying capacity.

Surveys were conducted by the Engineering and Mining Journal on the use of trucks in the metal and nonmetal mining industries.[6] According to one study, an estimated 8,930 off-highway trucks were in use in the United States in 1968. Over 67 percent of the trucks in use were over 30-ton capacity; 28 percent were over 70-ton capacity. The great majority were equipped with automatic transmissions and power steering. Vehicle availability averaged 82 percent and operating costs averaged $15.64 per hour. The survey indicated continued mining industry expansion and forecasts major growth in truck haulage, and increasing use of over 100-ton units.

According to the second survey, over 30,000 on-highway trucks were in use at domestic metal and nonmetal mines in 1968. More than half of these trucks were pickup or panel types, and over 60 percent had a gross weight of over 10,000 pounds. In contrast to off-highway trucks, comparatively few on-highway trucks were equipped with automatic trnsmissions and power steering. Operating costs averaged $5.39 per hour. The survey indicated that the use of this type vehicle will grow at the same rate as the mining industry.

Big hole drilling continued to hold the interest of miners, contractors, and manufacturers as the Second Symposium on Rapid Excavation was held late in the year.[7] It was indicated that raise boring as a method for creating mine openings has accounted for 90,000 to 100,000 feet of big hole raises in all parts of the world to date. Canada heads the list of raise drilling machines in operation with 16 and the United States was next with 12. The worldwide total was 51.

The International Nickel Co. Inc., a pioneer in bore hole raising, reported a 40-percent decline in mining costs and a 60-percent increase in mining rate.[8]

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[3] Haley, W. A. Trends In Front End Loaders. Min. Cong. J., v. 55, No. 5, May 1969, pp. 58–60.
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[8] Scott, James J. Underground Mining. Min. Cong. J., v. 56, No. 2, February 1970, pp. 35–41.

Mining minerals from the ocean continued to interest many individuals and concerns. At the First Annual Offshore Technology Conference, sponsored by nine professional technological societies, a prototype underwater mining system suitable for commercial exploitation of sea resources was described.[9]

Surface mines continued to account for 95 percent of total material handled and 94 percent of the crude ore produced. Underground mining was rsponsible for substantial percentage of crude ore production in five States; 19 States reported no underground activity.

Lower ratios for crude ore to marketable product were the trend compared with 1968, but were generally higher than those in 1964. Ratios for material handled to marketable product for various mineral commodities were generally slightly higher than in 1968, but large-volume commodities were substantially higher.

Exploration and development activities continued to accelerate owing primarily to increased activities at copper, lead, and uranium properties. Stripping operations for copper in Arizona accounted for 35 percent of total material handled by exploration and development activities. Arizona also reported over 500 million tons of material handled. This is the first time that any State reported reaching this milestone.

In 1968 the use of ammonium nitrate blasting agents continued to increase, whereas the use of permissible explosives continued to decline. The industrial consumption of explosives in 1968 was 2 percent higher than in 1967, but was lower than the record year of 1966

MATERIAL HANDLED

Total material handled at metal and nonmetal mines and quarries in the United States, approached 4 billion tons during 1969. The quantity of material handled during the past 10 years has increased at an average annual rate of 3.6 percent. A significant portion of this increase was in waste material handled at surface mines which indicated an increase of 5.9 percent annually; crude ore production increased 2.5 percent.

Waste material accounted for one-third of the yearly total of material handled owing primarily to stripping activities in the copper industry. For metal operations, copper mines led in waste and total material handled, and iron mines led in crude ore production. The States of Arizona and Florida continued to be the leaders in material handled as they have been since 1965. The quantity of material handled in Arizona, Nevada, and New Mexico was more than twice as much as the quantity in 1960. Mineral commodities that indicated a significant gain in material handled, compared with 1968, were copper, manganiferous ore, molybdenum, uranium, and sand and gravel. Total material handled decreased for placer gold and dimension stone.

Surface mines accounted for 95 percent of total material handled during the year; the same as in 1964. However, the quantity of material handled at surface metal mines increased to 93 percent compared with 90 percent in 1964.

MAGNITUDE OF THE MINING INDUSTRY

In 1969, the number of mines reporting crude ore production to the Bureau of Mines totaled 1,831. In addition, there were 1,423 clay mines, 4,704 crushed and broken stone operations, and 638 dimension stone mines in operation. The 1969 grand total was 8,596 mines, compared with 8,555 mines in 1968; both years exclude sand and gravel operations. Reporting metal mines decreased by 258 mines, of which 50 percent were uranium operations. Nonmetal reporting mines increased by 43 and were spread over a number of mineral commodities.

Three iron mines joined the list of those mines producing over 10 million tons of crude ore, but two phosphate rock mines dropped from this category. The Utah copper mine of Kennecott Copper Corp. was the metal mine leader in both output of ore and of total material handled, whereas the Noralyn mine of International Minerals and Chemicals Co. was the leader of nonmetal mines in both categories.

COMPARISON OF PRODUCTION FROM SURFACE AND UNDERGROUND MINES

Surface mining accounted for 94 percent of the total crude ore production and 95 percent of the total material handled. Although the percentages remained the same as in 1968, some minor shifting occurred for the various mineral commodities. Five

[9] Flipse, John E. An Engineering Approach to Ocean Mining. Paper Number OTC 1035, Off-shore Technology Conference, May 18–21, 1969, 16 pp.

metal commodities, registered an increase, but four registered a decrease for surface crude ore output. For nonmetal commodities, five indicated an increase, but four decreased in crude ore output.

Crude ore production at surface metal mines was more than five times higher than at underground mines; total material handled at surface mines was 14 times higher than at underground mines. Of the nearly 2.5 million tons of material handled at nonmetal mines, only 82,000 tons were from underground operations.

Underground mining accounted for substantial percentage of crude ore handled in five States: Colorado, 43 percent; New Mexico, 40 percent; Missouri, 29 percent; Wyoming, 24 percent; and Kentucky, 23 percent. Nineteen States reported no underground activity.

RATIO OF ORE TO MARKETABLE PRODUCT

The trend for most mineral commodities for the year was toward lower ratios of ore to marketable product compared with 1968, but ratios were generally higher than for 1964. At surface metal mines the ratios were mixed compared with 1968, with about equal distribution of gains and losses. Of the large-volume commodities, copper registered an increased ratio, and iron ore indicated a reduced ratio. In general, surface nonmetal mines indicated smaller ratios compared with 1968 with only feldspar and vermiculite registering increased ratios.

Ratios of material handled to marketable product for various mineral commodities indicated increased ratios for nearly one-half of the listed commodities compared with 1968. Copper continued to have the highest ratio as stripping continued to develop new properties and expand other operations. Compared with 1964, the ratio increased 53 percent for copper, 25 percent for iron, and 35 percent for phosphate rock, and marketable units increased 28 percent, 6 percent, and 47 percent, respectively.

Most metal commodities indicated an increase in average value per ton compared with 1968 with only mercury and uranium showing a decrease in value. Of the 27 listed nonmetal commodities, 16 indicated increased values, compared with the previous year. Total average value of metal commodities rose to $6.15 from $5.61 in 1968. Total average value data for nonmetal commodities are not comparable with previous published data.

EXPLORATION AND DEVELOPMENT

The upward trend in exploration and development accelerated in 1969 and totaled 31.7 million feet, compared with 25 million feet in 1968. The data, however, is not comparable because clay and stone mines were not included in the 1969 total. Exploration and development work for clay and stone mines totaled 1.5 million feet in 1966, 1.6 million feet in 1967, and 1.2 million feet in 1968. For metals, a significant increased activity was noted for copper, iron, and uranium mines. Rotary drilling accounted for most of the gain at copper and uranium mines, whereas percussion drilling was largely responsible for the increase at iron mines.

Arizona, Colorado, Idaho, New Mexico, Texas, Utah, and Wyoming accounted for 86 percent of total footage of exploration and development and were also the only States reporting over 1 million feet. This compares with 1968 when five States reported over 1 million feet each. Rotary drilling accounted for 76 percent of the total activity, and all categories, except trenching and diamond drilling, registered increased footage.

Stripping operations for copper in Arizona accounted for 35 percent of total material produced by exploration and development activities. The total tonnage produced increased 28 percent compared with 1968.

Increased mining activity in Arizona resulted in the total material handled exceeding 500 million tons of for the first time. Montana and Wyoming joined the list of States reporting over 100 million tons; New York and Pennsylvania dropped from the list.

EXPLOSIVES

Explosive statistics for the year of review are released too late for incorporation in this chapter. For 1968, 1,948 million pounds of industrial explosives were reported consumed in the United States. This total was 2 percent higher compared with 1967, but was slightly lower than the record high of 1,970 million pounds in 1966. The coal mining industry used 35 percent of the total, metal mines used 21 percent, and quarrying and nonmetal mines, 20 percent. This is in contrast to 1963, when coal mining accounted for 35 percent, metal mining, 17 percent, and quarrying and nonmetal mining, 22 percent of the industrial consumption.

The use of ammonium nitrate blasting agents continued to increase, whereas the use of permissible explosives continued to decline. There was no reported use of liquid oxygen explosives during 1968.

The five top ranking States in order of total quantity of explosives and blasting agents consumed were as follows: Pennsylvania, Kentucky, Ohio, Arizona, and Illinois. This was in contrast to 1963 when the ranking order was Pennsylvania, Ohio, Kentucky, Illinois, and Minnesota. In 1968, the explosive consumption of the ranking States totaled 751 million pounds, or 39 percent of industrial explosives and blasting agents used in the United States. In 1963 the ranking States used 545 million pounds or 37 percent of all industrial explosives consumed.

More detailed explosive information is published by the Bureau of Mines in the Annual Explosive issue of Mineral Industry Surveys prepared by Andris Viksne.

TABLE 1.—MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES, BY COMMODITIES, IN 1969

[In thousand short tons]

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	[1] 2,501	[1] 3,437	[1] 5,938	(2)	(2)	(2)	2,501	3,437	5,938
Beryllium	176	507	683	2		2	178	507	685
Copper	198,439	621,726	820,165	27,486	452	27,938	225,925	622,178	848,103
Gold:									
Lode	1,614	8,980	10,594	2,104	355	2,459	3,718	9,335	13,053
Placer	2,195	772	2,967		1	1	2,195	773	2,968
Iron ore	213,997	168,593	382,590	14,877	2,413	17,290	228,874	171,006	399,880
Lead	6	32	38	9,507	749	10,256	9,513	781	10,294
Manganiferous ore	1,009	2,832	3,841				1,009	2,832	3,841
Mercury	278	535	813	204	19	223	482	554	1,036
Molybdenum	5,339	36,579	41,918	15,861	156	16,017	21,200	36,735	57,935
Nickel	1,184	362	1,546				1,184	362	1,546
Silver	128	75	203	653	298	951	781	373	1,154
Titanium: Ilmenite	22,204	3,529	25,733				22,204	3,529	25,733
Tungsten	26	3	29	442	20	462	468	23	491
Uranium	1,823	89,307	91,130	3,497	1,306	4,803	5,320	90,613	95,933
Zinc	571	1,419	1,890	10,032	7,926	17,958	10,603	9,245	19,848
Other [3]	4,082	2,328	6,410	12		12	4,094	2,328	6,422
Total metals	455,000	941,000	1,396,000	85,000	13,000	98,000	540,000	954,000	1,494,000

See footnotes at end of table, p. 50.

TABLE I.—MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES, BY COMMODITIES, IN 1969—Continued

[In thousand short tons]

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Nonmetals:									
Abrasives [4]	396	141	537	48	---	48	444	141	585
Asbestos	2, 178	1, 363	3, 541	22	3	25	2, 200	1, 366	3, 566
Barite	6, 038	3, 157	9, 195	115	17	132	6, 153	3, 174	9, 327
Boron minerals	12, 461	12, 010	24, 471	---	---	---	12, 461	12, 010	24, 471
Clays	57, 524	[5] 50, 000	107, 524	1, 063	[5] 16	1, 079	58, 587	50, 016	108, 603
Diatomite	1, 042	7, 701	8, 743	268	---	268	1, 310	7, 701	9, 011
Feldspar	1, 698	389	2, 087	9	---	9	1, 707	389	2, 096
Fluorspar	62	40	102	470	1	471	532	41	573
Gypsum	7, 691	11, 968	19, 659	2, 328	73	2, 401	10, 019	12, 041	22, 060
Mica	661	463	1, 124	---	---	---	661	463	1, 124
Perlite	612	1	613	---	---	---	612	1	613
Phosphate rock	126, 056	278, 411	404, 467	671	20	691	126, 727	278, 431	405, 159
Potassium salts	---	---	---	16, 989	819	17, 808	16, 989	819	17, 808
Pumice	3, 952	136	4, 088	---	---	---	3, 952	136	4, 088
Salt	5, 400	3	5, 403	14, 371	636	15, 007	19, 771	639	20, 410
Sand and gravel	936, 906	---	936, 906	---	---	---	936, 906	---	936, 906
Sodium carbonate (natural)	---	---	---	4, 072	124	4, 196	4, 072	124	4, 196
Stone:									
Crushed and broken	822, 077	[5] 68	822, 145	38, 935	[5] 270	39, 205	861, 012	338	861, 350
Dimension	[5] 4, 000	[5] 900	[5] 4, 900	29	---	29	4, 029	900	4, 929
Sulfur:									
Frasch-process mines	8, 003	---	8, 003	---	---	---	8, 003	---	8, 003
Other mines	---	2	2	---	---	---	---	2	2
Talc, soapstone, and pyrophyllite	553	1, 235	1, 788	519	14	533	1, 072	1, 249	2, 321
Vermiculite	1, 505	4, 150	5, 655	---	---	---	1, 505	4, 150	5, 655
Other [6]	1, 946	2, 836	4, 782	85	---	85	2, 031	2, 836	4, 867
Total nonmetals	2, 001, 000	375, 000	2, 376, 000	80, 000	2, 000	82, 000	2, 081, 000	377, 000	2, 458, 000
Grand total	2, 456, 000	1, 316, 000	3, 772, 000	165, 000	15, 000	180, 000	2, 621, 000	1, 331, 000	3, 952, 000

[1] Includes underground; Bureau of Mines not at liberty to publish separately.
[2] Withheld to avoid disclosing individual company confidential data.
[3] Magnesium, manganese, platinum-group metals, rare-earth metals, and vanadium.
[4] Emery, garnet, and tripoli.
[5] Estimated.
[6] Aplite, graphite, greensand marl, kyanite, lithium minerals, magnesite, olivine, pyrites, and wollastonite.

TABLE 2.—MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES (INCLUDING SAND AND GRAVEL AND STONE), BY STATES, IN 1969[1]

[In thousand short tons]

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	32,257	18,251	50,508	1,974	248	2,222	34,231	18,499	52,730
Alaska	22,627	1,475	24,102	------	------	------	22,627	1,475	24,102
Arizona	135,273	353,935	489,208	16,639	384	17,023	151,912	354,319	506,231
Arkansas	32,465	4,574	37,039	946	17	963	33,411	4,591	38,002
California	195,658	56,729	252,389	2,103	36	2,139	197,761	56,765	254,526
Colorado	23,523	125	23,648	17,777	1,323	19,100	41,300	1,448	42,748
Connecticut	16,817	42	16,8 9	------	------	------	16,817	42	16,859
Florida	183,565	245,043	428,608	------	------	------	183,565	245,043	428,608
Georgia	40,531	61	40,592	995	------	995	41,526	61	41,587
Idaho	16,385	12,795	29,180	1,755	323	2,078	18,140	13,118	31,258
Illinois	99,102	1	99,103	2,429	------	2,429	101,531	1	101,532
Indiana	53,047	------	53,047	905	34	939	53,952	34	53,986
Iowa	45,722	6,218	51,940	1,306	------	1,306	47,028	6,218	53,246
Kansas	27,804	195	27,999	2,671	6,000	8,671	30,475	6,195	36,670
Kentucky	32,683	12	32,695	7,350	1	7,351	40,033	13	40,046
Louisiana	33,045	------	33,045	5,914	------	5,914	38,959	------	38,959
Maine	12,642	1,187	13,829	6	------	6	12,648	1,187	13,835
Maryland	30,409	16	30,425	57	------	57	30,466	16	30,482
Massachusetts	27,635	------	27,635	------	------	------	27,635	------	27,635
Michigan	130,789	14,104	144,893	14,090	379	14,469	144,879	14,483	159,362
Minnesota	206,133	91,412	297,545	------	------	------	206,133	91,412	297,545
Mississippi	13,909	------	13,909	------	------	------	13,909	------	13,909
Missouri	51,300	2,348	53,648	21,277	462	21,739	72,577	2,810	75,387
Montana	41,566	59,071	100,637	868	15	883	42,434	59,086	101,520
Nebraska	17,540	------	17,540	33	------	33	17,573	------	17,573
Nevada	33,265	61,223	94,488	353	108	461	33,618	61,331	94,949

TABLE 2.—MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES (INCLUDING SAND AND GRAVEL AND STONE), BY STATES, IN 1969 [1]—Continued

[In thousand short tons]

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
New Hampshire	6, 683		6, 683				6, 683		6, 683
New Jersey	37, 428	286	37, 714	150	1	151	37, 578	287	37, 865
New Mexico	28, 819	117, 087	145, 906	18, 790	1, 241	20, 031	47, 609	118, 328	165, 937
New York	86, 225	5, 148	91, 373	5, 938	214	6, 152	92, 163	5, 362	97, 525
North Carolina	46, 866	16, 817	63, 683	52	10	62	46, 918	16, 827	63, 745
North Dakota	7, 174		7, 174				7, 174		7, 174
Ohio	103, 886		103, 886	5, 654	400	6, 054	109, 540	400	109, 940
Oklahoma	24, 950	5, 525	30, 475	1, 178		1, 178	26, 128	5, 525	31, 653
Oregon	29, 811	472	30, 283	1	1	2	29, 812	473	30, 285
Pennsylvania	84, 682		84, 682	7, 207	1, 836	9, 043	91, 889	1, 836	93, 725
Rhode Island	2, 900		2, 900				2, 900		2, 900
South Carolina	17, 713	869	18, 582				17, 713	869	18, 582
South Dakota	13, 501	1, 606	15, 107	1, 924	179	2, 103	15, 425	1, 785	17, 210
Tennessee	43, 074	4, 870	47, 944	9, 970	766	10, 736	53, 044	5, 636	58, 680
Texas	90, 787	5, 066	95, 853	460	9	469	91, 247	5, 075	96, 322
Utah	68, 434	89, 554	157, 988	2, 687	398	3, 085	71, 121	89, 952	161, 073
Vermont	6, 563	48	6, 611	215		215	6, 778	48	6, 826
Virginia	46, 024	168	46, 192	2, 811	708	3, 519	48, 835	876	49, 711
Washington	50, 737	787	51, 524	284	116	400	51, 021	903	51, 924
West Virginia	13, 478		13, 478	1, 918		1, 918	15, 396		15, 396
Wisconsin	62, 298	1, 943	64, 241	858	48	906	63, 156	1, 991	65, 147
Wyoming	16, 480	85, 831	102, 311	5, 285	143	5, 428	21, 765	85, 974	107, 739
Other States [2]	9, 796	30	9, 826				9, 796	30	9, 826
Total	2, 454, 000	1, 265, 000	3, 719, 000	165, 000	15, 000	180, 000	2, 619, 000	1, 280, 000	3, 899, 000

[1] Partially estimated data in table 1 not included in State totals.
[2] Delaware and Hawaii.

TABLE 3.—VALUE OF PRINCIPAL MINERAL PRODUCTS AND BYPRODUCTS OF SURFACE AND UNDERGROUND ORES MINED IN THE UNITED STATES IN 1969

[Value per ton]

Ore	Surface			Underground			All mines		
	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total
Metals:									
Bauxite	[1] $10.40		[1] $10.40				$10.40		$10.40
Beryllium	9.26	$0.05	9.31	(2)	(2)	(2)	9.42	$0.05	9.47
Copper	6.02	.42	6.44	$9.14	$0.94	$10.08	6.40	.49	6.89
Gold:									
Lode	10.92	.02	10.94	13.69	2.74	16.43	12.54	1.61	14.15
Placer	.47		.47				.47		.47
Iron ore	3.79		3.79	7.45	.27	7.72	4.04	.02	4.06
Lead	40.00	19.00	59.00	13.69	5.58	19.27	13.70	5.59	19.29
Mercury	19.50		19.50	43.00		43.00	29.30		29.30
Molybdenum	4.43		4.43	6.64	.29	6.93	6.16	.23	6.39
Platinum-group metals	.54		.54				.54		.54
Silver	5.48	2.64	8.12	39.95	8.13	48.08	34.57	7.28	41.85
Titanium: Ilmenite	.84	.27	1.11				.84	.27	1.11
Tungsten	13.92		13.92	46.57	4.17	50.74	44.69	3.93	48.62
Uranium	27.22	.01	27.23	21.53	.03	21.56	23.97	.02	23.99
Zinc	12.67	4.41	17.08	11.92	2.93	14.85	11.96	3.01	14.97
Average value [3]	4.89	.20	5.09	10.33	1.53	11.86	5.73	.42	6.15

See footnotes at end of table, p. 54.

TABLE 3.—VALUE OF PRINCIPAL MINERAL PRODUCTS AND BYPRODUCTS OF SURFACE AND UNDERGROUND ORES MINED IN THE UNITED STATES IN 1969—Continued

[Value per ton]

Ore	Surface			Underground			All mines		
	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total
Nonmetals:									
Asbestos	$4.61		$4.61	$24.81		$24.81	$4.81		$4.81
Barite	2.28		2.28	16.10		16.10	2.53		2.53
Clays	4.43		4.43	8.13		8.13	4.49		4.49
Diatomite	41.54		41.54	9.32		9.32	33.59		33.59
Emery	19.85		19.85				19.85		19.85
Feldspar	4.90	$0.22	5.12	4.66		4.66	4.90	$0.22	5.12
Fluorspar	22.51	.01	22.52	14.41	$3.80	18.21	15.33	3.37	18.70
Garnet	25.09		25.09				25.09		25.09
Graphite	328.33		328.33				328.33		328.33
Gypsum	3.52		3.52	4.81		4.81	3.82		3.82
Kyanite	11.82	.24	12.06				11.82	.24	12.06
Lithium minerals	5.81	.76	6.57				5.81	.76	6.57
Magnesite	2.75	.12	2.87				2.75	.12	2.87
Mica: Flake	3.69	.01	3.70				3.69	.01	3.70
Olivine	16.73		16.73				16.73		16.73
Perlite	8.24		8.24				8.24		8.24
Phosphate rock	1.60		1.60	11.70		11.70	1.62		1.62
Potassium salts				4.00		4.00	4.00		4.00
Pumice	1.35		1.36				1.35		1.35
Salt	16.73	.75	17.12	6.39	.67	7.06	9.39	.69	10.08
Sand and gravel	1.14		1.14				1.14		1.14
Stone:									
Crushed and broken	1.52		1.52	1.63		1.63	1.52		1.52
Dimension	51.06		51.06	156.51		156.51	52.69		52.69
Sulfur: Frasch	24.09		24.09				24.09		24.09
Talc, soapstone, and pyrophyllite	6.32		6.32	7.92		7.92	7.10		7.10
Tripoli	14.13		14.13	4.10		4.10	8.53		8.53
Vermiculite	4.49		4.49				4.49		4.49
Average value [3]	1.69	.01	1.70	3.87	.13	4.00	1.77	.02	1.79
Average value—metal and nonmetals [3]	2.28	.05	2.33	7.16	.85	8.01	2.59	.10	2.69
Average value—nonmetals (excluding stone, sand, and gravel) [2]	3.97	.12	4.09	5.77	.26	6.03	4.24	.14	4.38
Average value—metals and nonmetals (excluding stone, sand and gravel) [3]	4.57	.18	4.75	8.83	1.12	9.95	5.23	.32	5.55

[1] Includes underground; Bureau of Mines not at liberty to publish separately.
[2] Withheld to avoid disclosing individual company confidential data.
[3] Including unpublished data.

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INTRODUCTION

a chapter from
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UNITED STATES DEPARTMENT OF THE INTERIOR

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INTRODUCTION

By Warren E. Morrison [1] and Robert E. Johnson, Jr.[1]

THE EVOLVING MINERALS ECONOMY

The first major evaluation of the nation's raw materials prospects after World War II was completed by the President's Materials Policy Commission (Paley Commission) in 1952 and submitted to the President in June of that year, as a five-volume study entitled *Resources for Freedom*. The bulk of the report was devoted to an analysis of the past, present, and probable future of the Nation's mineral supply industries.

The Commission's evaluation of the future situation regarding minerals was derived from its forecasts of the probable domestic demand for the major minerals in the 1970's. This demand analysis was made in the context of probable worldwide demand. Several crucial assumptions were made by the Commission's forecasters. It was assumed in 1950 that the next 20 to 30 years would see no major wars and be a period of sustained economic growth. Another assumption was that the anticipated demand for raw materials must be supplied at essentially no increase in real cost in order to avoid crucial supply problems. The Commission's forecasts were derived within the context of the country's expected future rate of economic activity. The gross national product (GNP) growth to 1975 was derived from projections of the number of people in the labor force, hours of work, and an index of probable production measured per unit of labor input. It was believed labor hours would decrease and labor productivity would increase. The result was a forecast GNP growth rate of 3 percent.

Operating within the framework of forecast GNP, approximately two dozen mineral commodities were analyzed by the Commission in terms of major industrial sectors that consumed the particular mineral. Forecasts for major consuming sectors were made through technologic evaluation of the growth of sectors. It was predicted that aluminum would displace copper for many electrical uses. Lead was forecast to be replaced entirely by plastic for cable covering.

The most sophisticated forecasts were in the energy area. The energy fuels were seen as competing with each other in the major markets, particularly for electricity generation. The Commission realized that a good possibility existed for the massive introduction of labor-saving capital equipment into coal mining, but concluded that the industry was too fragmented and financially weak to be able to incur the costs of mechanization. In retrospect, such mechanization has occurred, costs have fallen, and coal use in the electricity generation market has increased more rapidly than anticipated by the Commission. However, coal has lost other markets such as process heating more rapidly than anticipated a generation ago.

The Commission also concluded that domestic crude oil production would not be able to meet domestic demand at constant costs, and anticipated supplementary supplies from oil shale and coal liquefaction by 1970. It also felt that unrestrained crude imports would be necessary to keep costs and prices from rising. What actually happened is that petroleum prices declined. Oil from shale and coal is not yet profitable, and petroleum imports are restricted under a national control program.

The Commission's electricity consumption forecast was only two-thirds of the actual consumption level during 1950–70. This is partly explained by the fact that the average real price of electricity has declined 40 percent in 20 years. The case of natural gas is even more startling. The Commission's forecast of natural gas consumption turned out to be very much on the low side. At the same time the real price of natural gas has risen more than the price of any of the other minerals analyzed by the Commission.

In general, the Commission's mineral consumption forecasts were neither consistently high nor low. The estimates for copper, lead, and coal were from one-quarter to one-third too high. The forecasts for the consumption of aluminum, crude oil, natural gas, and electricity

[1] Office of the Assistant Director, Mineral Resource Evaluation.

were too low by one-quarter to one-half. The actual consumption figures for steel, ferroalloys, zinc, sulfur, and total electricity fell within 25 percent of the accuracy range.

If the Paley Commission's commodity forecasts are adjusted to reflect the actual GNP growth of 3.5 to 4 percent rather than the anticipated 3 percent, individual forecasts that were low are improved somewhat. Aluminum, crude oil, and electricity are moved to within the 25 percent error range. But the shift is not dramatic. The adjustment for GNP error does not correct the forecasts substantially.

With the advantage of hindsight, it is now seen that the last two decades have demonstrated almost uninterrupted growth in the economies of industrialized nations and major shifts in the demand pattern for minerals. While the United States has shared in this growth and is still the world's single largest minerals consumer, it no longer dominates the world scene. European countries and Japan have increased their demand for minerals at a much faster rate than the United States and account for an increasing portion of total world demand.

The geographic pattern of mineral production has also changed. Production has grown most rapidly in areas of the world that produced few minerals prior to World War II, such as the Near East, Africa, and Australia. Present indications are that further discovery and development of extensive mineral wealth in these and other areas that were formerly overlooked, will continue as new technologies and science are applied. The Arctic land masses hold great promise as a future source of minerals in spite of the forbidding climate which renders development a challenging and expensive task.

The actual U.S. mineral pattern in the last 20 years is characterized by a strong shift away from mineral self-sufficiency. The domestic minerals economy is now much more dependent on world mineral markets than it was in 1950, particularly for petroleum, iron, aluminum, and copper. This same shift has also been pronounced in other parts of the world. Europe, which was to a large extent self-sufficient in fuels a generation ago, depending largely on indigenous coal reserves, has in recent years shifted to a petroleum-dominated energy economy. Virtually all of the petroleum consumed is imported from the Near East and Africa. Europe also depends on outside sources for many of its other mineral requirements.

Japan is an extreme example of a highly industrialized economy that has become almost completely dependent on imports for mineral raw materials. To support its industrial growth, Japan imports gas from Alaska, coal from Canada and the United States, oil from the Mideast and Indonesia, and iron ore, bauxite, and coal from Australia. Japan also imports large quantities of nonferrous ores from South America and southern Africa. To develop these sources, Japan has found it necessary, in many instances, to provide financing and technology for the development of these mineral supplies. The Japanese are even finding it expedient to finance development of coking coal reserves in the most capital-rich country in the world—the United States.

One result of the sustained rapid industrialization in many parts of the world since 1950 has been the establishment of complex worldwide markets for many of the major mineral raw materials. Not only are the industrial nations moving away from self-sufficiency, their dependence on single outside sources is also declining. Industrial nations draw on many diverse foreign sources, and the mineral producing countries export their raw materials to several or all the industrial countries.

It is impressive that the world's mineral producers to date have been able to satisfy this massive growth in demand for minerals in an orderly fashion. A generation ago there was anxiety that the United States and the rest of the industrial world would not be able to secure minerals except at steeply increasing costs. An impressive job has been performed by the suppliers of the world's mineral raw materials in the last generation, yet anxiety over the prospect of scarce supplies and more expensive minerals persists.

The Paley Commission's most important single recommendation was that there be a continuous attempt to anticipate the future, and adjust policy. One of the most important conclusions the Commission presented was that the job of insuring an adequate and dependable flow of materials at the lowest cost consistent with national security must be carried on cooperatively by Government and private citizens on a sustained basis. Emerging situations demand continuous reevaluations. Each generation should reassess its requirements for raw materials and adequacy of the resource base. The recent pervasive anxiety for the maintenance of the quality of our environment further calls for a reassessment of social and economic costs in the mineral industries.

THE FUTURE OUTLOOK

In assessing the progress of the minerals industry in the United States during the two decades since 1950, two main influences stand out. These are the sustained high rate of economic growth and the revolutionary impacts of science and technology on the materials demand sectors.

The influence of economic growth on the Nation's mineral industries derives from their vital character as suppliers of raw materials essential to the productive process, as well as from their high proportional contribution on a value-added basis to all goods and services, as represented in the gross national product (GNP). Until the 1960's, an average growth of 3 percent per year in the GNP was generally accepted as a sustainable rate. Actual experience since 1950 has shown GNP growth in constant dollars to be 3.5 to 4 percent annually. For the remainder of the century, the GNP growth rate is predicted as 4 percent. Population growth is predicted at 1.6 percent and industrial production at 4.2 percent. Growth of domestic mineral resource demand during the forecast period is forecast within a probabilistic range of 3.4 to 5.5 percent per year (tables 1 and 2). This growth is based on contingencies assumed for the future demand for some 88 mineral resources in this volume during the period 1968–2000.

TABLE 1.—Value of world primary demand for minerals, 1968, and forecasts to the year 2000 [1] [2]
(Billion constant 1968 dollars, except as noted)

Commodity group	1968	Forecast range, 2000		Cumulative demand 1968–2000		Growth rate (percent)	
		High	Low	High	Low	High	Low
U.S. PRIMARY DEMAND							
Energy	20.4	103.2	48.1	1,740.3	1,087.0	5.2	2.7
Ferrous	2.0	6.1	4.3	116.1	94.4	3.5	2.4
Nonferrous	5.5	52.0	26.9	679.6	466.1	7.3	5.1
Nonmetallic	5.8	27.3	17.6	415.8	326.8	4.9	3.5
Total	33.7	188.6	96.9	2,951.8	1,974.3	5.5	3.4
REST-OF-THE-WORLD PRIMARY DEMAND							
Energy	35.9	184.8	110.1	2,919.1	2,066.1	5.3	3.6
Ferrous	7.1	20.4	14.3	393.4	326.1	3.3	2.2
Nonferrous	15.5	132.2	62.9	1,464.3	948.3	6.9	4.5
Nonmetallic	24.3	119.1	81.2	1,871.3	1,477.7	5.1	3.8
Total	82.8	456.5	268.5	6,648.1	4,818.2	5.5	3.7
TOTAL WORLD PRIMARY DEMAND							
Energy	56.3	288.0	158.2	4,659.4	3,153.1	5.2	3.3
Ferrous	9.1	26.5	18.6	509.5	420.5	3.4	2.3
Nonferrous	21.0	184.2	89.8	2,143.9	1,414.4	7.0	4.6
Nonmetallic	30.1	146.4	98.8	2,287.1	1,804.5	5.1	3.8
Total	116.5	645.1	365.4	9,599.9	6,792.5	5.5	3.6

[1] For detailed commodity breakdown, see tables 1 and 2 in Energy, Ferrous, Nonferrous, and Nonmetallic introductory sections.
[2] The range of forecast demand by end uses in many of the commodity chapters was subjected to a probability adjustment within two standard deviations about the mean. While recognizing that a totalling of the high-low ranges for competing or substitute commodities includes some further bias, this is shown to provide an order of magnitude of the probabilistic range of forecast demand by commodity groupings.

The second major influence on the domestic mineral industries, namely that of technology on evolving materials needs in major mineral end use markets, has had an even greater overall impact on the pattern and growth of the Nation's minerals supply and demand. Since the 1950's, new materials forms and end uses have been proliferating in response to the evolving needs of users in existing as well as new markets. Science and engineering have been altering properties, improving performance factors, and creating material combinations. Materials users are more and more concerned with these altered properties, performance factors, and combinations, and less with the primary resources they are derived from.

In contrast to these impacts of economic growth and science and technology on materials demand, there has been a lagging technological response from the mineral supply industries. As far back as 1950, the Paley Commission predicted that future trends of technology in the primary mineral resources industries might not be able to cope with the growing need to exploit lower grade raw materials to meet the rising demand within the current price structure. Twenty years later there is increasing evidence that the Paley Commission's fears regarding lagging technological progress in the mineral supply industries have been realized. Total real costs within a number of primary minerals industries, especially in the nonferrous group, have apparently been rising at a faster rate than for the economy as a whole.

TABLE 2.—Economic indicators used for forecast base projections to year 2000

Year	Gross national product (billion constant 1968 dollars)	Total U.S. population (millions)	FRB Index of Industrial Production (1968=100)
1964	562.6	192.1	80.0
1965	621.1	194.6	86.8
1966	698.4	196.9	94.6
1967	763.0	199.1	95.6
1968	865.7	201.2	100.0
2000	2,008.1	334.2	372.7
Annual growth rates, 1968–2000 (percent)	4.0	[1] 1.6	4.2

[1] More recent estimates indicate that this figure may be too high; the current suggested rate is 1.35 percent.

Sources: GNP, *Survey of Current Business*, December 1968, Office of Business Economics.
Population, *Population Estimates*, March 14, 1968, Bureau of Census.
FRB Index, National Planning Association.

Many of the Nation's primary minerals industries continue to be oriented toward the production and primary processing of a single resource, with occasional related byproduct or coproduct output. It is increasingly difficult for raw materials suppliers to predict and interpret the changing needs of materials users in the demand sectors. Confusion and disruption on the supply side may occur either from sudden increases in resources demand that cannot be supplied at current costs or prices within existing capacity, or from abrupt declines in traditional markets with resultant surpluses or cutbacks. Despite the apparent healthy state of many mineral industries and the increasing demand for their output, the rate of new discoveries and development of reserves is declining for a wide range of minerals. Technology has not been forthcoming to lower costs and increase available supply from presently classified marginal and submarginal resources. The trend for a growing number of primary minerals is toward higher costs, a leveling off of domestic production, losses of traditional markets, recourse to substitutes, and increasing dependence on foreign sources of supply.

Instead of a single heterogeneous source, materials needs are to an increasing degree met from some combination or mix of primary resources, which in turn is derived from a relatively fixed domestic resource base. The failure of some primary mineral industries to readily respond technologically and organizationally to the changing pattern of materials needs is having adverse effects of supply-demand relationships. It is essential that the growing gap between primary minerals supply and evolving materials demand in such industries be narrowed and some kind of balance restored. To achieve this reconciliation will require a number of changes and innovations in the domestic minerals industries, some already in progress and others yet to be implemented.

A first requirement is the extension of the technological revolution that has so drastically affected the growth and pattern of materials uses to the primary mineral industries on the supply side. To stem the rising tide of real costs in key mineral industries, science and technology will be called upon to increase available supplies at reasonable costs as well as to alter and broaden the properties of more abundant, lower cost available domestic resources, with the objective of increasing their substitution potential for scarce, high cost, or imported resources. Technology must be applied to broadening the recoverable portion of the resource base through development of new techniques of exploration and discovery for resources, lowering the cost of development of presently classified marginal and submarginal reserves, extending mineral supply through recycling, and maximizing the recovery and utilization of byproducts and coproducts. There is also a vital need for technological innovation with regard to the development of nondestructive approaches to resources and materials production and usage, and to assure the maintenance of the quality of the environment during the entire minerals cycle from production to final use.

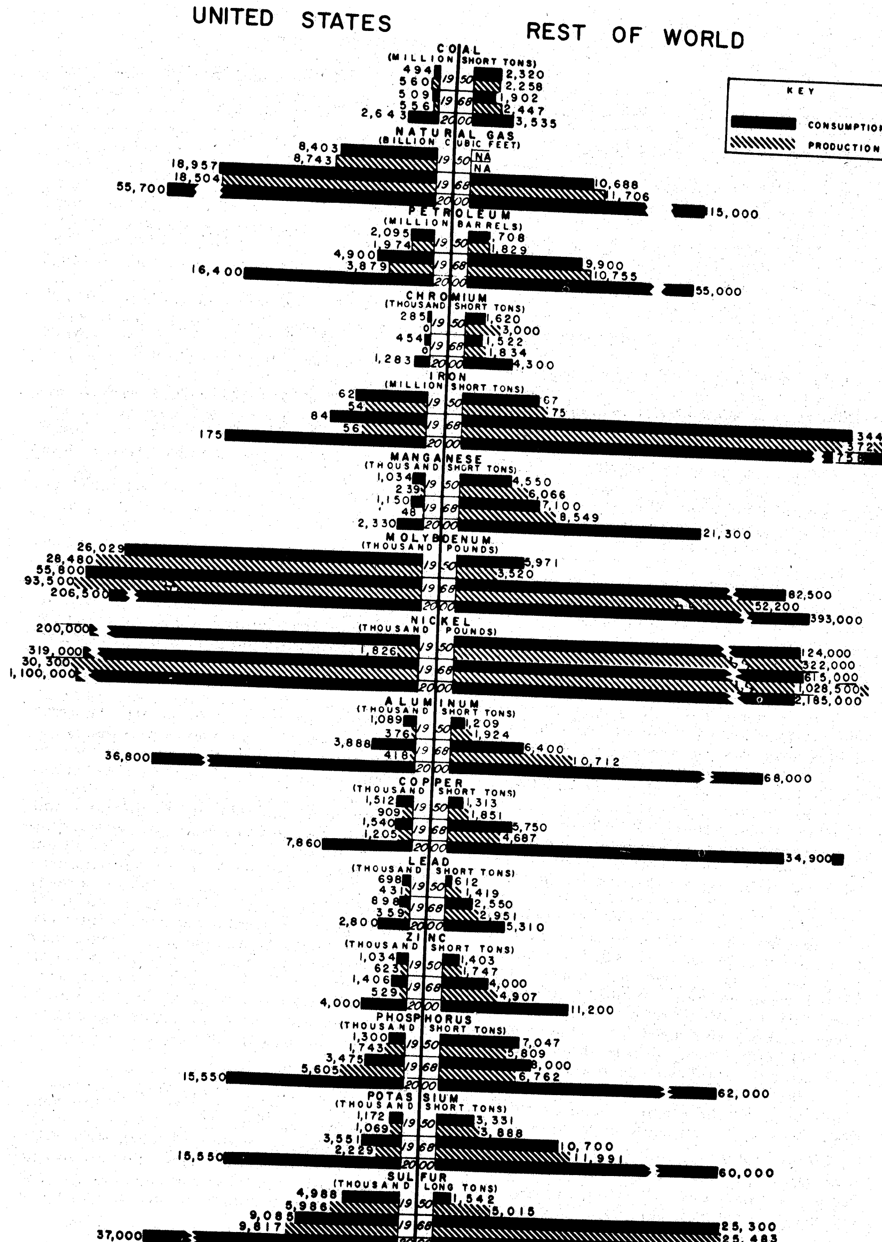
A second prerequisite for closing the widening gap between minerals resources supply and materials demand is the need for a "goal oriented" approach to minerals planning, programing, and management. The rationale for this approach is that man is increasingly able to control and determine his future. To an increasing degree technology, as well as economic and social needs, can be literally planned, programed, and managed into reality. In the minerals area evolving user needs demand new technology which in turn generates new materials requirements and performance factors. To anticipate these shifts and to assure their success, alternative futures for materials uses and requirements can be forecast and simulated on the basis of contingency assumptions for future technology and other influences. From the contingency forecasting of alternative futures for minerals demand, predicted shifts in materials needs can be worked back to calculate the strain on the resource base and which resource mix will be required under the assumptions. More importantly, forecasts and simulations of future supply-demand relationships for minerals are useful for planning, prescribing, and managing needed change and innovation in the minerals area.

A third requirement for improvement of the working balance between primary resources and their materials uses is the restructuring of some minerals industries along horizontal and vertical paths. A number of industries that are presently oriented exclusively toward primary production and processing of single resources and their byproducts or coproducts are tending to merge horizontally into functional resource groupings that reflect major use patterns—such as energy, nonferrous, ferrous, and nonmetals uses. In a vertical process of integration some primary resource producers and processors are also becoming increasingly involved beyond the primary processing stages and tending to integrate and merge with materials processing, manufacturing, and user industries. This process of evolution from a commodity to a functional approach in resources-material management is already apparent in the primary fossil fuels industries.

Many aspects of resource-materials interrelationships tend to be unique and characteristic of the specific minerals resources and materials uses to which they are applied. However, some general observations can be made with respect to probable levels of requirements for mineral resources to the end of this century.

ALL MINERALS

Based on the aggregation of the contingency forecasts for some 88 mineral resources in the following chapters, it is estimated that the value of world primary demand for minerals by the year 2000 will range from about $365 to $645 billion in constant dollars. About one-quarter of



Year 2000 consumption data are the high range contingency forecasts developed in this volume.

FIGURE 1.—United States and Rest of World Mineral Demand and Supply, 1950, 1968, 2000.

the total, or $97 to $189 billion, represents the value of the U.S. range of forecast mineral demand for the year 2000. Relating the range of forecast demand for the United States to the situation in 1968, the annual growth of total domestic minerals demand will range from 3.4 to 5.5 percent for the remainder of the century (table 1). Some idea of the magnitude of these future requirements for mineral resources, and an indication of the capital outlays that will be necessary to achieve them, are evidenced from the cumulation of the value of the probabilistic forecast rate of mineral resources demand between 1968 and 2000. For the United States, the cumulative value to the end of the century is $2.0 to $2.9 trillion, and for the world $6.8 to $9.6 trillion (table 1).

In the last 30 years the United States has consumed more minerals than the entire world for all time before. Based on the forecasts for the year 2000 the total constant dollar value of demand for minerals in the Nation is expected to increase from three to five times the current level. This substantial increase will result from continuing economic and population growth and be characterized by increasing affluence, urbanization, and industrialization. Technological progress and innovation will continue to be the main influencing factors in the demand for all resources in the year 2000.

THE ENERGY GROUP

With respect to the energy group of mineral resources under known technology, the conventional fossil fuels—including petroleum, coal, and natural gas, the new fissile fuels including uranium and perhaps thorium, and hydropower—will be the principal energy sources for the remainder of this century. Increasing quantities of the fossil fuels supplemented by fissile fuels will be required for the production of energy within the present conventional energy system of direct fuels utilization and secondary electricity generated from fossil fuel and nuclear plants. Nuclear reactors powered by uranium and eventually thorium are expected to account for an increasing portion of the electric power generating capacity and output. However, fossil fuel plants will still be the major source of utility electricity generated in the year 2000.

Contingency forecasts of the total demand for energy to the year 2000, in both constant dollars and British thermal units call for average annual energy growth rates ranging from 2.7 to 5.2 percent annually. The total calorific value of the cumulative requirement for energy resources to meet forecast domestic demand for energy in the United States to the end of the century is predicted within a range of 166 to 239 quadrillion British thermal units. In constant dollar value this represents $1.1 to $1.7 trillion, or about one-third of the total forecast value of all mineral resources demand forecast for the period (table 1). Thus energy resources are expected to continue to dominate the total minerals requirement for the foreseeable future.

The technology of energy resources processing and utilization within the present conventional energy system has progressed to the point where virtually all of the major fossil fuels, as well as the newer fissile fuels, are substitutable for each other in output of energy in the form of electricity or process heat. There is also increasing use of fossil fuels for nonenergy uses such as chemicals. As the demand for total energy grows, domestic fossil and fissile fuels compete and substitute for each other on the basis of cost-price relationships and their technical ability to meet the evolving requirements of energy forms and markets. In the case of petroleum about one-quarter of domestic demand is met from foreign sources of supply.

In response to the increasing demand for secondary energy in the form of electricity or heat, producers of primary fossil fuels—such as coal, oil, and gas—are beginning to group together, becoming energy companies producing a range of primary and secondary energy and raw material products. The most palpable recent evidence of this horizontal restructuring has been the movement of U.S. oil companies into the coal and uranium businesses. Primary oil companies are also integrating vertically by becoming increasingly involved in secondary materials processing and beyond, into the fields of petroleum chemicals and other energy and nonenergy material uses. In the process of moving from a commodity to a functional energy approach, primary energy resource producers are increasingly able to relate to the evolving forms and shifting uses of the demand sectors.

The principal problems anticipated for the rest of this century in respect to energy supply and demand are related to the technological limitations of the present conventional energy system and the required mix of resources necessary to sustain it. There is particular concern for possible future shortages of certain primary resources such as natural gas and uranium with respect to the known technology of the uses of these resources in process heat and generation of electric power. Another major cause for concern is the ability of the domestic petroleum industry to meet anticipated future demand for liquid fuels at world prices and what portion of future requirements will have to be met from foreign sources of supply under known and anticipated technology.

With respect to the present energy system, the inefficiencies and environmental problems of direct utilization of fossil fuels for space and process heat, transportation, and electricity generation are increasingly evident. There are also growing doubts concerning the efficiency of the system of long-distance transportation and related line loss of utility electricity generated at large thermal electric powerplants, using either fossil or fissile fuels. Finally the environmental problems of electric utility generation from conventional fossil fuel and nuclear power generating plants as well as direct uses of fossil fuels are of increasing national concern.

It is believed that the conventional energy system, because of upper limits on its efficiency, the restraints of the resource base, and detrimental environmental effects, will evolve toward alternate systems for which technology is known but not yet commercially viable. Such known systems include improved all-electric systems based on fossil or fissile fuels and single-fuel systems such as onsite fuel cells. The latter might provide electricity and heat with full efficiency at part load, dispensing with long-distance transportation of power, and with no environmental problems such as are associated with thermal power.

Probabilities for the emergence into widespread commercial use of one or more of these energy systems before the end of the century depend on the relative efficiencies of such a system to meet forecast energy demand, the impacts on the resource base necessary to sustain it, and the environmental problems involved from either the system or resources side. For example, the present controversy on the relative efficiency of nuclear power versus conventional systems, the prospects of new technology such as breeder reactors, the potential problems of future uranium supply, and the general ecological problems of nuclear power must be analyzed within the larger context of alternative energy systems and resource mixes. Looking beyond the year 2000, increasing consideration will also have to be given to the eventual exhaustion of conventional energy resources within proved and possible energy systems and the need for the introduction of exotic unproven systems, such as solar energy and fusion, to meet the nation's very long-term energy needs.

THE FERROUS GROUP

Within the ferrous group, iron predominates both in quantity and value. It is also the source of the key metal within the spectrum of metals, steel. Other components of the ferrous group serve principally as additive elements for forming alloys for steel and other metal combinations. The major alloys are manganese, silicon, chromium, nickel, cobalt, columbium, tungsten, tantalum, molybdenum, vanadium, etc. Whereas the value of primary domestic demand for iron is currently two-thirds of the total value of the ferrous minerals group, the alloy minerals, especially superalloys, are of increasing importance for bringing higher quality and improved performance factors to metals.

With respect to the ferrous position in total minerals demand, the group accounted for only 6 percent of the total value of domestic minerals demand in 1968. Based on the contingency forecasts made for the various components of the group to the year 2000, the domestic demand for ferrous minerals is forecast to grow at annual rates ranging from 2.4 to 3.5 percent during 1968–2000 (table 1). This is a somewhat slower rate than predicted for the other mineral groups—nonferrous, nonmetals, and energy. The reasons are believed to lie in anticipated increases in efficiency through new technology that will be brought to the iron and steel industry during the balance of the century, such as direct reduction, as well as the effects of substitution by materials derived from other minerals, including the nonferrous and nonmetallics.

The last decade has witnessed a revolution in the technology and economics of use of the ferrous group of metals. Much of this has affected supply requirements for higher quality ores and alloys. It is expected that the technological revolution will continue within the user industries, and will affect the future requirements for high-grade iron and superalloys.

The iron industry is expected to become increasingly user-oriented and responsive to changing materials forms and performance factors. These shifts will come from major consumers such as the construction and the transportation industries, as well as from the growing industrial processing and user markets. To an increasing degree the evolution of the domestic iron industry will also be contingent on the ability of the industry to maintain the quality of the environment on both the demand and the supply side. This will mean increased costs or the introduction of new technology to maintain costs at current levels.

The main tasks that face the ferrous group are quality improvement particularly with regard to the provision of special alloys and superalloys; richer iron ores from domestic sources or foreign sources at reasonable costs; and the implementation of new technology to lower overall costs within the group, especially with respect to domestic resources presently classified as marginal and submarginal. Other requirements necessary to improve the economics of the ferrous group of minerals include direct reduction, improvement of methods of overland transportation of ore to reduce costs, reclaiming secondary metals from superalloy scrap, and improved byproduct and coproduct recovery from raw materials production. Improvement in metal recovery at all stages would significantly lower overall costs. Marine sources of ferrous metals also offer possible major new sources of supply and an opportunity to broaden the resource base. Finally technology is needed to further reduce the costs of producing domestic iron and also increasing the domestic availability of a number of the alloying metals.

THE NONFERROUS GROUP

The nonferrous group range from the major industrial minerals—aluminum, copper, lead, zinc, mercury, magnesium, and titanium—to the precious minerals—gold, silver, and the platinum group. Within a broad spectrum of chemical and physical properties, these minerals meet a major portion of the evolving and diversified metals needs of the user markets.

The nonferrous minerals constitute the largest group within the total minerals complex, accounting for about one-sixth of the total dollar value of all minerals demand in the United States, as well as the rest of the world, during 1968 (table 1). Based on contingency forecasts of trends of demand to the end of the century, domestic demand for minerals of this group is predicted to expand faster than for the other groups, with annual rates of growth for 1968–2000 ranging between 5.1 and 7.3 percent.

The anticipated growth of value for the minerals in the nonferrous group will derive largely from growth in the major components of the group, aluminum and copper, magnesium and titanium, and the precious metals, gold, silver, and the platinum group. In the rest of the world, anticipated growth for nonferrous minerals is also expected to exceed that for the other groups (ferrous, nonmetallics, and energy). Based on the forecasts in the nonferrous chapters, rest of the world value is predicted to grow within a range of 4.5 to 6.9 percent annually during the rest of the century.

The domestic nonferrous mineral industries have been experiencing rising real costs and land use conflicts. In many nonferrous industries there has been a failure of technological progress to bring forth new recoverable reserves or decrease the cost of development of presently classified marginal and submarginal resources. For some of the minerals in this group, their byproduct-coproduct relationships with other minerals production places limitations on the present and anticipated supply. In other instances, the persistent high costs of domestic production are being solved by recourse to foreign sources of supply. The environmental problems within this minerals group are also increasing on both the supply and demand sides.

The need to meet the rapidly growing domestic demand for the nonferrous minerals while maintaining the quality of the environment, maintaining real costs at reasonable levels, and assuring that the ratio of domestic production to imports is maintained are the major challenges for the nonferrous mineral industries. Much of the response to these challenges will have to come from new technology. There is also some benefit to be expected from the increasing tendency toward horizontal and vertical integration among some of the mineral industries in this group. A number of copper-producing companies have expanded their operations to include the production of primary aluminum. Because of the many common markets shared by aluminum, magnesium, and titanium, the production and processing of two or more of these elements by single firms is likely to continue to expand during the remainder of the century. With respect to vertical integration, a number of major aluminum and copper companies are increasingly involved, beyond the primary processing stages, with materials needs and product end uses.

THE NONMETALLIC GROUP

The nonmetallic minerals are numerous and range from such bulk commodities as sand and gravel and stone, the annual domestic demand for which is quoted in billions of short tons, down to industrial diamonds and gem stones, which are measured in carats. The last three decades of this century will be a period of rapid growth for the nonmetallic mineral industries. The requirements for new buildings, road construction, rehabilitation of blighted cities, food production, chemical manufacture, ceramics, metalworking, and the host of other established uses of nonmetals can be expected to increase in volume. Of equal long-term significance are the opportunities to supplement and replace metals as they become scarce and expensive. Development of performance specifications will expand the use of composites of metals, nonmetals, and nonmineral materials in new and improved end products. Research leading to significant improvements in the properties of the abundantly available nonmetals also will enhance their utility.

In 1968 nonmetallics were the second largest group of minerals, accounting for one-sixth of the total dollar value of all primary minerals demand. Future demand, in constant dollars, is forecast to grow at average annual rates ranging from 3.5 to 4.9 percent to the year 2000 (table 1). The probabilistic forecast range is based on the contingencies assumed for the nonmetallic mineral demand during the forecast period. Sand and gravel and crushed stone are expected to remain the largest value items in the group and to have the fastest rates of growth. In the rest of the world, growth rates to the end of the century are expected to be comparable to those predicted for the United States.

The domestic nonmetallic mineral industries, with a few exceptions, should be able to provide adequate supplies from domestic sources at reasonable costs to the year 2000. For the exceptions, supplies can be obtained from foreign sources or alternatives such as substitutes. However, the maintenance of a high degree of domestic self-sufficiency will require solution of many technical and economic problems. For some commodities, such as quartz crystal, lump kyanite, corundum, and industrial diamond, synthesis from domestic raw materials offers a feasible solution to supply problems. Increased recovery of byproducts, improvement of technology enabling use of lower grade reserves, and improvements in production and transportation facilities and costs are other means of enhancing the domestic supply position. Maintenance of ample domestic supplies of the nonmetals provides a foundation on which the United States can adapt to anticipated future shortages when demand outruns supply of the scarcer minerals.

Serving, as nonmetallics do, extremely heterogeneous markets, there is less tendency toward vertical and horizontal integration than in some of the metallic and fuel categories. However, there are advantages of scale and organization to be gained in some of the larger industries so there has been some consolidation among producers serving the construction and fertilizer fields. Continuation of this trend may be expected where efficiency benefits can be achieved.

Urban and environmental problems loom as major factors in the further development of the nonmetallic industries during the balance of the century. Nonmetallic minerals, mined predominantly by open pit methods, in large volume, have a variety of waste disposal and pollution control problems. Most urgent are those involving encroachment of urban development on mining operations and mineral reserves, particularly for bulk resources such as sand and gravel. Conflicting land use situations will have to be resolved through multiple land use programs. Publicly acceptable and economically feasible methods of controlling air and water pollution and waste disposal will also be required.

MINERALS PREDICTION

This edition of Mineral Facts and Problems features an expanded Outlook section in each of the 88 separate commodity chapters. The main objectives of this new coverage are to analyze and forecast alternative future mineral supply demand relationships and to assess their impacts on the resource base. The emphasis on prediction in the 1970 edition is prompted by the increasingly complex relationship between primary resources availability and minerals uses, an acknowledged need for improved resources materials management, and the increasing role of planning in both Government and the private sector with respect to assuring the Nation's long-term needs within a fixed resource base.

The forecasting method used for predicting future mineral resource supply-demand relationships in each of the commodity chapters of this edition of Mineral Facts and Problems is called contingency or technological forecasting. The technological label is the one most frequently applied to the method and derives from the fact that much of the work done with the method to date has been involved with technological contingencies. However, in view of the method's potential for taking other influential variables or contingencies besides technology into account, the term technological can be misleading.

Briefly described, contingency forecasting consists of predicting and simulating alternate futures based on contingencies assumed for technological, economic, social, environmental, and other relevant influences. The contingencies and the assumptions for these are identified, quantified, and analyzed through "scenarios." The techniques used for the preparation of the scenarios may be described as eclectic or opportunistic since there is considerable flexibility for the use of judgment, experience, and intuition in the forecasting procedure. The method may avoid many of the rigidities of projection by trend extrapolation, such as mechanical curve fitting, or the uncertainties of trend correlation or econometric procedures wherein determining or influential variables cannot be precisely identified, quantified, and forecast within a mathematical framework. Conversely, any or all of these techniques may be applied as part of a technological forecasting procedure. Hence, the use of the term eclectic for describing the method.

One way to illustrate the use of method is to describe its application within a quantified model. In Mineral Facts and Problems, contingency forecasting for the major energy resources is carried out within the framework of the Bureau's national energy model, featured annually in the introductory review chapter of the Minerals Yearbook, Volumes I–II, Metals, Minerals, and Fuels.

The following is a discussion of the forecast techniques used in the "Bituminous Coal and Lignite," "Natural Gas," "Petroleum," and "Uranium" chapters of the 1970 edition of Mineral Facts and Problems. The methodology of the forecasts is discussed in three phases: First, the conditional projections to the year 2000 of current end uses for the major energy components in the Bureau of Mines 1968 energy balance; secondly, the calculation of deviations from these projections on the assumption of contingency situations leading to the establishment of probabilistic ranges of forecast demand; thirdly, the establishment and analysis of future supply-demand relationships for energy resources during the forecast period.

The first phase of the forecast procedure is the projection of the major forms and end uses of the resource components of the Bureau of Mines 1968 energy balance to establish a forecast base for each end use in the terminal forecast year. The projections are described as "surprise free" in that they merely reflect past trends and are conditionally related to forecasts for the growth of population, economic activity, industrial production, or other relevant indicators (table 2). The projections do not reflect any technological shifts or other contingency impacts on the energy components.

The forecast base for each of the major end uses of energy in the year 2000 is a point of departure for the second phase, which is the contingency forecasting exercise. This involves the establishment of contingency situations that are quantified as deviations from the forecast base projections. The contingency analysis is carried out within separate scenarios prepared for each end use. The scenarios set forth assumptions for alternative contingencies that will cause quantitative deviations from the year 2000 forecast base. Scenario contingencies reflect either threats or opportunities for each end use in terms of predicted technological, social, political, economic, environmental, and other relevant influences.

In this second phase, a forecast range of contingency demand is calculated for each end use of the major resources within quantitative limits established for both the high and low of the range. Aggregation of these high and low limits of the forecast range for each end use provides an aggregate forecast range of demand in the year 2000. Where the spread between the high and low limits of the aggregated forecast range for a particular mineral resource is extremely wide, the range is subjected to a probability analysis that includes adjustment of the forecast range for one to two deviations from the mean.

In each energy commodity chapter, a forecast range of demand for the subject resource is also established for the rest of the world in the year 2000. Because of the absence of comparable end use data for projection of the rest-of-the-world demand for mineral resources, the calculation of the year 2000 forecast range is based on the 1968 rest of the world totals. The rest of the world probabilistic forecast range for each resource in the year 2000 is derived from analysis of parallels with technology, demand, supply, and other influential variables anticipated for the United States. Expected deviations from the U.S. forecast range are reflected in adjusted growth rates for the rest of the world.

The third phase of the contingency forecasting exercise consists of relating the energy demand forecasts for the year 2000 to available supply to determine future supply-demand relationships. The demand forecasts of energy components for the year 2000 can be worked back to the base year 1968 to establish whether cumulative requirements during 1968–2000 can be met from the available or predicted supply of primary energy resources. Strains on the resource base and the required energy mix necessary to meet contingency situations on the demand side can be assessed.

Analysis of probabilistic relationships between contingency demand and available supply under varying assumptions provides insights on future potential problem areas. An example is whether domestic supplies of natural gas or uranium in the United States and in the rest of the world will be available, at economic costs and prices, to meet the cumulative range of forecast demand for these resources to the year 2000. Alternative approaches and possible solutions to these and other potential problems may be simulated quantitatively within the model. On the demand side, contingencies may be simulated and assumptions varied to alter the forecast range for the energy components. On the supply side, alternative assumptions can be made for price-cost shifts, for technological progress leading to new discoveries or lower cost development of presently classified submarginal reserves, for shifts in the ratio of imports to domestic production, and for the introduction of substitutes to displace or supplement high-cost energy resources.

With respect to the potential uses of contingency forecasts in the energy area, one of the main purposes is to provide insights into future supply-demand relationships and identify problem areas or opportunities. In table 4 in the Energy Resources summary, the probabilistic range of forecast demand is quite broad for most of the energy resources, and for any single component the precise point on the range where future demand is most likely to occur may be dependent on a complex set of interrelationships. However, where problem areas are identified, probability analyses can be used to establish most likely points on the range.

This brings us to what might be called a fifth phase of the contingency forecasting exercise—namely, its potential uses for planning, programing, and decisionmaking in the minerals area. Increasing concern with minerals problems both in the private sector and Government is related to identifying, anticipating, and providing for alternative approaches and solutions to threats or opportunities, sufficiently in advance for action to be taken. The establishment of goals or norms for the future, and the taking of prescribed action by the Government or the private sector, can greatly influence the probability of success and make realities out of present contingencies. Man is to an increasing degree able to control and determine his environment. Within limits, technology, as well as economic and social needs, can be literally programed and managed into existence. With respect to technology, it can be said that all of the inventions or innovations that are likely to improve or change the existing minerals supply-demand system and the ability of the resource base to meet anticipated needs during the balance of the century have probably been identified. The same may be said of many of the other influences that will shape the pattern of future supply and demand. The real challenge of prediction, and of contingency forecasting in particular, is to identify and analyse the impacts of those contingencies most likely to achieve major prominence and large-scale development and have pronounced effects on the economy and the resource base. In addition to reducing uncertainty about the future, contingency forecasting can also be a major tool for the management, provision, and assurance of future energy needs.

Past issues of Mineral Facts and Problems have been essentially "supply" oriented. The 1970 edition adds a new dimension to the minerals demand analysis by introducing material forms and end uses. This is accompanied by the prediction of the evolution of such uses to the year 2000 and the possible impacts on the resource base from contingencies assumed for demand.

In the scenarios on future mineral uses in the Outlook sections of the 88 commodity chapters, in the 1970 edition, considerable care has been taken to include all of the assumptions and analysis leading to these contingencies. Readers are invited to simulate other forecast ranges based on alternative assumptions. The quality and depth of analysis in these scenarios reflect the amount of information and data available for each resource, as well as the judgment, intuition and experience of the analyst. It is hoped that useful dialogues will ensue between Bureau of Mines analysts and knowledgeable persons elsewhere in the Government and in the private sector on the subject of the contingency analyses and forecasts carried out in this edition. Authors will welcome all critical comments and suggestions for revisions in the next edition of Mineral Facts and Problems. In the intervening years between the 5-year editions of Mineral Facts and Problems, the Bureau of Mines plans to make annual adjustments and revisions to these contingency forecasts. This is necessary to reflect new information, improved data, identification of new problem areas, and to assess the prospective impacts of new technologies, and other contingencies that will affect the future supply-demand relationships for mineral resources.

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ENERGY RESOURCES

a chapter from
mineral facts and problems, 1970 edition

UNITED STATES DEPARTMENT OF THE INTERIOR

United States Department of the Interior

Bureau of Mines

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ENERGY RESOURCES

The demand for energy in the United States has been increasing at an average rate of 3.1 percent annually for the last 20 years. Gross consumption of energy resources in 1968 was 62 quadrillion British thermal units (Btu), having a value of approximately $20 billion.

Rest of the world energy demand has grown at a rate nearly double that of the United States in recent years. The greatest growth has been in the highly industrialized countries of Europe and Asia; however, commercial energy consumption in less developed regions is now growing at an even faster rate than in the highly developed areas. In 1968, energy consumed outside the United States was valued at approximately $36 billion.

TABLE 1.—U.S. primary production and demand for fuel minerals, 1968, and forecasts to the year 2000 [1,2]

Commodity	Quantity units	Value units	Average unit price (1968 dollars)[3] 1968	Average unit price (1968 dollars)[3] 2000	1968 Primary production (quantity)	1968 Value (million dollars)	1968 Primary demand (quantity)	1968 Value (million dollars)	Year 2000 primary production, constant ratio[4] High Quantity	High Value (million dollars)	Low Quantity	Low Value (million dollars)
Anthracite	Thousand short tons	Short ton	8.48	12.40	11,461	97.2	10,160	86.2	4,100	50.8	1,100	13.6
Bituminous coal	Million short tons	do	4.67	4.67	545	2,545.2	499	2,330.3	2,884	13,468.3	1,393	6,505.3
Carbon	do	do	22.00	22.00	32	704.0	25	550.0	76	1,672.0	46	1,012.0
Helium	Million cubic feet	Thousand cubic feet	30.00	60.00	867	26.0	842	25.3	3,710	222.6	1,440	86.4
Hydrogen	do	do	.25	.22	2,060	515.0	2,060	515.0	....	....	15,500	3,410.0
Do	do	do	....	[6].35	.....	....	.....	....	52,530	18,385.5	.....	....
Natural gas (dry)	Billion cubic feet	do	....	[6].262	.....	....	.....	....	54,900	14,383.8	.....	....
Do	do	do	.164	.410	18,504	3,034.7	18,957	3,108.9	.....	....	34,300	14,063.0
Peat	Thousand short tons	Short ton	11.68	11.68	619	7.2	907	10.6	1,637	19.1	818	9.6
Petroleum	Million barrels	Barrel	2.81	2.90	3,879	10,900.0	4,900	13,769.0	13,000	37,700.0	5,800	16,820.0
Shale oil	do	do	3.00	3.00	(7)	(7)	(7)	(7)	2,000	6,000.0	.....	....
Thorium	Short tons	Pound	6.82	3.40	110	1.5	110	1.5	2,500	17.0	240	1.6
Uranium	do	do	9.43	20.00	10,463	197.3	2,700	50.9	51,000	2,040.0	48,100	1,920.0
Total			XX	XX	XX	18,028.1	XX	20,447.7	XX	93,959.1	XX	43,841.5

Commodity	Quantity units	Value units	Year 2000 forecast range primary demand High Quantity	High Value (million dollars)	Low Quantity	Low Value (million dollars)	1968–2000 cumulative primary demand High Quantity	High Value (million dollars)	Low Quantity	Low Value (million dollars)	Growth rate[5] (percent) High	Growth rate (percent) Low
Anthracite	Thousand short tons	Short ton	3,600	44.6	1,000	12.4	198,800	2,075.5	122,000	1,273.7	−3.2	−7.5
Bituminous coal	Million short tons	do	2,639	12,324.1	1,275	5,954.3	41,833	195,360.1	26,955	125,879.9	5.3	3.0
Carbon	do	do	60	1,320.0	36	792.0	1,300	28,600.0	700	15,400.0	2.7	.4
Helium	Million cubic feet	Thousand cubic feet	3,600	216.0	1,400	84.0	59,400	2,673.0	34,900	1,570.5	4.5	1.5
Hydrogen	do	do	.....	....	15,500	3,410.0	520,000	148,200.0	220,000	62,700.0	10.6	6.5
Do	do	do	52,530	18,385.5	.....	....	....	....	....	....	....	....
Natural gas (dry)	Billion cubic feet	do	55,700	14,593.4								
Do	do	do	.....	....	34,800	14,268.0	1,130,000	379,680.0	860,000	288,960.0	3.4	1.9
Peat	Thousand short tons	Short ton	2,400	28.0	1,200	14.0	50,000	584.0	30,000	350.4	3.1	.9
Petroleum	Million barrels	Barrel	16,400	47,560.0	7,300	21,170.0	308,000	877,800.0	195,000	555,750.0	3.8	1.3
Shale oil	do	do	2,000	6,000.0	.....	....	20,000	60,000.0	(7)	(7)	....	....
Thorium	Short tons	Pound	2,500	17.0	240	1.6	25,000	255.5	5,400	55.2	9.8	2.4
Uranium	do	do	67,000	2,680.0	61,000	2,440.0	1,530,000	45,043.2	1,191,000	35,063.0	10.2	10.6
Total			XX	103,168.6	XX	48,146.3	XX	1,740,271.3	XX	1,087,002.7	5.2	2.7

XX Not applicable.

[1] Small differences between data in this table and commodity chapters due to rounding.

[2] The range of forecast demand by end uses in many of the commodity chapters was subjected to a probability adjustment within two standard deviations about the mean. While recognizing that a totalling of the high-low ranges for competing or substitute commodities includes some further bias, this is shown to provide an order of magnitude of the probabilistic range of forecast demand by commodity groupings.

[3] Price base used in calculating energy values are described in the individual chapters.

[4] Quantity of primary minerals that would be derived from domestic sources if present primary supply-demand ratios are maintained.

[5] Growth rates for individual commodities were based on demand quantities; total was calculated on demand values.

[6] Used to calculate high values. [7] Less than ½ unit.

TABLE 2.—Rest-of-the-world demand for fuel minerals, 1968, and forecasts to the year 2000

	Quantity units	Value units	Average unit price (1968 dollars)		1968		2000				Cumulative 1968–2000			
							High		Low		High		Low	
			1968	2000	Quantity	Value (million dollars)	Quantity	Value (million dollars)	Quantity	Value (million dollars)	Quantity	Value (million dollars)	Quantity	Value (million dollars)
Anthracite	Thousand short tons	Short ton	8.48	12.40	194,000	1,645.1	135,000	1,674.0	125,000	1,550.0	5,063,000	52,857.7	4,950,000	51,678.0
Bituminous coal	Million short tons	do	4.67	4.67	1,708	7,976.4	3,400	15,878.0	2,300	10,741.0	77,300	360,991.0	63,400	296,078.0
Carbon	do	do	22.00	22.00	147	3,234.0	246	5,412.0	163	3,586.0	6,000	132,000.0	4,900	107,800.0
Helium	Million cubic feet	Thousand cubic feet	30.00	60.00	50	1.5	1,000	60.0	200	12.0	9,700	436.5	3,400	153.0
Hydrogen	do	do	.25	.22	2,995,000	748.8	...	...	24,950,000	5,489.0	600,000,000	171,000.0	330,000,000	94,050.0
Do	do	do	...	[1]1.35	...	...	63,950,000	22,382.5	...	...	...	...	...	...
Natural gas (dry)	do	do	...	[1]1.262	...	...	115,000,000	30,130.0	...	...	...	...	...	...
Do	do	do	.164	.410	10,688,000	1,752.8	...	...	70,000,000	28,700.0	1,400,000,000	470,400.0	970,000,000	325,920.0
Peat	Million short tons	Short ton	11.68	11.68	220	2,569.6	400	4,672.0	300	3,504.0	9,700	113,296.0	8,200	95,776.0
Petroleum	Million barrels	Barrel	1.80	1.80	9,900	17,820.0	55,000	99,000.0	30,000	54,000.0	865,000	1,557,000.0	590,000	1,062,000.0
Shale oil	do	do	3.00	3.00	30	90.0	1,000	3,000.0	100	300.0	7,400	22,200.0	2,000	6,000.0
Thorium	Short tons	Pound	6.82	3.40	88	1.2	5,600	38.1	1,038	7.1	59,000	603.0	17,900	182.9
Uranium	do	do	9.43	20.00	2,200	41.5	64,000	2,560.0	55,000	2,200.0	1,300,000	38,272.0	900,000	26,496.0
Total			XX	XX	XX	35,880.9	XX	184,806.6	XX	110,089.1	XX	2,919,056.2	XX	2,066,133.9

XX Not applicable. [1] Used to calculate high values.

ENERGY RESOURCES

TABLE 3.—Estimates of energy resources of the United States and cumulative demand, 1968–2000

	Estimated recoverable resources [1]			Cumulative demand, 1968–2000					
				High			Low		
Resource	Units	Quantity	Trillion Btu	Quantity	Trillion Btu	Percent of recoverable resource	Quantity	Trillion Btu	Percent of recoverable resource
Anthracite	Million short tons	[2] 6,485	167,000	199	5,000	3	122	3,000	2
Bituminous coal and lignite.	do	[3] 773,453	19,557,000	41,833	1,058,000	5	26,955	656,000	3
Petroleum [4]	Billion barrels	[5] 532	2,975,000	308	1,730,000	58	195	1,096,000	37
Natural gas (dry)	Trillion cubic feet	[6] 2,400	2,477,000	1,130	1,166,000	47	855	822,000	33
Oil in bituminous rocks.	Billion barrels	[7] 4	23,000	......	......	..	......	......	
Shale oil	do	[8] 80	464,000	20	116,000	25	0	0	0
Uranium (as U)	Short tons	[9] 552,500	[10] 325,000	1,367,824	804,000	248	1,126,992	663,000	204
Thorium (as Th)	do	[11] 527,000	[12] 2,901,000	25,000	138,000	5	5,400	28,000	1

[1] See Mineral Facts and Problems commodity chapters for data sources.
[2] At 50-percent recovery.
[3] At 50-percent recovery; approximately 928,000 at 60-percent recovery.
[4] Includes crude oil and natural gas liquids.
[5] Includes proved reserves: 30.7 billion barrels of crude oil and 8.6 billion barrels of natural gas liquids reported by the American Petroleum Institute.
[6] Includes 287.4 trillion cubic feet of proved reserves reported by the American Gas Association.
[7] An approximate average of the minimum and maximum estimates of recoverable reserves of oils in surface and near-surface oil-impregnated rocks in the United States, which are shown as 2,495 million barrels and 5,483 million barrels, respectively, in Bureau of Mines Monograph 12, page 7.
[8] At 50 percent of the in-place oil of only the shales averaging 30 to 35 gallons per ton, lying less than 1,000 feet below the surface and recoverable by the demonstrated room-and-pillar method of mining (a small portion of the deposits from which oil eventually may be extracted using other technology).
[9] Reasonably assured reserves of U_3O_8 at less than $10 per pound, contained in measured and indicated ore, are estimated at 300,000 tons; the U_3O_8 content of inferred ore deposits is estimated at 350,000 tons. Uranium content of the 650,000 tons of U_3O_8 in both categories is 552,500 tons.
[10] With present technology; theoretical maximum energy equivalent is approximately 39,000,000 trillion Btu or 39 quintillion.
[11] Reasonably assured reserves of ThO_2 at less than $10 per pound, contained in measured ore, are estimated at 100,000 tons; the ThO_2 content of inferred ore deposits is estimated at 500,000 tons. Thorium content of this 600,000 tons of ThO_2 in both categories is 527,000 tons.
[12] With present technology, theoretical maximum energy equivalent is approximately 37 quintillion Btu.

Primary production and demand for individual mineral fuels in 1968 and forecasts to the year 2000, for the United States and the rest of the world, are shown in tables 1 and 2, respectively. As indicated, the cumulative demand for major energy resources from 1968 to the year 2000 is enormous. Also, it is anticipated that world demand for major mineral fuels will exceed current levels by 2 to 5 times in the year 2000, depending upon technological, economic, environmental, and related contingencies.

In combination, there is an abundance of energy fuels throughout the world to meet all foreseeable levels of demand to the year 2000 and beyond, with the United States being adequately endowed with indigenous resources to assure self-sufficiency in this respect, either directly or through conversions. Nuclear power will improve its position tremendously in the energy system, and hydropower as we know it today will continue to provide a nominal amount of energy. Although the total of energy resources in the United States is only a relatively small part of world resources, the United States has been the most enterprising country in employing them to advance its economy and standards of living, and in upgrading and broading its fuels resource base in keeping with its technological needs.

The primary sources of energy currently consumed in the United States include petroleum, natural gas, bituminous coal and lignite, anthracite, hydropower, and uranium. Minor sources include wood and geothermal steam. Oil shale may become an important source of oil and gas, though it does not yet supply any of the domestic energy consumed commercially. Solar energy, the greatest source of heat, is yet unharnessed except on a very limited scale. The fossil, or hydrocarbon, fuels are by far the largest contributors of energy in the United States, at present supplying approximately 96 percent of the Nation's gross energy inputs. The balance is provided largely by hydropower, and nuclear plants supply a very small amount. In addition, a small percentage of fossil fuels is used as a source of raw materials.

The possible range in cumulative domestic requirements for each of the major energy resources during the period between 1968 and the year 2000 is indicated in table 3. The high and low ranges were estimated on the basis of contingency forecasts of the impact of technological, environmental, economic, social, and related factors on the demand for the respective resources, with their major end uses.

The estimated recoverable resources available at current prices with today's technology in both the United States and the rest of the world are ample in total to meet all foreseeable energy requirements to the year 2000 and well beyond. Technologic advances are anticipated that could substantially increase the amount of economically recoverable resources. The technological factors that may have the most pronounced effect upon individual fuel supplies are the rate of development of fast breeder nuclear reactors to improve fuel consumption and electricity generation efficiency, continued mechanization and advanced mining and transportation systems in coal mining, new or improved exploration and recovery methods for petroleum and natural gas exploitation, and altered energy forms such as the production of synthetic gas from coal.

There is a high degree of potential substitutability among the various fuels, and new or improved conversion and utilization technologies are expected to change the quantities and forms in which fuels are used. Conversion of solid and liquid fuels to electricity and gas will be accelerated by the development of improved electric generation methods, gas synthesis processes, and fuel cells. Development of an electric car as a substitute for the internal combustion engine and increased use of direct reduction processes and electric furnaces in place of coke in iron and steel making are examples of utilization technologies that may have a profound impact on individual fuels.

Increasingly, environmental and social considerations can be expected to constrain the supply and limit the use of direct fuels to those that are nonpollutant. Land use and ecological considerations may restrict strippable coal supply. Increased concern with health and safety standards in mining will accelerate mechanization. In turn, demands for skilled in place of unskilled labor may present manpower problems of such magnitude that coal output is constrained.

Other factors influencing domestic fuels supply are changes in supply sources. New discoveries of large petroleum and natural gas resources in Alaska, increased exports of coking quality coals, and greater imports of petroleum and natural gas, including liquefied natural gas, are examples of recent developments. Imports of petroleum, natural gas, and uranium, all of which are more abundant in foreign countries, are expected to become more important as supplemental supply sources. The level of imports is subject to Government regulations, and changes in the present oil import program are under consideration. Drastic changes would produce substantial impacts on individual fuel markets, such as electric power generation on the east coast.

As we move into the 21st century, energy systems will depend less on fossil fuels and more on natural heat and power forces. The sun, the oceans, and geothermal heat will emerge as viable sources of energy.

The energy market constitutes four major consumer sectors: Transportation, industrial, household and commercial, and electricity generation (utilities). Table 4 shows energy consumption in the United States, by these major consumer classifications, and energy sources in 1968 and contingency forecasts for the year 2000.

In 1968, the percentages of total gross energy utilization (62,424 trillion Btu) contributed by the respective energy sources, by market sectors, were as follows:

Energy source	Percent			
	Household and commercial	Industrial	Transportation	utilities Electric generation,
Oil	48	23	96	8
Natural gas	48	48	4	23
Coal	4	29	–	51
Hydropower	–	–	–	17
Nuclear	–	–	–	1
Total	100	100	100	100

The relative position of electricity in the energy mix has increased in the last two decades at the expense of direct fuel use. This is demonstrated by the following tabulation of the percentage distribution of energy resource use by form:

Form	Percent	
	1948	1968
Direct fuels [1]	82	72
Utility electricity generation	14	23
Raw materials	4	5
Total	100	100

[1] Includes miscellaneous and unaccounted for.

The consumption of energy resources as raw materials for the production of petrochemical feedstocks, asphalt, road oils, lubricants, and miscellaneous products is growing both absolutely and as a percentage of the total, with petrochemical feedstocks the dominate use.

Whereas coal was the major fuel source at the beginning of the century in the United States, and continues to be in most world areas, petroleum and natural gas became the dominant sources of overall energy supply in the United States before midcentury. This shift was in response to the changing nature of steadily increasing demand (which increased 84 percent between 1948 and 1968) as reflected by the phenomenal growth requirements for gasoline and related products, overriding factors of convenience, and new technologies of energy utilization that tended to discount cost differentials.

By the year 2000, total energy consumption is expected to increase from the 1968 level of 62 quadrillion Btu to a range of 166 to 239 quadrillion Btu. The low and high forecasts presented in table 4 for the supply of and demand for the respective energy sources in the year 2000 are based on a variety of contingency assumptions and adjustments that are explained in the individual commodity chapters.

As indicated in table 4, the growth in demand for electricity generation by utilities is expected to be the major phenomenon in the energy market. This is particularly apparent when

TABLE 4.—Consumption of energy resources by major sources and uses, 1968 and contingency forecasts for year 2000

End uses	Direct resources inputs: Anthracite, Thousand short tons	Anthracite, Trillion Btu	Bituminous coal and lignite, Thousand short tons	Bituminous coal and lignite, Trillion Btu	Natural gas, dry[1], Billion cubic feet	Natural gas, dry[1], Trillion Btu	Petroleum[2], Million barrels	Petroleum[2], Trillion Btu	Total (Trillion Btu), Unadjusted	Total (Trillion Btu), Adjusted	Nuclear power[3], Billion kwhr	Nuclear power[3], Trillion Btu	Hydropower (plus imports)[3], Billion kwhr	Hydropower (plus imports)[3], Trillion Btu	Total gross energy inputs (Trillion Btu Adjusted)[4]	Utility electricity[5] generated and distributed, Billion kwhr	Utility electricity[5] generated and distributed, Trillion Btu	Total three sector inputs (Trillion Btu)[6]
Household and commercial:																		
1968 p	4,759	120	15,224	447	6,251	6,451	1,149	6,581	13,599	......	......	......	.....	.....	13,599	723.0	2,467	16,066
2000:																		
Low range	75	2	......	....	13,800	14,242	318	1,992	16,236	21,142	......	......	.....	.....	21,142	6,127.0	20,906	42,048
High range	500	13	335,000	8,790	22,227	22,938	2,440	13,940	45,681	40,774	......	......	.....	.....	40,774	6,929.0	23,643	64,417
Industrial:																		
1968 p	(3,152)	(80)	(188,450)	(5,536)	(8,971)	(9,258)	(812)	(4,474)	(19,348)	......	......	......	.....	.....	(19,643)	(598.3)	(2,044)	(21,687)
2000:																		
Low range	(850)	(21)	(88,674)	(2,399)	(15,930)	(16,440)	(1,445)	(7,367)	(26,227)	(32,982)	......	......	.....	.....	(32,964)	(3,285.4)	(11,210)	(44,174)
High range	(2,850)	(72)	(744,602)	(20,127)	(21,097)	(21,772)	(4,882)	(24,783)	(66,754)	(59,999)	......	......	.....	.....	(59,996)	(3,715.4)	(12,677)	(72,673)
Food and kindred products:																		
1968 p	.....	...	8,480	260	575	593	22	134	987	......	......	......	.....	.....	987	35.9	123	1,110
2000:																		
Low range	.....	...	1,200	32	1,205	1,244	3	17	1,293	1,535	......	......	.....	.....	1,535	188.7	644	2,179
High range	.....	...	24,288	653	1,710	1,765	58	331	2,749	2,506	......	......	.....	.....	2,506	213.7	729	3,235
Paper and allied products:																		
1968 p	.....	...	14,888	460	330	341	35	211	1,012	......	......	......	.....	.....	1,012	29.9	102	1,114
2000:																		
Low range	.....	...	7,550	204	830	857	5	27	1,088	1,321	......	......	.....	.....	1,321	169.7	579	1,900
High range	.....	...	34,300	926	1,080	1,115	77	445	2,486	2,253	......	......	.....	.....	2,253	192.2	656	2,909
Chemicals and allied products:																		
1968 p	.....	...	21,483	659	1,181	1,219	302	1,426	3,304	......	......	......	.....	.....	3,304	173.5	593	3,897
2000:																		
Low range	.....	...	20,000	540	3,405	3,514	944	4,336	8,390	11,169	......	......	.....	.....	11,169	953.7	3,254	14,423
High range	.....	...	247,314	6,675	3,630	3,746	3,172	14,638	25,059	22,281	......	......	.....	.....	22,281	1,078.2	3,679	25,960
Petroleum refining and related industries:																		
1968 p	.....	...	......	....	981	1,012	264	1,589	2,601	......	......	......	.....	.....	2,601	23.9	82	2,683
2000:																		
Low range	.....	...	......	....	1,820	1,878	394	2,393	4,271	5,314	......	......	.....	.....	5,314	132.2	451	5,765
High range	.....	...	72,577	1,952	3,250	3,354	860	5,222	10,528	9,486	......	......	.....	.....	9,486	149.5	510	9,996

Stone, clay, glass, and concrete products:																		
1968 p			13,003	404	435	449	14	87	940	.....	.....	.....	....	....	940	29.9	102	1,042
2000:																		
Low range			10,000	270	1,020	1,053	2	10	1,333	1,566	.....	.....	....	....	1,566	160.6	548	2,114
High range			36,572	987	1,510	1,558	32	184	2,729	2,496	.....	.....	....	....	2,496	181.4	619	3,115
Primary metal industries:																		
1968 p	1,280	32	99,313	2,785	836	863	59	306	3,986	.....	.....	.....	....	....	3,986	137.6	469	4,455
2000:																		
Low range	675	17	29,500	802	1,540	1,589	23	138	2,546	3,588	.....	.....	....	....	3,574	755.2	2,577	6,151
High range	2,600	66	180,200	4,901	2,130	2,198	277	1,638	8,803	7,760	.....	.....	....	....	7,757	854.0	2,914	10,671
All mineral and other manufacturing industries:																		
1968 p	1,872	48	31,283	968	4,633	4,781	116	721	6,518	.....	.....	.....	....	....	6,518	167.6	573	7,091
2000:																		
Low range	175	4	20,424	551	6,110	6,305	74	446	7,306	8,489	.....	.....	....	....	8,485	925.3	3,157	11,642
High range	250	6	149,351	4,033	7,787	8,036	406	2,325	14,400	13,217	.....	.....	....	....	13,217	1,046.3	3,570	16,787
Transportation: [7]																		
1968 p			417	12	591	610	2,699	14,514	15,136	.....	.....	.....	....	....	15,136	5.3	18	15,154
2000:																		
Low range			......	....	1,700	1,754	5,443	30,464	32,218	36,359	.....	.....	....	....	36,359	28.4	97	36,456
High range			380,000	9,956	2,800	2,890	7,890	44,221	57,067	52,927	.....	.....	....	....	52,927	32.2	110	53,037
Electricity generation, utilities: [5]																		
1968 p	2,203	57	294,739	7,074	3,144	3,245	188	1,181	11,557	.....	12.3	130	222.9	2,359	14,046	[9] 1,327.6	4,529	.....
2000:																		
Low range	75	2	845,000	20,282	3,370	3,478	137	861	24,623	29,505	5,421.8	[8] 40,965	632.0	5,056	75,526	[9] 9,441.0	32,213	.....
High range	250	6	1,520,000	36,480	9,576	9,882	1,200	7,544	53,912	49,029	3,614.6	[8] 31,327	632.0	....	......	......	.....	.....
Miscellaneous and unaccounted for: 1968 p	46	1	......	....	.....	.....	52	294	295	.....	.....	.....	....	....	......	......	.....	.....
Total gross energy inputs:																		
1968 p	10,160	258	498,830	13,069	18,957	19,564	4,900	27,044	59,935	.....	12.3	130	222.9	2,359	62,424	......	.....	52,907
2000:																		
Low range	1,000	25	933,674	22,681	34,800	35,914	7,343	40,684	99,304	119,988	5,421.8	40,965	632.0	5,056	165,991	......	.....	122,651
High range	3,600	91	2,980.102	75,353	55,700	57,482	16,412	90,488	223,414	202,729	3,614.6	31,327	632.0	5,056	239,109	......	.....	190,127

p Preliminary.

[1] Excludes natural gas liquids.

[2] Petroleum products including still gas, liquefied refinery gas, and natural gas liquids.

[3] Represents outputs of hydropower and nuclear power converted to theoretical energy inputs at the prevailing average heat rate at central electric stations. Excludes inputs for power generated by nonutility plants which are included within the other consuming sectors.

[4] Gross energy is that contained in all types of commercial energy at the time it is incorporated into the economy, whether energy is produced domestically or imported. Gross energy comprises inputs of primary fuels (or the derivatives) and outputs of hydropower converted to theoretical energy inputs. Gross energy includes energy used for production, processing, and transportation of energy proper. Industrial sector includes 295 trillion Btu "Miscellaneous and unaccounted for."

[5] Utility electricity, generated and imported, distributed to the other consuming sectors as energy resources inputs. Distribution to sectors is based on historical series in the Edison Electric Institute Yearbook. Conversion of electricity to energy equivalent by sectors was made at the value of contained energy corresponding to 100-percent efficiency using a theoretical rate of 3,412 Btu per kilowatt-hour.

[6] Energy resource inputs by sector, including direct fuels and electricity distributed. Industrial sector includes 295 trillion Btu "Miscellaneous and unaccounted for."

[7] Includes bunkers and military transportation.

[8] Adjusted from 43,374 and 28,917, respectively.

[9] Average heat rates: 10,582 Btu/kwhr in 1968; 8,000 Btu/Kwhr the year 2000.

energy inputs to the three consuming sectors are adjusted to include purchased electricity distributions as shown in the last column in the table. It is estimated that total gross energy inputs into electric power generation will increase between 400 and 500 percent between 1968 and the year 2000.

Among the many factors supporting these estimates are heavily increasing demands for air conditioning, acceleration in the shift by many industries from the self-generation of power to purchased electricity, and dynamic technological progress in electronics and in the development of new uses for electricity in homes and businesses.

Principal among the influencing factors on power generation will be tremendous growth in nuclear energy, from 130 trillion Btu in 1968 to an estimated range of 31,327 to 40,965 trillion Btu in year 2000. The timing, extent of growth, and relative efficiences in nuclear generation in relation to total energy demand will strongly influence the extent of interchangeability among the respective energy sources in meeting total requirements.

The changing role of fossil fuels in electric power generation will depend substantially on nuclear technology. Based on differences in contingency assumptions in this respect, the adjusted percentage participation of the respective energy resources as inputs to power generation will be as follows:

Source	1968	2000 Low fossil	2000 High fossil
Nuclear	1	54	37
Coal	51	30	40
Natural gas	23	6	10
Oil	8	3	8
Hydropower	17	7	5
Total	100	100	100

Notwithstanding an anticipated phenomenal increase in the utilization of nuclear energy, oil and natural gas will be the predominant energy sources. Petroleum will continue to be the largest single source of primary energy throughout the balance of the century, principally because of heavy demands in the transportation market and for petrochemical feedstocks. In the low range of estimated total demand, natural gas follows closely as a source of energy; however, it is exceeded by coal in the high range of demand. Coal's position in the high range results from the inclusion of approximately 30,000 trillion Btu in coal equivalent of synthetic fuels that could be required, in addition to synthetic fuels from oil shale, to supplement supplies of conventional oil and gas.

In summary, future energy supply and demand will be characterized by significant shifts in the nature of the energy mix. These shifts will be influenced by the rate of total energy growth, the relative availabilities of the respective energy sources, their cost-price relationships, and changes in technologies of production, distribution, and utilization of the respective sources. The major tasks ahead for the resolution of energy problems are those related to (1) the need for new technologies to improve the efficiencies of present conventional energy systems, (2) the need to improve production and use of energy fuels to meet urgent requirements to end or drastically reduce air and water pollution and other environmental concerns, and (3) the need to develop entirely new energy systems because of possible limitations of the resource base and efficiencies of conventional systems.

[From the Congressional Record]

Remarks by Rogers C. B. Morton, Secretary of the Interior, at a Meeting of the Interstate Mining Commission, Lexington, Ky., October 21, 1971

It was a most fortunate day . . . April 27th of this year . . . when officials from Kentucky, North Carolina, Oklahoma, and Pennsylvania met at Raleigh to create this interstate body that is committed to improving surface mining and other practices of mineral extraction.

The Interstate Mining Commission came about because of initiative exercised by these states.

While the powers of the Commission are of a recommendatory, consulting nature, its very existence can foster many needed changes in the practices and conditions of the mineral industry.

The membership of your Commission seems likely to increase . . . and I sincerely hope that it will. I know during your founding meeting at Raleigh, you urged all other states that have surface mining operations to give serious consideration to joining your compact. Keep after them.

The increasing demand for coal and other minerals and the industry's improved recovery ability have increased mining activity, especially in strip mining. This industry is an important link in our economy, but we must realize that it is capable of disastrous effects upon the environment.

It is the surface mining industry that, in the future, will provide a strong domestic mineral supply base and prevent our dependence on foreign sources of mineral raw materials from becoming dangerously large or prohibitively expensive.

Surface mining in 1969 accounted for 94 percent of all domestic production of crude metallic and nonmetallic ores: 2.45 billion tons compared with 165 million tons from underground mines.

Approximately 38 percent of all coal in 1969 came from surface mines. Preliminary data for 1970 indicates that this figure has risen sharply to 44 percent.

On a comparison basis, surface mines in 1969 produced 218 million tons and 269 million tons in 1970. Underground mines produced 347 million tons in 1969 compared with 338 million tons in 1970. Only the sharp increase in surface-mined coal enabled the industry to meet demand last year.

Many in the coal industry are saying that surface mining in 1971 will overtake underground mining and that—for the first time in history—more coal will come from above ground than below.

That prediction could very well come true. If surface mining doesn't overtake underground mining in 1971, it seems bound to occur soon.

While we find ourselves in a period of expanded reliance on surface mining, we are also, in 1971, facing an environmental imperative.

More than three million acres of land have been disturbed by surface mining and approximately 150,000 acres are added each year. If the trend continues, by 1980, some 5 million acres will have been affected by mining activity. Much of this acreage has been rendered inaccessible, unsightly and disgraceful.

Drainage is one of the terrible penalties of surface mining. Our lakes and streams become polluted when acid mine drainage, leaching liquors, processing plant chemicals and mine waters with high iron content are released untreated to local water systems.

Runoff from denuded surface-mined land and mine waste accumulations cause siltation of stream channels and possible flooding in affected drainage basins.

Stagnant water in strip pits is a breeding ground for insects and a hazard to public safety.

As of 1967, surface and other forms of mining had adversely affected fish and wildlife habitat in 13,000 miles of streams . . . 281 natural lakes . . . and 168 reservoirs and impoundments.

In 1969, the stripping of overburden and the removal of ore by surface mining in 20,314 active surface mines disturbed an estimated 193,000 acres of land. About 38 percent—73,000 acres of this land—was disturbed as the result of coal mining activity. It is estimated that coal mining disturbed 90,000 acres in 1970.

This is an absolutely abhorrent form of land use which should not be tolerated.

The land is our greatest resource. We are merely temporary tenants upon a good earth which will remain a hundred thousand years after we're gone. A lot of folks will want to use it in that time, so, while we are in custody of it, nothing but the highest forms of stewardship should be acceptable.

I believe, in 1971, that the environmental disturbances engendered by unrestrained mining practices are neither inherent in the mining process, or an economic necessity. I also know that, with proper controls and enforced reclamation, adverse environmental effects can be minimized and held well within acceptable limits.

PRESS SERVICE NATIONAL COAL ASSOCIATION

Coal Building | 1130 Seventeenth Street, Northwest | Washington, D. C. 20036 | NAtional 8-4322

(For Thursday a.m.'s, Sept. 16)

SURFACE-MINED COAL IS USED TO GENERATE ALMOST ONE THIRD OF NATION'S ELECTRIC POWER, COAL EXECUTIVE SAYS

WASHINGTON, Sept. 15--Surface-mined coal is used to generate almost one third of the electric power that lights, heats and cools homes, business and industrial enterprises throughout the country, Carl E. Bagge, president of the National Coal Association, said today.

The electric utilities are the heaviest users of coal in the nation, Mr. Bagge pointed out, relying on it for half of their steam-generating capacity. A survey just completed by NCA economists shows that coal recovered by surface mining made up 44 per cent of the nation's total bituminous and lignite coal production in 1970, and three fourths of this surface-mined coal went to electric utilities.

"It should be clearly understood that many major electric utilities would be in bad shape for fuel supplies if there were to be a serious interruption in surface mine production," Mr. Bagge said. "It is not stretching the facts in any way to say that without coal from surface mines, brownouts and even blackouts would be inevitable in many heavily populated areas."

The NCA study of coal distribution from surface mines was made in preparation for hearings before the Mines and Mining Subcommittee of the House Interior Committee next week on proposals for Federal regulation of strip mining. Mr. Bagge reiterated that the Association he heads is not opposed to legislation requiring surface-mine operators to meet federal standards in land reclamation, but wants to leave the primary job of developing specific regulations to the states because of variations in climate and typography.

"We recognize that federal standards are needed," Mr. Bagge said, "but the study just completed by our staff shows how utterly ridiculous it would be for Congress to give serious consideration to prohibiting surface mining altogether, as some members of Congress have advocated, especially since the technology exists to achieve effective reclamation."

Mr. Bagge made public these results of the study:

1. Surface-mined coal production totaled 264 million tons in 1970, or 44 per cent of the total 602.9 million tons of bituminous and lignite coal production.

2. Approximately 198 million tons--75 per cent--of the 264 million tons produced by the surface mining method went to U.S. electric utilities for power production. This 198 million tons amounted to 60 per cent of total shipments of 331 million tons to the electric utilities in 1970 from all bituminous and lignite coal mines.

3. The 198 million tons of surface-mined coal is the equivalent of some 431.8 billion kilowatt hours of electricity. This would represent 28.2 per cent of total electric energy production of 1,529.6 billion kilowatt hours in 1970. Surface-mined coal was 23 per cent higher in 1970 than in 1969, while underground production decreased 2.4 per cent in 1970 compared with 1969. Further increases in surface mine production in 1971 are indicated.

4. The 431.8 billion kilowatt hours also is the equivalent of the output of some 62 nuclear generation plants of 1,000 megawatts each, operating at 80 per cent of plant capacity. The 198 million tons of surface-mined coal is the equivalent of 33.7 per cent of the 1,282.3 billion kilowatt hours produced by all fuels, including nuclear power.

5. The 431.8 billion kilowatt hours of electricity is approximately the same as the total 1970 generation of electricity in the New England, South Atlantic and East South Central census regions (18 states and the District of Columbia).

Mr. Bagge said that 264 underground mines of one million tons annual capacity each would be required to produce the coal that came from surface mines in 1970. The capital cost of 264 underground mines would be from $3.2 to $3.7 billions, Mr. Bagge said, and the time required to build them would be a minimum of three to five years--if the capital and the manpower were available.

Underground mines employed some 100,500 men in 1970, compared with 24,800 in surface mines. It would cost an additional $500 million to produce underground the coal that came from surface mines in 1970, Mr. Bagge said.

NATIONAL COAL ASSOCIATION
COAL BUILDING
WASHINGTON, D. C. 20036

FACT SHEET ON U.S. SURFACE-MINED COAL IN 1970

1. In 1970, surface-mined coal production totaled 264.1 million tons, or some 44 percent of the total of 602.9 million tons of bituminous and lignite coal production.

2. The 1970 production of 264.1 million tons from surface mines was up 50.8 million tons, or 23.8 percent over the 1969 production of 213.4 million tons. The 1970 production of 338.8 million tons from deep mines was down 8.3 million tons, or 2.4 percent, from the 1969 level of 347.1 million tons.

3. Approximately 198,015,000 tons, or some 75 percent of the 264.1 million tons of surface-mined coal produced in 1970, were shipped to U.S. steam-electric utilities.

4. The 198 million tons amounted to 59.8 percent of some 331.4 million tons of 1970 bituminous coal and lignite production shipped to U.S. electric utilities.

5. The 198 million tons of surface-mined coal shipped to the utilities represents the equivalent of some 431.8 billion kilowatt-hours of electricity which, when compared with the actual 1970 experience, would amount to:

   a. 28.2 percent of total electric energy production of 1,529.6 billion kwhrs.

   b. 34.3 percent of 1,259.5 billion kwhrs produced by fossil fuels (excludes hydro and nuclear).

   c. 33.7 percent of 1,282.3 billion kwhrs produced by all fuels, including nuclear power.

6. The estimated 431.8 billion kwhrs of generation from surface-mined coal closely approximates the total 1970 generation of electricity in the New England, South Atlantic and East South Central Census Regions (18 states and the District of Columbia).

7. The estimated 431.8 billion kwhrs generation from surface-mined coal is the equivalent of the output of some 62 nuclear generation plants of 1,000 MW capacity each, operating at 80 percent of plant capacity.

8. In barrels of oil equivalent (converted on basis of 24 million Btu/ton of coal and 6.3 million Btu/bbl of oil):

a. 198 million tons of surface-mined coal equals some 752.5 million bbls of imported oil valued at $2.3 billion, on basis of $3 per bbl.

b. 264.1 million tons of surface-mined coal equals some 1,003.7 million bbls of oil valued at over $3 billion.

9. Some 264 deep mines (of 1 million tons annual capacity) would be required to produce the 264.1 million tons of coal produced by surface mines in 1970.

10. The capitalization cost of 264 new deep mines would range from some $3.2 billion to $3.7 billion ($12 to $14 per ton of annual capacity).

a. It requires approximately 3 to 5 years for a new deep mine to reach full production.

11. In 1970 the approximate number of workers at bituminous coal and lignite mines (excluding mill workers) was: Deep mines, 100,500; surface mines, 24,800. (Preliminary data from Office of Accident Analysis, U.S. Bureau of Mines.)

12. Underground production of bituminous and lignite coal in 1970 totaled 338,788,000 tons. (338,788,000 tons divided by 100,500 average men working daily (excluding mill workers) equals 3,371 tons per man per year.)

13. Some 78,358 deep mine workers (excluding mill workers) would be required to produce 264.1 million tons of coal (on basis of 1970 experience).

14. Assuming that all surface mine workers (24,800) would accept employment at deep mines, an additional 53,558 miners would be required to produce 264.1 million tons of coal.

15. On a 1970 basis, the estimated wages and salaries (including vacation and holiday pay) of mine production workers (including supervisors and on-site office workers and excluding mill workers) required to produce 264.1 million tons of coal would be:

a. Deep mines: $745 million

b. Surface mines: $248 million

16. On basis of Item 15, it would cost an additional $497 million in wages and salaries to produce the 264.1 million tons (of surface-mined coal) at deep mines. (Increased cost of some $1.88 per ton in additional wage and salary expense.)

[From Field & Stream, August 1971]

LET'S LOOK TOWARD AN EARLY END OF STRIP MINING

(By Richard Starnes)

URIAH HEEP is literature's preeminent hypocrite—a meaching, unctuous dissembler, a hand-washer who pretends to be a forthright and upstanding guy but who is really a crook and a moral leper. It may seem more than a bit strange to start off a piece about TVA and the strip miners by alluding to old Uriah, but in fact the Tennessee Valley Authority and Dickens' celebrated rogue have certain startling similarities.

Both pretend to piety and good works, and both are double-dyed villians. In short, both are terrible hypocrites.

In all the calamitous national scandal of strip mining, there is a gaudy array of malefactors, to be sure. But none quite touches TVA for the wicked role it has played. It is the worst not only because it is by far the world's largest user of strip-mined coal, but perhaps even more because it traditionally pretends to be on the side of the conservationist, ecologically-right-with-God angels.

I know of no worthwhile estimate of how many thousands upon thousands of hillside acres have been destroyed to fill TVA's insatiable furnaces. But its current "burn" is on the order of 31 million tons of coal a year—all of it strip mined.

And before we get into TVA's self-serving arguments for the defense, let us finally agree on one central fact about strip mining: There is no effective means of reclaiming or restoring the typical strip-mine site.

Except for a handful of essentially phony showpiece restorations, the prevailing custom among strip miners is to leave the ghastly scars in the earth pretty much the way they were when the last truckload of coal was removed—easy prey to erosion and to acid water runoffs that poison whole watersheds.

"Like putting lipstick on a corpse," is how current strip-mine reclamation efforts were described to me on a recent trip to West Virginia.

Look at the figures. The Bureau of Mines in 1965 said that over 1.3 million acres in the United States had been stripped by coal operators. Now the Bureau estimates that over the last six years another 480,000 acres have been stripped—but that only 56,000 acres have been reclaimed. It's a mighty dismal picture.

Until 1965 TVA didn't even pay lip service to restoring the land that had been destroyed to get it cheap coal. Then, in response to the outraged howls of a few journalists (of whom I am proud to say I was one) TVA grudgingly wrote a restoration clause into its procurement contracts. It was a sick joke then and it is a sick joke now, for most authorities at long last have agreed that even if good will and a willingness to pay the price are present, it just isn't possible to undo the horrible affronts to nature that are routinely committed by the strip miners.

But TVA's propaganda apparatus is almost as considerable as its steam plants, and for a time about 1965 it got away with pointing to the come-lately reclamation clause in its coal contracts. Look a-here, their flacks would declaim, we got it writ into our contracts. Don't you pay no mind to what some roughneck reporter is writing.

Weary and angered by it all, three environmental organizations recently filed a Federal lawsuit accusing TVA of ignoring environmental protection standards in contracting for strip-mined coal. They were joined by Harry Caudill, a Kentucky lawyer and author, who has fought a hard battle to save the mountains he loves.

Citing "the systematic destruction of mountains and countryside," the suit asked the U.S. District Court for the Southern District of New York to find that TVA had "blatantly" broken the National Environmental Policy Act of 1969.

There is no denying that TVA reservoirs have provided a lot of recreation over the years. Now, however, even some of the agency's best friends are scratching their heads in disillusionment at the overpowering environmental damage it has caused.

TVA has run the whole gamut of arguments to defend its role in strip mining. But all of them collapse because ultimately people go and look at the land still being ruined despite the 1965 reclamation clause. So now, after decades of oleaginous writhing that would have done credit to old Uriah himself, the great strip-mine conspiracy has arrived at its last line of defense:

The nation, goes thc ultimate argument, is deep in the throes of an energy crisis (that is to say a shortage of electricity) and hence any evil can be condoned if it produces more coal for the steam plants of TVA and other power companies.

I think it is possible to demonstrate that the energy crisis is largely boloney, a sausage having the aroma of fine old gorgonzola that has been contrived by the philosophers of strip mining and off-shore oil drilling, the oil import quota entrepreneurs, and other such high-minded chaps.

But, temporarily and for the sake of argument only, let us assume that there is an energy crisis, or that there soon will be one. It seems to me that the answer to the profligately wanton use of electricity for which America is noted is to reduce the amount of electricity we use—and often waste—not to destroy the very earth we live on in an attempt to meet ever-expanding demands for power.

No other people are as hooked on bright lights as we are. Big cities like London do have their bright spots but they do not have the endless miles of garish neon highways spoking away in every direction. Outside this country, it is rare to find homes heated by electricity. The household appliances that Americans take for granted are still novelties to most of mankind. And even if we do continue to give the strip miners carte blanche to rape our mountains, can we meet the insatiable demand for electrical energy that will be heard if our present habits carry over to a population that some soothsayers claim will double in three or four decades?

Of course not. Sooner or later the nation will have to adopt a more rational energy policy. Unless this is done, we will likely have no real means of defending the land against the depredations of the strippers.

But those steps, in my judgment, lie somewhere in the future. For now it should be sufficient to show that the energy crisis is a cynical ploy that is being attempted to serve wicked ends.

The fact is that we are still a coal *exporting* nation, particularly to Japan. I am indebted to one of TVA's prime propaganda organs, its quarterly (mailed free at taxpayers expense, by the way) called Tennessee Valley Perspective, for informing me that Tennessee Consolidated Coal Co. has contracted to sell up to a million tons of coal mined in Marion, Grundy and Sequatchie counties to the Japanese metallurgical industry. There is also at least one $1.6 million contract to ship West Virginia coal to Japan.

At long last, constructive action may be forthcoming from Washington. In late 1969 Congress forced coal men for the first time to provide honestly for the safety and health of their workers. Now at least half a dozen bills have been introduced to deal with the strip-mining scourge. The toughest of them all, and very possibly the best, sponsored by Representative Ken Hechler, of West Virginia, has attracted more than sixty-five co-sponsors in the House and is picking up support in the Senate as well.

Hechler's bill, HR 4556, is unique. It would ban all strip mining within six months. Strong medicine? Sure, but that's what is called for to save the patient. As the determined West Virginia legislator—the environmental "doctor" of the case—aptly analyzes the disease: "Billions of tons of valuable topsoil, trees, rocks, the habitat for wildlife and the hills themselves are being chewed and churned up because it's so cheap to make a quick killing when you can pass the environmental costs on to future generations."

The blunt fact is that strip mining is an earth cancer that is spreading at an ever faster rate. It can't be cured by cosmetics any more than it can be hidden any longer by lies. It needs to be stopped entirely, and those of us who want to stop it had better want to hard enough to ask our people in the Congress where they stand. The good life you save will be your own.

[From Massachusetts Audubon Newsletter, April 1971]

SOCIAL COSTS OF ENERGY

There are few issues that are more likely to divide the industrial community from those whose primary concern is environmental quality than the problems associated with the increasing production of energy and goods in the U.S. today. The problem is summarized in the recent report of the National Goals Research Staff:

> America appears to be at a point of profound change, frequently characterized as that from an industrial society to a "post industrial society" – from a society in which production of goods was of primary concern to one dominated more by services and the generation and use of new knowledge.[1]

We shall discuss some aspects of this problem, namely, the factors that encourage wasteful use of energy, and some of the social and environmental costs that should be included, but presently are not, in the total cost of energy.

The Role of Energy

It has been stated that availability of large amounts of concentrated energy has been a most important factor in the evolution of modern industrial society. As per capita consumption of energy has grown over the past two centuries so has the Gross National Product.

Growth in production and services seems to be, at least psychologically, one of the cornerstones of our economic system. It is therefore not surprising to find that the growth of energy production has been promoted not only by the federal government, but also by state and local governments. At a recent meeting of the American Institute of Chemical Engineers, Mr. Robert Jaske, a leading engineer in the area of heat rejection problems, summarized the situation:

> In the long run, the solution [to the heat rejection problems] may lie in a complete reevaluation of the use of energy . . . the time has come for serious examination of national energy policy on a broad front. Such an examination will discover early that the primary motivating force in the expansion of the use of energy has been the subsidization policy of the federal government.[2]

A similar view is expressed in the recent report *Electric Power and the Environment*, prepared by the Energy Policy Staff of the Office of Science and Technology:

> There are numerous statutes enacted over the past few decades which expressly state a U.S. government policy of promoting low energy costs. This policy affects not only the pricing of electricity generated by federally owned entities but the policies of federal regulatory agencies and recipients of federal loans as well. These policies should be reconsidered to assure that they are best adapted to the future needs of the Nation.[3]

Nor are the policies of low energy rates the only mechanisms used to subsidize cheap energy. By failing to enforce air and water pollution regulations both federal and state governments are indirectly promoting the growth of consumption of energy and goods. Such growth occurs, however, at the cost of both the health of industrial workers and those persons living near major polluters, and the gradual deterioration of the quality of life. There is, moreover, a feedback effect at work: the more that pollution is allowed in the production of goods the faster the goods will deteriorate and therefore have to be replaced by new ones. Pollution then favors both "conspicuous consumption" and "accelerated obsolescence."

Social Costs of Energy Production

One of the major reasons that pollution has been allowed to advance to its present state is that its harmful effect on man, vegetation, and materials are not clearly recognized by the public. Ralph Nader has characterized air pollution as a form of "subtle violence," meaning that it is administered over a long period, frequently at moderate doses. Regrettably too many of us have unconsciously "adapted" to these levels of pollution. The effects are not directly associated in space and time with the sources, and as a result both the public and our governments tend to recognize only the benefits of energy consumption and not its costs.

Nor are all the environmental costs of pollution known to either scientists or economists. In fact, few economists seem to have taken interest in the problem, and then at the risk of being chastised by colleagues for making assumptions that may not be entirely realistic. As a result almost all economic estimates of environmental damage are characterized by their authors as being "conservative" and probably vastly underestimating the true costs.

For the most part no economic price tag can be placed on the emerging man-made effects on the global environment. For example with the atmosphere, global trends are imperfectly understood. There always have been naturally occuring changes in global climate which complicate the analysis of man's impact. Volcanoes, in particular, can cause these changes rather quickly.[4] What is of concern now is that man-made activities, particularly those associated with energy production through combustion, are of sufficient magnitude to explain presently occurring trends.[5] If future research shows this definitely to be the case we shall be faced with a new sort of "cost-benefit" analysis. What price shall we place on the loss of lands to deserts or to the melting of ice caps resulting from a rise in global temperature? Or, conversely, would we rather try to calculate the cost of a drop in the earth's temperature from failing to control particulate air pollution:

> As civilization continues to contaminate the atmosphere, the number of small, dust-like particulate pollutants in the air steadily increases. Calculations done at the Environmental Science Services Administration (ESSA) indicate this steady increase of particulate matter in the atmosphere may ultimately create eternal winter on earth.[6]

The assessment of the costs and benefits of possible global changes in the environment is beyond the scope of this paper. We have tried to stress that such effects are real and they will have to be considered in the not too distant future.

There are other, more tangible and more apparent, undesirable side effects of energy production which are beginning to receive serious attention because of the increase in public concern over environmental quality. The extent to which the public will support the financial programs needed to control these unwanted or second-order effects depends on how the costs are presented. If they are viewed in isolation, with no reference to the other legitimate costs of energy such as fuel transportation and refining, they will be accepted within a narrow framework of "improving the environment" or perhaps "preventing pollution." It would be far preferable to accept these costs as part of the overall price of living in a highly technological society while at the same time maintaining a viable environment.

Social Costs of Energy Production from Fossil Fuels

At present almost 96 percent of the energy demands of the United States are met through burning fossil fuels. Nuclear power which is used for the generation of electricity accounts for about 1 percent of the U.S. energy production. However, this source is predicted to grow during the next ten years at an average annual exponential rate of about 32 percent (which means that the total nuclear capacity must be doubled every 2.1 years.) At this growth rate, nuclear power will be providing about 22 percent of all electricity by 1980 and perhaps as much as 60 percent by the year 2000.

Electricity and Fossil Fuels

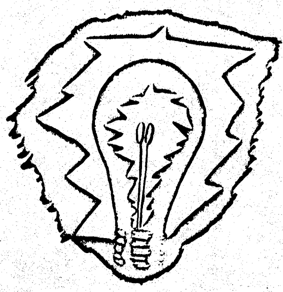
We shall restrict ourselves to considerations affecting energy production from coal and oil. Natural gas, the third major fossil fuel, creates virtually no particulate or sulfur oxide problems and except for possible nitric oxide production (a problem common to all forms of combustion) can be considered pollution free. Gas is the scarcest of the three fossil fuels though this situation may change as techniques for converting coal to liquid and gaseous forms are perfected.

Some Side Effects of Coal Production

About 60 percent of the coal mined each year is used to generate electricity. And nowhere are the social costs of power production more evident than in the human misery experienced by soft coal miners in the United States. In effect, the nation's electricity and industrial production are subsidized by sacrificing the health and lives of the country's 150,000 mine workers.

It has been known for some time that coal mining is the most dangerous industrial occupation in the country. As a result of a chronic neglect to provide safe working conditions, one of every 300 mine workers dies each year and one in every 30 is severely injured. Such accident and death rates could be drastically reduced, as demonstrated by the much safer conditions in European mines.

In addition to high death rates from accidents coal miners in the U.S. also are faced with the almost certain prospect of irreversible lung damage from pneumo-



coniosis, or as it is called, "black lung disease." This disease results from the prolonged breathing of dust particles and, according to one theory, leads to the destruction or impairment of the lungs' tiny blood vessels, thus inhibiting the transfer of oxygen to the blood. The Surgeon General of the U.S. has estimated that over 100,000 miners suffer from black lung disease, which means that most miners have it and that large numbers probably die from it. Yet through what only can be described as a conspiracy involving coal mine operators, "company doctors," union officials and government officials, few miners have been compensated for their destroyed health.

It is possible that some of the costs presently borne by coal miners will be "internalized" or passed on to the consumer because of the Federal Coal Mine Safety Act of 1969. The act requires many new safety measures and places limits on the concentrations of coal dust in mines. According to a Bureau of Mines analysis the costs of the new safety and health measures could add up to 10 percent to the cost of coal. That is, for about 40¢ a ton much of this human suffering and death could be avoided.

Some Social Costs of Strip Mining

In 1969 there were about 560 million tons of coal mined in the U.S. valued at more that $2.5 billion. About one-third of this coal was extracted through "strip mining." Strip mining, as it is presently practiced, produces coal at about half the cost of deep underground mining. This savings in cost, coupled with the great simplicity of the process, has led to a rapid increase in its use over the past ten to fifteen years. As with underground mining, however, there are enormous social costs involved. These costs, in the form of ruined land, are presently not being paid by either the producers or consumers of coal. In all likelihood it will be the federal government that will have to assume the costs of restoring the land, where it is possible, to some semblance of normalcy.

The amount of land subjected to strip mining in the U.S. was estimated, in 1965, at more than 3.2 million acres, an area almost two-thirds the size of Massachusetts. About 41 percent of this land, or about 1.3 million acres was strip mined for coal. As of 1965 more than 2 million acres of all the land blighted by strip mining had not been restored in any significant way. The cost for a minimal reclamation program for this land was estimated in 1968 at $757 million.

The devastation from strip mining could be avoided by properly restoring the land as soon as it is mined. In Ohio there is a model area of more than 100,000 acres that is one of the more popular recreational sites in the state. There are 250 ponds and lakes, wooded areas, public campgrounds, picnic tables, wells, and fireplaces all provided free to the public as a result of a joint venture between the Ohio Power Company and the Ohio Division of Wildlife.

One can justly ask why such programs are not more common. The answer, as with mine safety, seems to be one of economics: either profits of the coal producers would be reduced, or the cost of coal would be increased. Or both. As indicated earlier electric utilities account for 60 percent of the coal consumed in the U.S. According to H.M. Caudill, a Kentucky attorney and vocal critic of strip mining, the TVA is the "nation's biggest coal consumer and its purchasing policies have set the pace for the market elsewhere."[7] Mr. Caudill argues that by insisting on rock bottom coal prices for its generating plants TVA has provided a strong incentive for aggressive strip mining. Cheap electricity, he argues, is promoted at the expense of destroyed land.

The Hidden Costs of Oil Products

Petroleum products constitute the largest source of energy in the country and presently supply about 43 percent of our total energy needs. Nevertheless they account for only 12 percent of the electricity generated.

Present world production of oil is about 1.8 billion metric tons. About .1 percent of this oil, 2 million metric tons, is introduced into the oceans each year.

According to the recent MIT report, *Man's Impact on the Global Environment,* at least 90 percent of this oil "originates in the normal operations of oil-carrying tankers, other ships, refineries, petrochemical plants, and submarine oil wells; from disposal of spent lubricants and other industrial and automotive oils; and by fallout of airborne hydrocarbons emitted by motor vehicles and industry . . ."[8]

The effects on the oceans of this much oil are discussed in the MIT report. They include the poisoning of clams, oysters, scallops, fish and marine birds; and the possible long-term devastation of marine life from mass destruction of juvenile forms and of the food sources of higher species. Dr. Max Blumer of the Woods Hole Oceanographic Institution and one of the leading authorities on oil pollution, has expressed the fear that there may develop an "accumulation in human food of long-term poisons derived from crude oil, for instance, of carcinogenic compounds."[9] He is concerned that through oil pollution of the seas "we may eventually destroy the yield and the value of the food which we hope to recover from the sea."[10]

About 500,000 tons of the oil reaching the oceans arise from tankers that routinely pump oily waters directly from their bilges into the oceans. These losses could be cut by 99 per cent by following a relatively simple procedure known as "Load On Top." About 80 percent of the world's tankers now follow this procedure. The 20 per cent that do not – because of small costs and inconveniences – account for 95 percent of all oil losses from tankers.

It has been estimated that another 500,000 tons of oil reach the oceans from engine crankcases. At the present time it is uneconomical to recover or collect these wastes. As a result the oceans pay the price. The MIT report suggests that an automobile tax be added to the cost of oil in an effort to adjust the economics of the situation by placing the costs of disposing of oil on the consumer where they belong.

Another 400,000 tons of oil pollution results from off-shore oil well production and refinery wastes. It is clear that these wastes could be reduced if they had to be and that the added costs of gasoline and oil should be passed on to the users of petroleum products.

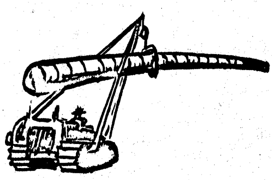
Other Costs

We have discussed some of the costs associated with the extraction and delivery of fossil fuels. There are other costs which result from the burning of these fuels. Among these are the release of large quantities of SO_2 and particulates with consequent damage to vegetation, metals, buildings, automobiles, and, most importantly, human health. It could cost upwards of 2.5 billion just to install scrubbing equipment on all the fossil-fuel power plants in the country. There would of course be additional costs in operating this equipment, adding perhaps 5 percent to 15 percent to the cost of electricity. The costs of controlling the thermal pollution of rivers and lakes also could add a few per cent to the cost of electricity, depending on whether cooling ponds or towers are used.

We have not attempted to construct a balance sheet for the costs and benefits of reducing the environmental destruction that presently results from using fossil fuels. Nor do we believe that any such calculation seriously could be undertaken. There are too many intangibles in the form of aesthetics and unknown risks. For example, there are a growing number of biologists who believe that what we now term "aesthetics" may be more important biologically than we generally think. More research is needed to determine the importance of "aesthetic considerations" in the development and maintenance of community mental health. On the other hand the permanent impairment of oceanic or atmospheric functions should be avoided at *all* costs. Since we do not now understand the relationships between our activities and their long-term effects the only prudent policy is to minimize the risks. In general this means applying all available technology to reduce the effects of pollution.

Social Costs of Energy Production from Nuclear Sources

In the United States the AEC has the responsibility for development of nuclear energy for peaceful purposes. The primary emphasis in nuclear power production has been on commercial development of light water reactors – the kind which are currently being constructed in the United States. According to a recent article in Fortune, the AEC has spent more than $2 billion in federal funds so far to bring nuclear power to commercial status. This program has not been developed without criticism, and as with fossil fuel power plants, the roots of the unhappiness can be ultimately traced to economic considerations.



To see how the economics of nuclear power production can generate tragic social costs one need only consider the very high incidence of lung cancer that occurs among underground uranium miners in the U.S. It was known in the country in the 1940s that lung cancer was occurring frequently among the miners in the Schneeberg mines of Saxony and the Joachimsthal mines of Bohemia. According to Dr. Karl Z. Morgan, director of the Health Physics Division of Oak Ridge National Laboratory,

> . . . In spite of these centuries of unhappy human experience from exposure of miners to uranium ores, the Federal Radiation Council did not take the initiative in calling attention to the many miners in the Colorado plateau who were engaged in mining operations where the levels of exposure probably were equal to or greater than those that led to early tragic experiences, and in any case they often were 10 to 100 times the levels set by ICRP [International Commission on Radiological Protection]. Even after the seriousness of this problem was brought into focus by the excellent work of Holaday . . . and others with the Public Health Service, the FRC was slow in recognizing the problem and taking appropriate action. Finally, after long delays, the FRC recommended what amounted to one working level, WL, which was three times the .3WL recommended by the Department of Labor.[11]

As Sheldon Novick summarized the situation,

> Although the AEC published its first price schedule for uranium in 1948, it was not until July of 1967 that a safety standard of any sort for uranium miners was enforceable. All this despite the record of disastrous experience in European uranium mines. A very similar pattern can be seen in the history of radioactive water pollution from uranium mines.[12]

According to Mr. R.L. Faulkner, director of the AEC's Division of Raw Materials, a decision is pending to lower the permitted exposure by 66 percent from the present permitted level of 1WL.

Among the factors to be considered in the decision are "radiation concentration and exposure levels and control, health and medical aspects, **economic impact** and concentration exposure measurement techniques and equipment."[13] (Emphasis added). It certainly would compound a past tragedy if the presently permitted levels are sustained because of the economic impact that safer levels would have on electricity rates.

The major area of public concern with respect to nuclear power involves, of course, the radiation exposures from reactors. We have here an almost perfect example of the difficulties that arise in making "cost-benefit" judgments in the large scale application of technology. To begin, the exact biological effects on large populations from receiving small doses of radiation are now being hotly disputed. The estimates range from **negligible** (by the AEC) to **disastrous** (by scientists such as Gofman, Tamplin and Pauling). The situation is unique in that actual numerical estimates are being made on the number of deaths that will occur from the routine operations of reactors. The dispute on the size of the numbers involved has focused public attention on the real central question: how much monetary value will we assign to human life for a given technological benefit? Or, stated differently, how do we decide on the extent of an emissions-control program for reactors if the long-term effects of radiation are still unknown?

(Interestingly, these same questions must also be asked for the radioactive natural gas that has been recovered in the AEC's Plowshare program. The doses that would be received from using this gas have been estimated to be of the same order as those that would be received by living near the edge of a reactor site.)

Conclusion

At the beginning we cited the statement of the National Goals Research Staff to the effect that the United States is making a transition from a production-oriented society to one dominated more by the delivery of services. We would add to their statement the corollary that the country is becoming more concerned with the quality of its existence than with the quantity of goods that it produces. A major factor in this transition from emphasis on quantity to quality will be the internalizing of costs that are now being manifested in the forms of environmental pollution. As pollution is reduced energy and goods will, of course, cost more. As a result we will become less wasteful, less frivolous and less consumption oriented. **We shall, in effect, be taking the first steps toward the closed-cycle economy that in the long run will have to be reached.**

Dr. James J. MacKenzie

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9. Max Blumer, "Oil Pollution of the Ocean" in *Oil on the Sea,* Plenum Press, 1969, p. 10.
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11. Morgan, K.Z., Struxness, E.G., "Criteria for the Control of Radioactive Effluents," SM-146/10, Symposium on Environmental Aspects of Nuclear Power Stations, August 10-14, 1970, p. 26.
12. Sheldon Novick, *The Careless Atom* (Boston, 1969), p. 132.
13. Remarks by R.L. Faulkner before the Uranium Committee of the American Mining Congress, San Francisco, October 19, 1969. p. 7.

ENVIRONMENTAL EFFECTS

[From Surface Mining and Our Environment, U.S. Department of the Interior, 1967]

Basic Disturbances

Surface mining affects the environment in three ways. To some degree, it influences the quality of our air, land, and water; and, through these, animal and plant life.

Air.— Although air pollution is one of our more serious environmental problems, surface mining, per se, cannot be considered a major contributor. However, the dust and vibrations resulting from blasting and movement of equipment during mining operations can be annoying and, in densely populated areas, a public nuisance. Some abandoned surface mines and waste piles also may be a source of air-borne dust.

Land.—Two factors that are essential to the establishment of vegetation on surface-mined areas are the physical and chemical characteristics of the spoil. The spoil material was considered suitable for agricultural use at only 25 percent of the sites observed during the random-sampling survey. Where excessive stoniness exists (at about 20 percent of the sites inspected) the possibility of getting a quick, vigorous cover is hampered by the rapid run-off and lack of soil. Most of the remaining 55 percent might be receptive to tree or herbaceous type plantings if climatological conditions are favorable.

There were no serious erosion problems at about 60 percent of the areas examined primarily because some vegetation had been established and the slope of the land was relatively gentle before and after mining. Most of the remaining sites showed evidence of erosion in the form of gullies less than one-foot deep; but, at 10 percent of the sites gullies were found that exceeded this depth. Sediment deposits were found in 56 percent of the ponds and 52 percent of the streams on or adjacent to the sample sites.

Spoil bank materials which have a pH of 4.0 or less are lethal to most plants. A pH of 7.0 is neutral; values higher than 7.0 indicate alkalinity. Free acid may be leached enough in 3 to 5 years to permit planting, but the leaching process will not improve soil conditions if erosion is allowed to expose more sulfuritic minerals in the spoil. Although some plants achieve successful growth in spoil with a pH range under 5.0, most plants require a less acid environment for successful growth. Of the measurements taken on spoil banks, 1 percent showed a pH of less than 3.0 and 47 percent, a range between pH 3.0 and 5.0.

About 15 percent of the spoil banks are covered with vegetation sufficient to provide adequate site protection. Another 15 percent have fair to good cover which, with more time and some spot planting, should suffice to protect the areas and speed renewal of the soil. Twenty percent will require direct seeding, seedlings, and fertilization. About 30 percent of the sites inspected had little, or no, cover and will, therefore, require extensive treatment. On the remaining 20 percent of the sites examined, vegetation will be extremely difficult to grow because of excessive stoniness or toxic conditions. It was also observed that wide variations occur in the rate at which natural revegetation takes place because of differences in physical and chemical characteristics of the spoil, and proximity to seed sources.

It was assumed for the random-sampling survey that, generally, mined land had been used prior to mining for purposes similar to those on adjoining tracts, and that, if left untreated by man, the mining site would eventually regain the same types of cover. Field observations made during the survey showed this to be largely untrue, however, because only about one-half of the areas assumed to have been forested had returned to forest and land classified as idle had increased almost fourfold. Land which had been devoted to crops and human occupancy, of course, had not voluntarily returned to these uses. Curiously, most land assumed to have been grassland had returned to grass. Clearly then, in most cases, natural forces will need a strong assist from man if mined sites are to be brought back to their former uses.

When natural vegetation is removed by exploration and mining activities, the area becomes virtually useless for wildlife because it becomes barren of food, nesting, and escape cover. Even in the most arid areas of the country, erosion eventually follows removal of vegetation, and the resulting silt and sediment may affect fish and wildlife habitat. Thus, except in a few limited areas of the Midwest, poorer soils and vegetative cover resulting from surface mining create less favorable wildlife habitat. However, the rough broken ground found at many sites does afford protection from hunters for some species.

Water.— Although basic to human existence, water is perhaps America's most abused resource. The surface mining industries are not the major contributor to the degradation of our water supplies on a national basis, yet in many areas such as Appalachia, they are a significant source of pollution.

Chemical pollution of water by surface mines takes many forms. The polluted water may be too acid, too alkaline, or contain excessive concentrations of dissolved substances such as iron, manganese, and copper. High concentrations of dissolved minerals may make the water unsuitable for certain purposes, but not for others; for example, water unsuitable for domestic use because of chemical content may [illegible] be used by industry, and some forms of aquatic life may flourish in it.

Sulfur-bearing minerals are commonly associated with coal, and are a major cause of water pollution.

~~(continued from page 56)~~

When exposed to air and water, they oxidize to form sulfuric acid. This acid may enter streams in two ways: (1) Soluble acid salts formed on the exposed spoil surfaces enter into solution during periods of surface run-off, and (2) ground water, while moving to nearby streams, may be altered chemically as it percolates through spoil, or waste dumps.

Acid drainage is but one of several adverse chemical effects caused by surface mining. Even in minute concentrations, salts of metals such as zinc, lead, arsenic, copper, and aluminum are toxic to fish, wildlife, plants, and aquatic insects. Indirectly associated with acid drainage are the undesirable slimy red or yellow iron precipitates ("yellow boy") in streams that drain sulfide-bearing coal or metal deposits. Of the streams receiving direct run-off from surface mine sites, 31 percent of those examined contained noticeable quantities of precipitates. Water discoloration was recorded at 37 percent of the streams adjacent to the sites observed, suggesting chemical or physical pollution. The discoloration occurred most frequently in connection with the mining of coal, clay, sand and gravel, peat, iron, stone, and phosphate rock.

Streams are also polluted by acid water from underground mines, preparation plants, and natural seepage from unworked coal and other pyritic material. Because of the intermingling of effluents from these sources, it is difficult, if not impossible, to determine the quantity of acid that comes from surface mining alone. Many authorities believe, however, that not more than 25 percent of the acid load created by coal mining can be attributed directly to surface operations. Many streams in the Appalachian region are affected to various degrees by acid drainage from both surface and underground mines. Although acid conditions are associated with coal mining conducted elsewhere, the problems are not usually so severe because the topography is not as rugged, rainfall is less profuse, pyritic materials oxidize more slowly, and, in some cases, limestone formations act as a neutralizing agent. Where acidity is neutralized by alkaline water, or limestone, the concentration of certain dissolved substances still may remain high and the water may not be usable without treatment.

Acid mine drainage affects fish and wildlife in several ways. Acid changes the water quality of streams into which it is discharged and, although the concentration may not be lethal to fish or wildlife, it may bring about changes in their physical condition and rate of growth. However, acid may be present in such concentration as to be directly lethal to fish or tend to suppress or prevent reproduction of the most desirable species.

The Bureau of Sport Fisheries and Wildlife reported that in the United States some 5,800 miles of streams (about 57,000 acres) and 29,000 surface acres of impoundments and reservoirs, are seriously affected by surface coal mining operations. The Bureau reported that, in 1964, 97 percent of the acid mine pollution in streams and 93 percent in impoundments, resulted from coal mining operations. Similar data were obtained by a United States Geological Survey reconnaissance conducted in 1965, which disclosed that water quality at 194 of 318 sampling sites in Appalachia was measurably influenced by acid mine drainage. None of these data, however, reflect the percentage of damage that can be attributed to surface mining alone.

Access roads built of pyritic waste material may also be sources of acid water. In past years, some highway departments have hauled waste from the mines for road building purposes. This practice is not generally followed today, and is forbidden in some States; however, roads built of this material continue to acidify rainwater passing over them — despite long periods of leaching. In addition, some privately constructed mine-access roads are being built of pyritic material.

Roads opened on National Wildlife Refuges by prospectors frequently result in broken levees; interfere with controlled burning; increase human activity, which interferes with the nesting and breeding of birds and animals; and, restrict animal movements. The distance that each species, or even individual animals, will place between themselves and the disturbance varies greatly, but some species will leave an area entirely when their natural habitat is invaded by people and equipment.

Physical pollution is most serious in areas typified by high-intensity storms and steep slopes, particularly during and shortly after mining. In areas undisturbed by strip mining within the Appalachian region, the average annual sediment yield ranges from about 20 to 3,000 tons per square mile of watershed, depending upon land use. Research conducted in Kentucky indicated that yields from coal strip-mined lands can be as much as 1,000 times that of undisturbed forest. During a four-year period, the annual average from Kentucky spoil banks was 27,000 tons per square mile while it was estimated at only 25 tons per square mile from forested areas.

Erosion and sedimentation problems from surface mining are less severe in arid regions; however, even in such areas, storms do occur during which large quantities of sediment are discharged from mine workings, spoil heaps, and access roads. At some idle surface mines in arid country, the effects of wind and water erosion are still evident on steep spoil banks that were abandoned many years ago.

One of the major causes of sedimentation problems is the failure to control surface run-off following rainstorms. In areas outside Appalachia, 86 percent of the surface-mined areas investigated were found to have adequate run-off control. Areas lacking sufficient control were confined almost exclusively to the surface mining of coal, phosphate, manganese, clay, and gold.

Some 7,000 miles of stream channels have had their normal storm-carrying capacity reduced according to the Bureau of Sport Fisheries and Wildlife. It was observed that the normal water-carrying capacity of about 4,500 miles of these streams had been moderately to severely affected. The remaining 2,500 miles had been affected only slightly (debris reducing channel by less than one-third of capacity). Sediment generally was not a significant problem on small streams located more than two miles from the sample site.

Substandard access and haulage roads, and others built in connection with prospecting activities, are a major source of sediment. Based on the sample data, 95 percent of these roads were less than 3 miles long, but the proximity of many to natural stream channels had considerably increased their potential for sedimentation damage. The roads were fairly passable in the majority of cases; however, approximately 15 percent were eroded to a point that would make them difficult to traverse by ordinary vehicles.

Beneficial Effects of Surface Mining

When massive rocks are fragmented during surface mining, the resulting piles of material contain considerably more void space than existed in the fractures, partings, and pore spaces of the undisturbed rock. As a result, certain desirable hydrologic effects may occur. The danger of floods is diminished because a significant portion of the rainfall is trapped in depressions and behind the spoil banks where it sinks into the earth to augment ground-water supplies, rather than running off rapidly to nearby streams. Because water stored in the banks moves slowly, drainage will continue for a long time before the water level declines to that of adjacent streams. Thus, streams near surface-mined areas often maintain a longer sustained flow during dry weather than those draining undisturbed ground. This phenomenon was verified through field studies conducted in the Midwest by the Indiana University Water Research Center, but it occurs less frequently in most of Appalachia because of the rapid run-off.

In the Western United States, some surface mines have exposed ground-water sources and made water available where none existed before. This water has proved invaluable to livestock and wildlife. At some surface mining operations along mountainsides, the pits impound surface run-off from torrential rains, minimize the sediment load of streams draining the area, and effect considerable ground water recharge as well.

In California, piles of dredge tailings are quite permeable. However, because of their irregular conformation, they undoubtedly inhibit surface run-off to a greater degree than the original slopes, thus making some contribution to flood control and ground-water recharge. In Alaska, dredge mining for gold has destroyed the permafrost and the resulting tailings and mined areas are considered premium property for residential and industrial development.

Many mine-access roads, when properly repaired and maintained, can be of considerable value since they may be used to promote the multiple-land-use potential of extensive areas. Accessibility for fire protection, recreation, and management activities, can mean the difference between use and isolation. For example, by improving fire protection, investments can be made more safely in growing timber, and hazards to human and wildlife considerably reduced. Where massive equipment was used in the mining process, the access roads were usually well constructed, and the cost of repairing and maintaining them would be low. By converting some of these roads to public use, tourism might also be encouraged because many of the sites examined (83 percent) were located in areas that afforded spectacular views of mountains, valleys, and lakes.

Surface mining has created many opportunities to develop recreational areas where none existed before. Water in the form of small ponds or lakes, and the spoil piles themselves, frequently provide a pleasant topographic change in areas of virtually flat land. Examples may be found in flat coastal areas and in such States as Kansas, Illinois, Indiana, Ohio, and California.

[From the Mineral Industry and the Environment]

POLLUTION OF THE LANDSCAPE

(By Samuel M. Brock, West Virginia University, Morgantown, W. Va., June 1970)

Considerable progress has been made in air and water pollution, both in terms of regulation through legislation and development of technology for pollution abatement. By contrast, pollution of the landscape through activities such as surface mining and disposal of solid wastes continues to present many unsolved problems. Indeed, progress in air and water pollution control has contributed to the complexity of these problems. Removal of particulates and other impurities in air, for example, creates additional solid waste for disposal.

Past trends in land use indicate that there often has been a lack of concern in extracting minerals and other natural resources from land resources. Mineral deposits which were most accessible, and which promised the greatest profit to the producer, were mined with little concern for associated destruction of the land. Social costs, including creation of millions of acres of derelict land through surface mining, were largely ignored. In recent years, however, such practices have been subjected increasingly to public criticism. This has led to more stringent regulation of the mineral industry. Surface mining, in particular, has been more rigorously controlled.

Simply stated, surface mining consists of removing the topsoil, rock, and other strata that lie above mineral or fuel deposits to recover them.[36] In the process protective vegetative cover is destroyed, and overburden often is cast in massive piles onto land adjacent to the mine site. The mining results in a considerable alteration of the land surface, and changes sub-surface drainage patterns as well. Acres upon acres of land may be disturbed to depths sometimes exceeding 100 feet. Such disturbances have led to massive landslides which have blocked rivers and highways. They also have contributed to water pollution by acid mine drainage and sediment. In addition, land areas have been isolated by mile after mile of contour benches, and aesthetic and other economic values have been seriously impaired.

Disturbances created by surface mining are evident in almost every state. However, probably nowhere are the results of mining more spectacular than in the mountainous Appalachian region. There, the contour strip mining of coal has produced about 20,000 miles of cliff-like highwalls.[37]

It has been estimated that prior to 1965, 3.2 million acres of land had been disturbed by surface mining in the United States.[38] This area includes only the excavation, or pit, and land upon which waste or spoil from mining was deposited. About 320,000 additional acres have been disturbed through the construction of access roads and by exploration. An estimated 95 percent of the acreage disturbed by surface mining can be attributed to seven commodities; coal, sand and gravel, stone, gold, clay, phosphate, and iron. All other commodities combined account for only 5 percent of the acreage.

The economic productivity of surface mining is subject to considerable debate. Economic returns are probably quite variable, depending upon such factors as the terrain, depth of the mineral or fuel deposit and its thickness, and possibilities for returning the land resources to productive uses following mining.[39] Undoubtedly, there are cases where the social costs incurred in mining coal and other commodities exceed the social benefits. In such cases, surface mining is wasteful of resources, and according to economic criteria, should be prohibited. However, even if surface mining is economically productive, society may be willing to bear the cost of prohibiting it in order to preserve the environment. Thus, the issue of whether or not to permit surface mining raises some difficult social, economic, and legal questions. Limited research has been undertaken to provide answers. Cost and benefit data for mining operations under varying conditions, for example, are not available, and are not easily obtainable.[40] Nor has the legality of prohibiting sur-

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[36] For a general description of surface mining and its effects on the environment, see U.S. Department of the Interior, op. cit. note 15. Also see D. B. Brooks, "Strip Mine Reclamation and Economic Analysis," Natural Resources Journal, Vol. 6 (1966), pp. 13–44.

[37] U.S. Department of the Interior, op. cit. note 27 at p. 22.

[38] U.S. Department of the Interior, op. cit. note 15 at p. 39.

[39] See, for example, S. M. Brock and D. B. Brooks, The Myles Job Mine—A study of Benefits and Costs of Surface Mining for Coal in Northern West Virginia. Research Series No. 1 (Morgantown: West Virginia University, Office of Research and Development, 1968).

[40] S. M. Brock, "Benefit-Cost Analysis of Surface Coal Mining," Mining Engineering, Vol. 21 (1969), pp. 75–77.

face mining even if it is clearly economically indefensible been resolved. These problems will require considerable research effort and social action, including litigation, to provide satisfactory solutions.

In contrast to pollution of air and water resources, which is regulated under various federal laws, there is no federal legislation regulating surface mining. Thus, no national program of mined-land conservation exists. Twenty of the 50 states now directly regulate surface mining. Regulation of mining under these laws often has not been consistent because of conflicting opinions concerning land use.

West Virginia was the first state to enact surface mining legislation. It passed its first law in 1939. Indiana enacted a similar statute in 1941, followed by Illinois, 1943; Pennsylvania, 1945; Ohio, 1947; Kentucky, 1954; Maryland, 1955; Virginia, 1966; and Tennessee, 1967. Since 1967, Kansas, Maine, Oklahoma, Alabama, Iowa, Wyoming, Colorado, Montana, Minnesota, North Dakota, and Georgia have enacted laws. All of these laws cover the surface mining of coal.[41] Only six states, however, regulate the surface mining of all commodities.

Land usually may be returned to productive uses following mining by the reclamation required by the state laws. Reclamation consists of backfilling, regrading, and revegetation the mined area. Regrading and revegetation tend to reduce or eliminate mine drainage problems and stabilize the soil, thus reducing erosion. Oftentimes, agricultural crops or commercial timber products may be produced on reclaimed land. Sometimes attarctive recreational areas may be created. However, restoration of natural scenic values often may be difficult or impossible, depending upon the type of mining and topography. Elimination of scars caused by highwalls may prove economically infeasible.[42]

Problems of reclaiming mined areas have not been adqeuately solved.[43] Finding less costly methods for successfully returning mined areas to productive uses presents an urgent research need. There also are technological and engineering problems that require solution. Previous research has provided only partial answers for such problems as eliminating acid and sediment pollution, and developing techniques to form and stabilize the soil. The identification of plant species that will thrive on mined areas is another research need.

The success and extent of previous reclamation efforts can be ascertained by comparing the acreage disturbed by surface mining with the total reclaimed. Of the 3.2 million acres that have been disturbed since surface mining began in the United States, about one-third has been judged by the Soil Conservation Service as needing no further treatment.[44] This means that about 2 million acres require further reclamation work.

Most of the reclamation that has been accomplished has been on coal lands. Only a very small acreage has been reclaimed in the case of other commodities. This may be explained by the fact that initial efforts to regulate surface mining have been primarily concerned with coal. In 1967, in six of the states with laws, more than 50 percent of the land disturbed by surface coal mining had been reclaimed. However, these state laws have been amended frequently to strengthen reclamation requirements. Thus, it would appear that the state governments themselves often have not been satisfied with the degree of reclamation achieved.

Destruction of land and water resources and natural beauty through surface mining represents a serious problem insofar as preservation of the environment is concerned. Recent concern over the problem merited provision for its study in the Appalachian Regional Development Act of 1965. The Act contained a section which directed the Secretary of the Interior to make a survey of strip and surface mining operations in the United States, and to submit to the President recommendations for a program of reclamation. The recommendations have been completed, and pertain to both repair of past damage and prevention of future damage.[45]

To prevent future damage, the report of the Secretary recommends that federal standards and reclamation requirements be drawn up as a basis for regulating future surface mining activity. These standards would be used to review state surface mining regulations, and to gauge the adequacy of state programs. In lieu of state legislation, the federal requirements would be imposed upon the surface mining industry. To repair past damage, the report recommends that the federal

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[41] A brief summary of the provisions of laws enacted prior to 1967 is given by U.S. Department of the Interior, op. cit. note 15 at pp. 118-20. Also see G. S. Bergoffen, op. cit. note 26 at pp. 32-61. The laws of individual states are generally reviewed in detail in law journals shortly after passage or amendment.

[42] S. M. Brock and D. B. Brooks, op. cit. note 39.

[43] See, for example, W. C. Lorenz, op. cit. note 20 and G. S. Bergoffen, op. cit. note 26.

[44] U.S. Department of the Interior, op. cit. note 15 at p. 14.

[45] Ibid. at pp. 104-8.

government share reclamation costs with state governments to rehabilitate abandoned surface-mined lands. This program would include purchase of privately-owned lands by the federal government in cases where this was deemed in the public interest. These recommendations have not yet been adopted.

Surface mining in other countries is also regulated to control future use of mined lands. In Germany, for example, mining and reclamation are considered an integral operation.[46] Mining methods depend upon the type of soil overlying the coal, and future use to which the land is to be put. Fertile surface layers of soil are segregated during mining, and replaced on the surface to ensure the future productivity of the reclaimed land. Similar procedures are required in Great Britain. There, land suitable for agricultural purposes is placed in the hands of the government immediately after mining and reclamation for a period of intensive care and management.[47] After five years, the land is returned to the farmer for agricultural use.

In the United States, and elsewhere, some of the major side effects of surface mining are "internalized" through regulation. Similar results might be obtained through a system of charges or payments.[48] Charges might be levied, for example, for discharge of acid mine water or sediment into adjacent streams. Unfortunately, there are not sufficient data for comparing the effects of regulation with those which might be realized through such alternative schemes.

The second major source of pollution of the landscape of concern to the mineral industries is solid wastes. The disposal, control, and reclamation of waste products resulting from the extraction, processing, and utilization of mineral substances are important technological and economic factors in the effective conservation of mineral resources.

In 1965, the annual rate of accumulation of solid wastes arising from the extraction, processing, and utilization of minerals and fossil fuels was about 1.1 billion tons.[49] Seven of the mineral-based industries contributed about 80 percent of these wastes. These industries were copper, iron and steel, lead, zinc, alumina, phosphate rock, and bituminous and anthracite coal. By 1980, it is estimated that the rate of accumulation of wastes will increase to 3.3 billion tons.[50] This does not include wastes associated with the recovery of oil from shale, which is expected to be in operation on a commercial scale by 1980.

Between 1942 and 1965, about 19 billion tons of solid wastes were produced by the mineral industry. In disposing of this material, approximately 2 million acres of land surface have been covered with waste products. This area is equivalent in size to the State of Delaware. Most of this land is unproductive, and will remain so, unless costly reclamation work is undertaken.

Most of the current annual accumulation of solid wastes produced by the mineral and fossil fuel industries comes from materials discarded at open pit mines, mills and coal preparation plants, blast furnaces, smelters and refineries or processing plants. The bulk of mine wastes produced at active underground mines is returned underground to fill mined-out areas and to provide a floor or platform for mining equipment.

Location of waste piles is frequently the most critical factor posed by solid waste disposal. Copper and iron ore mines, for example, are among the largest producers of solid wastes. However, for the most part, copper and iron mines are located in sparsely settled areas In such areas, disposal sites are abundant and land values low. On the other hand, the smaller quantities of waste products discarded by the coal, electric power, and phosphate rock industries pose much more intensive problems because these industries are usually located in densely populated areas.

Accumulations of mineral or fossil fuel wastes pose both health and safety problems. Billions of tons of unattractive barren piles of waste mar the natural beauty of the land. Dust from dried-out piles of waste, and smoke from burning culm banks contribute to air pollution Gob piles from coal refuse produce acid drainage problems. Other types of waste contaminate water supplies with salt and other noxious material. Use or stabilization of these wastes are the only viable means for controlling pollution.

The wastes generally consist of immense tonnages of materials discarded by selective mining or following the recovery of significant mineral values by milling or smelting. Often, mineral values in waste piles comprise only 2 or 3 per cent of

[46] W. Knabe, "Methods and Results of Strip-Mine Reclamation in Germany," The Ohio Journal of Science, Vol. 64 (1964), pp. 75–100.
[47] W. M. Davies, "Bringing Back the Acres," Agriculture, Vol. 70 (1963), pp. 133–38.
[48] D. B. Brooks, op. cit. note 36 at pp. 39–41.
[49] Information supplied by the U.S. Bureau of Mines.
[50] Ibid.

the discarded material. Only rarely can such low-grade ore be reprocessed to extract additional minerals at a profit.[51] Some mineral wastes are suitable for disposal as mine fill, railroad and highway road ballast, and land fill. Other wastes, such as fly ash, can be utilized as raw materials for making concrete, cement blocks, and brick.[52] However, the demand for wastes for these uses is small in relation to the amount of wastes produced.

Several means exist for stabilization of relatively fine-sized wastes which constitute the chief sources of air and water pollution. These include physical, chemical, and vegetative methods of stabilization.[53]

Fine tailings may be stabilized by covering them with rock and soil from adjacent areas. They also may be covered with bark or straw. Or, windbreaks may be constructed. Chemical stabilization involves reacting the waste with a reagent to form a water and air resistant crust or layer. Among the reagents commonly recommended are sodium silicate, lime, redwood bark extracts, amines, acetate salts of amine, dicalcium silicate, bituminous base products, elastomeric polymers, and resinous adhesives.

Vegetative stabilization often poses some difficult problems. Mill wastes are usually deficient in plant nutrients or contain materials noxious to plant growth. Tailings and other fine wastes usually must be covered to a depth of four inches or more with soil and fertilized prior to seeding. If care is taken in site preparation, a satisfactory vegetative cover usually may be established.

Disposal of radioactive wastes poses special problems. High-level solid wastes from reactor and chemical separation facilities are usually buried in a central burial ground.[54] Such wastes are placed in unlined trehches 20 feet deep, and covered with at least five feet of soil. Some wastes are encased in concrete.

Uranium mill tailings are impounded in large tailing ponds.[55] The major concern with radioactive tailings is to stabilize them so that they are not windblown into nearby streams or over populated areas. Tailing piles are usually graded and covered with earth. Where practical, these piles are planted with vegetation for stabilization.

The economic utilization of certain types of metallic scrap, such as automobile bodies, also poses a significant problem. Changes in the technology of steel making have made this type of scrap less desirable for reuse. New technology, which will allow the economic reuse of old automobiles, refrigerators, and other durable goods is badly needed. Recycling these discarded metal products into useful commodities, rather than disposal into auto graveyards and junk piles, would contribute materially to the preservation of the environment.

At the national level, waste disposal is regulated under provisions of the Solid Waste Disposal Act of 1965. This Act is jointly administered by the Office of Solid Wastes, U.S. Department of Health, Education, and Welfare and the Bureau of Mines, U.S. Department of the Interior.[56]

The major impetus of the federal law is on research, technical developmetn, demonstration, and planning for purposes of preventing and solving solid waste problems. With respect to mineral resources, the program has concentrated on areas where improved recovery systems would reduce mineral losses and the volume of products discarded, and has endeavored to develop methods to recover valuable metals and minerals from various types of waste.

As previously noted, 20 of the 50 states regulate the surface mining of minerals. Many of these laws pertain primarily to coal. Only six states regulate the surface mining of all commodities. Thus, in many cases, pollution resulting from surface mining is not controlled by state laws. Nor is disposal of solid wastes produced in the course of extracting, processing, and utilizing mineral substances adequately regulated. In view of the magnitude of the problem, which will assume even greater proportions in the future, this is a neglected area in environmental preservation. Studies of solid waste problems and methods at the state and local levels are urgently needed. Results of these studies should foster legislation which will provide the most economic solutions to the solid waste disposal problems currently confronting the mineral industry.

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51 K. C. Dean, H. Dolezal, and R. Havens, "New Approaches to Solid Mineral Wastes," Mining Engineering, Vol. 21 (1969), pp. 59-62.

52 G. C. Gambs, "Power Plant Ash—A Neglected Asset," Mining Engineering, Vol. 19 (1967), pp. 42-44.

53 These methods are discussed by K. C. Dean et al., op. cit. note 51.

54 S. D. Reichert, "Geology Plays an Important Role in Radioactive Waste Management," Mining Engineering, Vol. 20 (1968), pp. 98-103.

55 R. G. Beverly, "Unique Methods are Required for Uranium Mill Waste," Mining Engineering, Vol. 20 (1968), pp. 52-56.

56 U.S. Congress, op. cit. note 11 at p. 90.

[From Mining Congress Journal, March 1971]

HYDROLOGIC EFFECTS OF STRIP MINING WEST OF APPALACHIA

(Although undesirable side effects can result from strip mining, such operations can also prove to be hydrologically beneficial. West of Appalachia, strip-mined land can be managed to diminish floods, increase low flow and become a significant source of water)

(By D. J. Cederstrom, Hydrologist, U.S. Geological Survey)

In 1966, the author was one member of a group representing various disciplines, headed by the U.S. Bureau of Mines, whose task it was to assess the effects of strip mining on the environment in areas outside of Appalachia. The author's specific task was to note hydrologic effects of these strip-mining operations. The overall results of these inspection trips have been given in a Department of the Interior publication entitled, "Surface Mining and Our Environment." [1]

The hydrologic effects of strip mining noted west of Appalachia tend to be beneficial to the environment, or could easily be so in a great many places, although there are places where undesirable or potentially undesirable hydrologic effects were noted.

STREAM FLOW GREATER IN STRIP-MINED AREAS

At this point, it seems appropriate to consider the effect of surface mining on underground water as observed in Indiana and Illinois. Here on low-lying, gently rolling to almost flat ground, great areas have been torn up and turned upside down. In one of these areas, Don M. Corbett of the Indiana University Water Resources Research Center, found that in October 1964 a stream draining undisturbed ground had a flow of 1900 gpd per square mile, whereas a stream draining a strip-mined area had a flow of 120,000 gpd, that is, about 63 times as much.[2]

Let us see why this interesting difference has come about. Rain falls upon the earth (or snow melts following general warming of a winter climate) at which time a large part of the water received on the surface soaks into the ground and the remainder is shed to streams. Streamflow is at a relatively high stage but in a matter of hours or days the flow begins to decline. Unregulated streams, that is, streams lacking reservoirs in headwater areas, would then dry up completely (until the next rain) were it not for the seepage from the ground. Thus, the sustained low flow or base flow of our streams and rivers consists almost entirely of ground water outflow. During the higher flow periods, ground water, of course, continues to be contributed along with the generally larger volume of overland or direct runoff.

RECHARGE CAPACITIES OF EARTH FORMATIONS VARY WIDELY

The receptivity, or recharge capacity, of earth formations ranges widely. A square mile of level or gently rolling sandy terrain in the humid East may be expected to receive an average of 1 mgd recharge to the ground-water reservoir. The amount absorbed by the soil cover may be considerably greater but the soil characteristically acts like a blotter in retaining a significant part of the precipitation, after which it is lost as it evaporates or is transpired by the plant and tree cover.

About 1 mgd per square mile average recharge may be received by a sandy ground-water reservoir but where the earth material beneath a thin soil cover is rock of low permeability, a large part of the potential recharge water is rejected. Briefly, the soil may quickly become fully saturated if the rock below it cannot accept water readily. Failing to find space, precipitation (or snowmelt) is then rejected by the ground and becomes direct runoff instead of recharge to the ground-water reservoir.

The ground-water recharge in an area underlain by thick limestones and interbedded shales is much less than the 1 mgd per square mile noted above. DeBuchananne has estimated that the recharge of limestone terrane in the valley of Virginia is about ½ mgd per square mile.[3] Recharge in areas underlain largely by flat-lying shale and sandstone beds, according to Wyrick, may be less than ⅓ mgd per

[1] *A Special Report to the Nation*, U.S. Department of the Interior, Washington, D.C., 1967.

[2] Corbett, D. M. "*Water supplied by coal surface mines, Pike County, Indiana*," Water Resources Research Center, Report of Investigations No. 1, 1965.

[3] DeBuchananne, G. D. "*Ground-water resources of the James, York, and Rappahannock River basins of Virginia west of the Fall Line*," U.S. Geological Survey, 1968.

square mile.[4] In deeply dissected plateau areas, lateral leakage may be such that much of the recharge is discharged to streams relatively rapidly and hence is not available for streamflow in dry spells.

MINED LAND HAS GREATER RECHARGE POTENTIAL

Obviously, cast ground in a strip-mined area will tend to function as an extremely coarse gravel where the material is largely brittle rock fragments. We might assume that recharge would initially be as much as 2 mgd per square mile but with the slow gain of a true soil cover and a stand of trees or grass, the rate of recharge would decline to something like 1 mgd per square mile. Where the cast ground is shale, the fragmented material is finer and has a larger component of ground up rock. Hence, such ground should be much less favorable to recharge than cast ground made up of sandstone and limestone.

From the point of view of susceptibility to recharge, we may conclude that in the Midwest, cast ground made up of sandstone, limestone and shale is probably at least three times more favorable than those formations in their original undisturbed state.

At this point, let us examine the storage potential of cast ground and compare it with naturally occurring earth material. A sized gravel made up of well rounded grains has a void space of about 40 percent. Cast ground, made up of angular fragments, is at best rudely sized and does contain some fines. Hence, the void space in cast ground may be in the nature of 15 to 25 percent of mass.

The percentage of void space in consolidated rock is difficult to measure accurately. The voids range from minute pore spaces and openings along bedding planes to gross openings developed by joints and along fracture and fault zones. However, a storage potential of 1 or 2 percent of the rock mass is generally accepted as representative except perhaps for certain limestones riddled with solution openings. Hence, the storage capability of thrown ground may be from 7 to 25 times greater than that ground in an undisturbed condition.

PERMEABILITY CONTROLS RATE OF WATER MOVEMENT AND STORAGE

With regard to permeability, the measure of rate at which water will be transmitted through the ground under a unit hydraulic gradient, it will suffice to say that, upon imposing a hydraulic gradient, water should move rather rapidly down the hydraulic gradient through cast ground made up of brittle rock fragments but much less rapidly where the cast ground is largely shale.

It is of great importance from a hydrologic point of view to bear in mind that a block of cast ground will function essentially as a unit. With withdrawal or drainage of water from one point, water will begin to flow to that point from throughout the entire mass. In undisturbed ground, a channel or fissure zone may not be connected or may be poorly connected with adjacent channels or fissure zones, in which case the water tends to be compartmented.

Let us consider now what overall hydrologic advantages may have been gained in a strip-minded area. First, it must be appreciated that cast ground lying on steep slopes can hardly be thought of as other than detrimental to the hydrology of the area. Recharge is favorable, but water entering such ground will drain from it rather quickly and, depending on the type of ground, might carry a sediment load of harmful proportions. Full saturation of a fine-grained mass on both steep and gentle slopes will favor creep or sliding of the entire mass with various consequences, ranging from undesirable to dangerous to human life.

However, when we consider the thousands of square miles of disturbed ground in gently rolling to flat terrain, hydrologic advantages are apparent: 1) The ground will absorb a large volume of precipitation rapidly, 2) storage space is normally present in the disturbed ground (a 50-ft thickness of saturated ground one mile square might hold from 1.56 to 2.60 billion gal of water—27,878,400 $ft^2 \times 50\ ft \times 7.48\ gal \times 15$ or 25 percent), and 3) much of the water in storage could be moved with fair rapidity to any point by imposing a hydraulic gradient on the reservoir, either by lowering the outlet of this underground reservoir or by pumping wells.

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[4] Wyrick, G. G. "*Ground-water Resources of the Appalachian Region,*" U.S. Geological Survey, 1968.

CAST GROUND CAN AID RUNOFF CONTROL

To manage or to foresee management of a block of cast ground as a hydrologic resource, certain conditions are pertinent. If the purpose is to regulate the flow of adjacent streams the block should drain rather slowly. It may do so if the permeability of the material is only moderate and the area of discharge to the stream is small. If the outlet is too small or at too high a level relative to the depth of the block of cast ground, considerable dead storage of water will result. Dead storage might be avoided by trenching from the appropriate stream level to the base of the cast ground reservoir. An ideal situation would be a dam, of a sort across the drainage face or channel, the outlet of which could be controlled as needed.

Thrown ground can function favorably in stream regulation, as Corbett noted,[2] if it happens to be situated in the right place. A better approach would be a hydrologic appraisal followed by construction of suitable structures that would 1) insure drainage of the block of cast ground at times of low flow or no flow of the streams and, having this lowered the water level in the tract of distrubed ground, and 2) provide storage space for receiving and retaining excessive precipitation normally resulting in floods.

Wells ending in undisturbed hard rock in the Indiana area generally have very poor yields except where they may be overlain by saturated sandy material. About 20 gpm is considered a high yield in a well finished in limestone in Indiana and the average yield is much less. Wells constructed in cast ground should do much better. Where the cast ground is brittle sandstone or limestone, some large yields should be possible from wells constructed in them. Where the saturated thickness is 40 ft or so, wells in such ground might yield significantly more than 100 gpm. Further, the storage and recharge characteristics of the cast ground, as noted above, are such that wells in it will continue to supply ample water in times of protracted drought.

Where the cast material is largely true shale, the hydrologic characteristics are much less favorable. Storage characteristics would be relatively favorable but more difficulty would be experienced in obtaining high-yield wells. Slaty, limy, or sandy shale would function better than true shale as an aquifer.

It must be emphasized that the beneficial hydrologic effects noted are most noteworthy in areas where acidic waters are not generated. Although acidic stream water is undesirable or harmful, it may still be said that where cast ground acts to lessen potentially harmful flood flows, a benefit has resulted. Maintenance of a flow of more or less acidic water in periods of drought as opposed to no flow can hardly be considered helpful.

EFFORTS MADE TO CONTROL ACIDIC WATER

In the Midwest the problem of acidic water is seemingly much less acute than in Appalachia. In part, this may be due to the fact that the topography is gentle and pyritic material is generally less exposed to oxygenated waters. Very real efforts were being made at the mines visited to control the production of acidic waters and their flow to the streams. In one place, at least, acidic water was chemically neutralized before being allowed to drain out of the mine area.

Some success attends efforts to bury pyritic material beneath inert fill or to confine it to deeper furrows where it is overlain by many feet of deoxygenated water. However, in the latter situation, torrential rains will tend to stir the water as a result of which oxygenated water will come into contact with pyritic material. Two approaches to that problem suggest themselves. Where pyritic material lies at the bottom of a water-filled furrow, spreading a layer of clay or finely ground shale upon it should do much to negate the effect of occasional circulation of the overlying water. The other thought is that during mining operations, bottom acid-forming earth material should be dumped as low on the side of the last (active) ridge as possible rather than on the crest, where much or most of that material would roll to the furrow bottom. There it will ordinarily be covered when the succeeding ridge is built. This practice is followed in at least one mine. Such action should ameliorate the ill effects of acid waters upon the hydrologic environment.

Some of the present problems are carryovers from several decades ago. These include drainage from abandoned gob (waste) piles at sites of old operations and, to some extent, from the practice of local highway departments of using gob as road-building material. Road building with gob seems to be no longer practiced.

[2] Corbett, D. M. "*Water supplied by coal surface mines, Pike County, Indiana,*" Water Resources Research Center, Report of Investigations No. 1, 1965.

However, neutralization of the huge abandoned gob heaps that are found from place to place in the Midwest may not be accomplished in the near future. Some control of acid drainage presumably could be achieved by restricting circulation of meteoric or ground waters through the heaps.

LAKES HAVE BEEN CREATED

There are other hydrologic benefits from strip mining in Midwest fields where thousands of small lakes have been created in the resultant ridge and furrow topography. With specific respect to water supply, these lakes as such consitute a reservoir of significant magnitude. Further, upon pumping from lakes, saturated bank material, made up of moderately permeable shale fragments or highly permeable sandstone and limestone fragments, will contribute water to the lakes. In this sense, then, the lakes may be thought of as a series of dug wells in which considerable storage is present in each.

The ponds and lakes created by disturbed ground are commonly hydrologic benefits in the sense of improvement of the functioning of the hydrologic cycle and also in a secondary sense in that the ponds and lakes are, or can be, distinct assets with reference to use by humans and wildlife. Great stretches of the midwestern landscape are pleasant but, at least to the writer, somewhat monotonous. The lakes and ponds left after stripping provide not only scenic variation, but desirable housing sites, fishing, swimming and boating areas, duck ponds, and wildlife refuges. The general setting of the tracts set aside for these purposes ranges from lakes in furrows between raw ridges (where fishing is said to be good) to handsomely landscaped rolling ground with shade trees, beaches, clubhouse facilities or fine homes around small lakes or sinuous waterways.

I can't begin to evaluate the hydrologic benefit from a lake 80 miles long and a mile or two wide that will someday form in the Mesabi country. The eventual cessation of mining there and the filling of this tremendous pit will hardly come in the time of most of us living today. This question is then left unanswered except to note that unpolluted lakes are becoming scarcer every day, and this future lake may fill a real need in an otherwise contaminated world.

WATER-RETENTION STRUCTURES CAN PREVENT FLOODS

The phosphate mines in semi-arid Wyoming present an interesting situation. Here, long furrows are made high on mountain slopes and granular overburden material is disposed of on the lower slopes. One is reminded of the water-retention structures on the slopes above San Bernadino Calif. There, structures are built to intercept the flow of temporary torrential streams down the nearby mountains. Water flows into an unlined catchment, fills and overflows, is led to lower catchment, and so on. Meanwhile, in filling and passing from one catchment to another, the water has time to infiltrate the ground with the net result that San Bernadino is not only protected from flood damage but has also salvaged water that might be lost to an adjacent county or to the sea.

Something similar might be accomplished at small cost in the phosphate area referred to, and perhaps at some huge open-pit mines elsewhere in the West and Southwest, by judicious planning of spoil disposal. There seems to be little need for inducing additional recharge in the particular areas visited by the writer, although the idea is valid enough. Catchment structures of the type outlined above might be justified where flash floods are a local problem and, in any event, retention structures would minimize or eliminate the sediment load of temporary streams flowing through or from the disposal area.

GROUND WATER CONTAMINATION NOT A MAJOR PROBLEM

Contamination of ground-water supplies has occurred in consequence of leaching of pyritic copper ores in a very few localities in the Southwest. In one locality, an aquifer tapped by domestic wells became contaminated by waste leach water discharged into the stream course that recharged the aquifer. In another area, water used in irrigation downslope from the mining area is becoming more mineralized. However, here drainage from abandoned underground workings may be contributing acid water.

Speaking broadly, leaching operations are few, some are so located that leakage, if taking place, does not affect existing water supplies. We may say that this problem has some potential but is generally more interesting than it is acute. A similar snap summary might be made relative to possible pollution from uranium mining and processing and from acid leakage at phosphate processing plants.

In California and Alaska, large acreages of alluvial ground have been turned upside down in gold dredging. Here the surficial material has a very high degree of permeability. Following the line of argument outlined above pertaining to Illinois and Indiana, it would seem that in the gold fields a hydrologic benefit may have been gained. However, in a 1913 bulletin on the Fairbanks' gold fields, it was noted that the streams were flashy on dredged ground, but had lower peaks and higher low flows where they came off undisturbed ground.[5]

Mentally reexamining the California and Alaskan dredged areas, we can see that, although the ground there is undoubtedly highly receptive to recharge, it is also very highly permeable and drains rapidly. If ground becomes only moderately permeable, as in the Indiana and Illinois coal fields, we would look for a beneficial effect, but where the cast ground is very highly permeable, the hydrologic effects are undesirable in diminishing ground-water storage and imparting undesirable flow characteristics to streams and, without much doubt, a high sediment load.

PLANT COVER REDUCES SEDIMENTATION

Although not in the writer's field of specialization, a few more words may be said about sedimentation resulting from mine operations. Mining may be likened to urbanization in this respect. With great areas of ground broken up for dwellings and in the building of roads, ditches, and embankments, large areas of fragmented material are necessarily exposed to erosional forces and bleeding off of undesirable sediment into streams and reservoirs will almost inevitably occur. It is particularly interesting to note that measures to curb the sedimentation problem in urban areas involve, to a large measure, establishing a plant cover on the disturbed ground.

The mining industry is probably better prepared, by virtue of its research and thousands of acres of experimental plantings in a variety of climatic environments, to carry out sediment control measures than most municipalities. Further, the mining industry can eliminate some problems by planning and generally can exercise a unified control over large areas of affected ground, something which local governments cannot do in most urban areas.

[5] Prindle, L. M., and F. J. Katz. "*A geological reconnaissance of the Fairbanks quadrangle, Alaska*." U.S. Geological Survey Bulletin 525, 1913.

DEPARTMENT of the INTERIOR

news release

GEOLOGICAL SURVEY

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EFFECTS OF STRIP MINING ON BASIN IN KENTUCKY REPORTED

A report describing the influences of strip mining of coal on the hydrologic environment of a small stream basin in the Cumberland Mountains of Kentucky has been published by the U. S. Geological Survey, Department of the Interior.

The report, summarizing the findings of an 11-year (1955-66) interagency study of the 25-square-mile Beaver Creek basin in south-central Kentucky, reveals that strip mining of coal in the basin has significantly increased the acidity and mineralization of surface and ground water, and increased the sediment of streams below the mined area. These changes in water quality, in turn, have adversely affected aquatic life in the stream.

Strip mining in the Cane Branch basin, a small stream in the Beaver Creek watershed of McCreary County, Kentucky, afforded an opportunity to evaluate some of the effects of strip mining on the water, timber and land resources of the basin. Accordingly, a study by several Federal and State agencies was begun in the Cane Branch basin in 1955. Agencies collaborating on the report summarizing the studies are: the Geological Survey, Bureau of Sport Fisheries and Wildlife, the Forest and Soil Conservation Service, the Army Corps of Engineers, the University of Kentucky, and the Kentucky Department of Fish and Wildlife Resources.

C.R. Collier, R.J. Pickering, and J.J. Musser, hydrologists with the U. S. Geological Survey, and editors of the multi-author report, said that "Cane Branch became an acidic, highly mineralized stream in the spring of 1956 as a result of strip mining of coal in the southwestern part of the basin."

"Seepage and runoff from the spoil bank areas, and overflow from pools formed in the last mining cuts are the primary sources of the acid water that characterizes Cane Branch," the hydrologists said.

After the second of the two periods of mining in the area ended in 1959, concentrations of dissolved constituents and acidity levels in Cane Branch began to decrease slightly from those recorded immediately after mining had begun. Little change in the chemical composition of the water in Cane Branch occurred during the last few years of the study. According to the report the water in Cane Branch is still acid and devoid of aquatic life.

Some of the findings of the investigators:

* The stream in the mined area carried 12 times the dissolved-solids load of a nearby stream unaffected by mining. During the period 1957-62, Cane Branch transported a net dissolved solids load of about 1,370 tons per square mile of drainage area, as compared to 111 tons per square mile that was transported by Helton Branch, a nearby stream that was unaffected by mining, and therefore used as a basis of comparison. The contribution of the spoil banks alone was 14,000 tons per square mile, a chemical contribution 126 times that of the unmined Helton Branch basin.

* Even after active mining ceased, the mined area yield 75 times as much sediment per square mile as the unmined area. Sediment concentrations in Cane Branch during the study period commonly exceeded 30,000 parts per million during storms, whereas the maximum concentration was only 553 parts per million for Helton Branch. The annual sediment yield from areas not affected by mining averaged about 25 tons per square mile compared to an average of more than 1,900 tons per square mile for Cane Branch during the four years following cessation of mining, 1959-62. The average annual sediment yield from the spoil banks was about 27,000 tons per square mile during this period, more than 1,000 times greater than the yield from undisturbed areas.

* Sediment concentrations decreased in 1960 after mining ceased, but remained much higher than in the unmined Helton Branch basin. Further decreases in sediment concentration probably will not occur until revegetation of the spoil banks is sufficient to protect the banks from erosion. Some of the transported sediment has accumulated in stream-bottom deposits in Cane Branch and in Highes Fork, its receiving stream.

* As acid water from the Cane Branch study area moves downstream, it is diluted and neutralized by inflow from streams containing bicarbonate alkalinity. The effects of the mine drainage are almost undetectable in Beaver Creek, 3 miles downstream from the mined area.

* Acid water and smothering sediment have caused a decrease in the variety and abundance of bottom-dwelling organisms in Cane Branch and in Hughes Fork downstream from the entry of Cane Branch. Larvae of mayflies and caddis flies - the primary food for most small stream fish - were almost entirely absent from Cane Branch and were scarce in Hughes Fork as compared to streams unaffected by mining.

* No fish are present in Cane Branch, and only small seasonal populations are present in the most downstream part of Hughes Fork. The pH of Cane Branch water, commonly 3 to 4, is lethal to fish, and the limited fish population in Hughes Fork may be due to the limited availability of bottom organisms that serve as food for the fish.

The report, which also describes effects of mining on tree growth and on microscopic organisms in the streams, is titled "Influences of Strip Mining on the Hydrologic Environment of Parts of Beaver Creek Basin, Kentucky, 1955-66," and is published as Geological Survey Professional Paper 427-C. Copies may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 for $1.50 each (paper cover).

[From the Christian Science Monitor, January 16, 1970]

Mining Ore with Minimal Damage to Natural Beauty

(By Robert Cahn)

Empire, Colo.—Here in the mountains of Colorado, someone has changed the script.

Ordinarily, when an industry—in this case a major mining firm—plans a new development that may disrupt the environment permanantly, conservationists are up in arms, writing to congressmen, threatening law suits, fighting the "polluters" every step of the way.

But for once at least the would-be protagonists are sitting down over a conference table and trying to work out the problems before they happen.

The new Henderson molybdenum mine of the American Metal Climax Company (AMAX) is not due to go into opertion until 1974. Yet since 1966, a nine-member committee of company officials and representatives from the Colorado Open Space Council (COSC) have been holding frequent meetings.

Their purpose: to figure out ways in which the ore can be mined and a mill operated with minimal harm to the forests, streams, and wildlife and to the natural beauty of this Rocky Mountain area which straddles the Continental Divide, 40 miles west of Denver.

UNPLANNED MEETING

This "Experiment in Ecology," as it is called, is all the more unusual in that a "sister" mine of the company near Climax, Colo., is an acknowledged scar on the landscape. And conservation groups are protesting, and threatening a lawsuit, to stop a proposed molybdenum operation by another company in the Challis National Forest of central Idaho.

These days, starting any new mining development in wooded natural areas is to conservationists like waving a red flag in front of a bull.

The experiment came as the reslt of a mistake late in 1966 by two young lawyers, Stanley Dempsey and Roger Hansen, when both of them showed up for a conservation meeting at the right place on the wrong night.

Mr. Dempsey was then assistant counsel for the AMAX molybdenum division, and Mr. Hansen was executive director of COSC, the Rocky Mountain area's biggest conservation organization. Being a week early for the scheduled meeting, they decided at least to have dinner and discuss their mutual interest in conservation.

INITIAL HESITANCE

The talk quickly centered on the company's "Henderson" site near Empire, which Mr. Dempsey said might turn out to be one of the world's largest molybdenum deposits (molybdenum is an alloy used mostly for strengthening steel).

They agreed that a way should be found to avoid repeating the environmental damages of past operations in developing the Henderson site, and decided to see if the new mine could become an example of environmental planning. Shortly thereafter, four AMAX officials and five conservation leaders held their first meeting at the company office in Golden, Colo.

Both of the instigators of the experiment in ecology at first met doubt and resistance from within. Company officials felt that no matter how much they spent on environmental safeguards, they couldn't win—the conservationists would still be critical for the least changes that were made on the resources of nature.

The conservationists hesitated because they felt it might be just a public-relations gimmick, and that the company would do as little as possible. Also, they were looked on with suspicion by other conservationists for consorting with the "enemy," and were accused of selling out their principles.

Mr. Hansen, who now is executive director of the Rocky Mountain Center on Environment, admits that if the proposed mine had been in a wilderness area, conservationists generally would have opposed it. But in this case the company had a right under existing mining laws to pursue the development and could not be legally stopped: The site was not in a protected wilderness area, nor was the land of unique and outstanding recreational or esthetic value.

FLORA AND FAUNA EXPLAINED

At the first committee meeting, Dr. Beatrice E. Willard of the Thorne Ecological Foundation showed color slides of the flora and fauna, and explained the interrelationships of resources in the fragile alpine ecology of the area.

The company executives, somewhat hesitantly at first, divulged in detail their plans for development of the mine and mill which would transform the buried ore into the powder-like molybdenum disulfide.

The major problem was: what to do with the finely ground rock tailings, the waste coming out of the mill which ordinarily is stored in ponds near the mine? More than 300 million tons of tailing are expected before the mine is exhausted.

The company planned, before the experiment in ecology started, to place the mill and the pond near the mine alongside a major highway through the scenic Rockies. But at the suggestion of the conservationists, a search was started for a new location.

EXPENSES REDUCED

After checking all possible locations within a 25-mile radius of the mine, company engineers discovered a site 13 miles away that was hidden from public view and where the mill could be built in a way that would create a minimum of pollution potential. But there was a catch. To reach this site the company would have to tunnel under the Continental Divide.

Company studies showed, however, that the $25 million cost for a nine-mile tunnel and a rail line above the Williams Fork Valley could be economically justified.

At first, the ideas for environmental improvement came from the conservationists. But now, says Mr. Dempsey, the spirit of conservation has caught hold with the engineers who seek new ways of doing things so that as much as possible of the natural setting can be preserved. And although many of the changes are costly and have to be absorbed in the interests of a better company image, some of the changes have resulted in reducing expenses.

On their part, the conservationists question everything, Mr. Hansen says. They even want an explanation for every tree the company wants to remove.

Some of the changes are small—but the cumulative effect is significant.

Instead of the ordinary galvanized steel buildings at the mine site, colored siding which blends with the setting is being used.

Culverts and trestles are planned so that the railroad will not cut off the natural animal trails.

The topsoil and dirt removed from the main mine shaft is being kept in a pile, and the land will be reclaimed when the shaft is no longer needed.

Slopes that have been denuded around the mine for construction purposes are being reseeded. And operations have been kept as compact as possible so that only 300 acres are being used for the mine.

PUBLIC ACCESS PERMITTED

The mill will use water recycled from the tailing pond. And a series of canals will be built above the pond so water running off the mountain will bypass the pond. This should remove the danger that floods might carry tons of waste tailings into the valley below the ponds.

The company is permitting public access on thousands of acres of land around the mill site which had been closed to the public by the previous owners.

The conservation spirit was even infused into the utility which provides power to the mine site. The Public Service Company of Colorado was persuaded to cut selectively only a few trees where power lines were to go instead of bulldozing a a swath through the forests.

WIND PATTERNS CONSIDERED

A team of horses was then used to bring out the cut trees. The transmission towers were brought in by helicopter. And instead of using shining aluminum towers, the utility supplied wooden ones painted a shade of green designed to weather and blend into the setting.

Not all of the ecological problems have yet been solved. Dr. Willard, for instance, feels that information about wind patterns in the area of the tailing pond is inadequate, and that studies should be made to find out in the molybdenum tailings might be swept into the air in strong winds and carried into areas where they could affect plant life.

"We feel the experiment has been a success so far," says Mr. Dempsey. "However, we have a lot to learn about how we are going to do reclamation work on the tailing ponds. And we are planning to hire a full-time ecologist next month.

"The experiment has proved that an industry can work with conservationists in developing an operation. We hope it will serve as an example to others in industry and in conservation."

Mr. Hansen agrees that the experiment has proved that conservatonists can cooperate with industry in some cases. But he points out that some types of development in some locations are not consistent at all with protection of environmental values.

In these cases, where environmental damage would far outweigh the gains, conservation groups may legitimately oppose any kind of development, or seek to have the development moved to an area where it will not cause damage.

[From the Denver Post, Aug. 18, 1971]

New Henderson Mine: Mining, Environment Mountain

(By Dick Prouty)

Empire.—Can a herculean mining operation costing $250 million and taking eight years just to begin production be compatible with the Rocky Mountain environment?

For the Henderson Project of Climax Molybdenum Company the answer seems to be "yes."

The Henderson Project is a plan to mine molybdenum ore under 12,315 foot Red Mountain 8 miles west of here, about 50 miles west of Denver.

The ore body, with about 4½ to 5 pounds of molybdenum being extracted per ton of ore, is large enough to last 30 or more years, Climax officials say.

FIFTY MILLION POUNDS

Annual production is to be 50 million pounds of molybdenum.

The second of three Henderson shafts now is being put down 3,100 feet into the same mountain from which Climax' Urad Mine is extracting ore. Later a third shaft will be sunk.

To get the ore to the mill, 14.6 miles away, a 10-mile-long tunnel is being bored between the mine, under the Continental Divide to the upper reaches of the Williams Fork River.

Harold Wright, Henderson mine manager, said that when full production gets under way—target date is 1975—six completely automated electric trains with 30 cars each will be shuttling back and forth between mine and mill.

"They're completely automated, there's no one in them at all," Wright said of the trains, which are a low-profile narrow-gauge type.

Each train will have four, 50-ton rated locomotives of the Swedish ASEA manufacture, he said.

At the mill, where a mountain is being leveled for the site of a crusher and mill, two tailings ponds and a water reservoir also are under construction.

According to Bill Reno, Climax construction engineer, the tailings ponds will require about 130 acres of the 18,000 acres of land Climax has bought in the Williams Fork drainage.

The project isn't just Climax. It's also the product of the Thorne Ecological Foundation, Boulder, the Denver-based Rocky Mountain Center on Environment (ROMCOE), the U.S. Forest Service, Colorado Water Pollution Control Commission, the Colorado Open Space Council and others.

PAYING THE BILL

But it is Climax, a subsidiary of American Metals Climax, New York City, that's paying the bill. The environmental safeguards were undertaken with "a great deal of apprehension on both sides on how it would work out," said Jim Gilliland, a Colorado native who is director of environmental controls for Climax.

How much the environmental considerations will cost hasn't been calculated. But it's plenty, a company official said.

The first environmental controls were extensions of conservation measures worked out between the U.S. Forest Service and Climax in the early 1960s when the Urad mine was reopened.

The Colorado Water Pollution Control Commission didn't even exist then, but the Climax representative, the late Ernie Jones, pioneered the ecological outlook with Neil Edstrom, former Idaho Springs forest ranger.

LODE DISCOVERED

The Henderson lode was discovered in the mid 1960s. The scope of mining more than 300 million tons of ore, of having water for milling, tailing ponds for nearly 1,900 pounds of mill waste per ton, power lines, roads, housing for workers and other impacts on the environment generated studies on the ecological significance of the development.

Stan Dempsey, Climax attorney, was active in conservation work and as plans for Henderson were outlined he sought a broader input on environmental aspects from the fledgling Colorado Open Space Council.

Climax officials including Dempsey, Don Stephens and Bill Distler, then Henderson Project director and now in charge of mining operations for it, Urad and the Climax, Colo., mines, met with Roger Hansen, now executive director of ROMCOE; Bob Weiner, of COSC; Dr. Beatrice Willard, of the Thorne Ecological Foundation, and with others worked out what is known as "An Experiment in Ecology."

FROM BEGINNING

"The important thing," Distler said, "is that environmental considerations were a part of Henderson from the beginning."

The cooperative attitude of conservationists surprised some company officials and vice versa. But there were environmentalists who weren't—and aren't—happy about another development invading the mountains.

"It can't be hidden," Hansen acknowledged, "the landscape is considerably disturbed. But the impact is definitely minimized. There's no question about it."

"With all the construction, you can't tell now what it's ultimately going to look like," Hansen said.

"But the way it's going, the way it has gone and is intended to go, Henderson will be an ecological model for industrial development. I don't know of anyone in the country who has done the things Climax has done," he said.

WORK WITH PEOPLE

"We've been accused of doing a 'sell-out,' of being a turncoat to the environment and all sorts of things," Hansen, a lawyer and planner, said, "but environmentalists have to accept responsibility and to work with people in good faith."

The results of that faith are just beginning to show. For example:

—Ute Creek, the Williams Fork River, West Fork of Clear Creek and other streams are flowing clear and sparkling despite the enormity of the earthmoving and other work being done near them.

—Clumps of trees at the mine, near the railroad and powerline rights of way were left standing instead of being cut down. In one case a spruce fir stand with trees more than 300 years old still stands—a powerline route was changed instead of cutting the trees.

ABOUT 850 TREES MOVED

More than $20,000 was spent to dig up 850 trees—aspen, fir, spruce, pine—from 4 to 40 feet high and transplant them to provide a 100-yard-long test screen to a high tailing pond. The test plot, that is watered almost daily, will show what kind of trees can best survive the transplant shock. Eventually more trees will be moved to form a screen more than a third of a mile long.

While more than 300 acres of timber were harvested much of the waste was chipped for mulch instead of being burned.

Topsoil is stockpiled until final earth moving and construction is complete and then it will be distributed, seeded and planted with grasses, shrubs and trees.

The 10,000 gallons of water needed each minute in the milling process is to be recycled, a process that saves water and avoids pollution.

WATER COOLED

The 5,000 gallons a minute of warm water encountered in sinking shafts to the working mine level is being aerated to cool and oxygenate it before it goes into clear Creek via settling ponds.

New concepts in power line rights of way and screening were pioneered by Climax and Public Service Company of Colorado. No more wide, straight swathes through the mountains. The wires and towers are treated to blend instead of contrast with their surroundings.

Acres of grass now green disturbed slopes that would have been ignored before. A tertiary sewage treatment plant, almost a high-altitude experiment plant, at 10,320 feet, is planned for the mine and offices.

In the next century, when mining is over, plans for using the reservoirs and tailings ponds already have been outlined.

Fundamental to all this are the ecological inventories made and continuing under the direction of Dr. John Marr, noted University of Colorado ecologist, and Dr. Richard Beidleman, of Colorado College, and others involved in the Colorado environmental movement.

"This way we know what the situation was, what it is, and if it changes how it's changed so we know what to do about it," Gilliland said.

"We'll have the actual data. Instead of guessing and theorizing, we'll know," he said. He was referring to plant, wildlife, water life and other continuing studies.

One of the really tough problems is tailings reclamation. Work at the old Climax, Colo., mine has proven the challenge. Dr. William Berg of Colorado State University, is seeking reclamation answers under a Climax grant.

PROVIDE ACCESS

Not all the environmental improvements have worked. One that failed was Climax plans to open up thousands of acres of its own land in the Williams Fork Valley, and provide access to the Arapaho National Forest, for hunters and campers.

But the guests drove their vehicles across meadows, mountainsides and in other ways tore up the land. The area is now barred to vehicular access, Don Stephens, Climax, public relations representative, said.

"It's still open," he said, "you just have to walk or ride a horse."

He said Climax is considering running a twice-a-day truck route in the area this fall. Then hunters can haul their deer or elk to the access roads, and it willl be brought out in the company truck to the county road.

The impact of the enormous project and anticipated satellite development on the Williams Fork is a major concern of Colorado Game, Fish and Parks officials.

"It's going to change deer and elk migration routes, population concentrations and other factors," Paul Gilbert, area supervisor at Hot Sulphur Springs, said. To the west, across the Williams Fork Mountains, development in the Blue River Valley is affecting deer, elk, upland game birds as well as stream life.

He estimated there are 500 elk and about 500 deer in the area now.

WATER COMPETITION

Competition for water by various interests, including Climax, Denver and other developers is also worrying trout enthusiasts, he said.

"They're making every effort they can to keep the stream clean, but it's the combination of effects including adequate stream flows that concern me," Gilbert said.

The opening of once closed ranches and foot access to the national forest is working out "surprisingly well," he said.

Distler said the company spent weeks searching for a mill and tailing site that would minimize the environmental impact. Of 36 sites, only two were environmentally satisfactory.

The result is a small scenic valley just west of the Williams Fork River, north of Ute Pass.

A portion of the two-track, narrow-gauge railroad between the tunnel portal and the mill will be visible from the county road that follows the river back up the valley from the Colorado River.

The tunnel will be more than 52,000 feet long. The Dravo Corporation has bored more than 3,000 feet underground from the Williams Fork side.

The tunnel and train are expected to cost $50 million.

[From the Washington Star, Aug. 15, 1971]

Threat at Frostburg State—Strip Mining To Invade Campus?

(By Lee Flor)

Frostburg, Md.—Frostburg State College suddenly has found itself confronted with a most unusual problem—the possibility that a strip mining operation may someday gobble up the southern half of its campus.

The college has had high hopes for the southern half of the 212-acre campus. In its 10-year master plan, the administrators planned to put in two buildings and to build a winding road back in the rolling foothills of the land, which is at the base of the Big Savage Mountain.

Other parts of the southern 100 acres were to be an "ecology center," and would be natural woodland, reserved for whatever future use was needed.

But for years, the college administrators did not know that the mineral rights to the land were not owned by the college. Instead, they belong to the Georges Creek Big Vein Coal Company.

VIEWED FROM ABOVE

Strip mining already is being carried out higher on the slopes of the Big Savage. And from those high slopes, strip miners are viewing the campus and down below.

Ironically, the very battle the ecologists have been waging to halt air pollution, in turn, has caused the seam of coal under the campus to have more value.

Before, it was not economical to strip off the top 30 to 40 feet of surface soil to dig out a 36-inch thick seam of coal. But the seam of coal is no ordinary coal. It is Tysons Coal, and has a very low percentage of sulphur.

Ecologists have complained that high-sulphur coal creates too much sulphur dioxide when burned, so recent state and federal regulations have limited many power plants to burning only coal with 1 percent or less sulphur.

A few miles from Frostburg, the Virginia Electric Power Co. (Vepco), which supplies almost all of the electric power in Northern Virginia, has a major power plant. The plant, at Mt. Storm, W. Va., has to buy much of its low sulphur coal from the strip mining operation on Big Savage Mountain above Frostburg College.

So the fight to halt air pollution has transferred the problem to the Big Savage Mountain slope, and indirectly, is posing a threat to the small Frostburg campus.

MINERAL RIGHTS

Richard B. West, the Frostburg college administrator who has been dealing with the problem of the mineral rights and the strip mining possibility, said that no one was sure why the state had not acquired the mineral rights when it bought the land for the campus.

"It's common up here in the mountains for mineral rights to be owned separately from surface rights," he said.

The southern half of the campus was bought when the Maryland State Roads Commission had to acquire some right-of-way for its National Freeways now under construction south of Frostburg. The commission had to acquire a large parcel of land in negotiating with one landowner, and some 100 acres of the land turned out to be surplus after the freeway blueprints were finished. The land adjoined the small campus occupied by the old Frostburg College, so the state gave it to the campus.

West said the question of the mineral rights never came up until several years ago when the college, in the great tradition of college grantsmanship, asked for and received a grant from the Appalachian Regional Commission.

The $66,000 grant was for a pioneering effort to reclaim an old strip mine excavation in the 100-acre area. As part of the preliminary work under the grant, title examiners discovered that the mineral rights were owned by the Georges Creek Co.

600 TONS

The land just above the campus is now being strip mined by the Winner Brothers Coal Co., which owns some land and leases other land for its operations. Every day, the Winner Brothers, George and Albert, mine an average of some 600 tons of coal from their strip mining operation, with much of this destined for the Vepco power plant.

In the negotiations between the Georges Creek Co. and the college, the Winners have become an issue. Because they already are operating a strip mine bordering the campus, Robert C. Harvey, manager of the Georges Creek Co., has proposed leasing the campus coal rights to them.

Under his proposal, the Winners would strip off the top 30 to 40 feet of surface material, and then would scoop out the seam of low-sulphur coal. They would then backfill the strip mine area, and would plant trees and grass on the surface.

RESTORATION PLANNED

As part of their project, they would restore the old excavations left by previous strip mining there some 20 years ago, and then, finally, Georges Creek would surrender all mineral rights to the land.

However, West said the college felt it would be barbaric to have a strip mine on campus. He said he was working with Allan S. Levy, assistant Maryland attorney general, to work out some compromise which would avoid strip mining on the campus.

He said that at one point, Georges Creek had offered to sell the campus mineral rights to the state for $80,000. Levy and West and Georges Creek are still negotiating, and Levy said he felt there was a good chance they could work out a settlement, because Georges Creek management was trying to cooperate.

"If nothing else works, we can condemn the mineral rights," Levy said.

Other state agencies have higher powers of condemnation, called the "quick take," which permits a road agency, for example, to seize a right-of-way and argue in court afterwards about its value.

The state apparently does not have this much power for a college. But then, whoever expected a college to face the peril of a strip mine.

PRESS SERVICE NATIONAL COAL ASSOCIATION

Coal Building | 1130 Seventeenth Street, Northwest | Washington, D. C. 20036 | NAtional 8-4322

(For Sunday a.m.'s, Sept. 19, 1971)

COAL PRODUCTION HIGHEST SINCE 1947 WITH VALUE OF $3.8 BILLION, BAGGE SAYS

WASHINGTON, Sept. 18--Carl E. Bagge, president of the National Coal Association, said today bituminous and lignite coal miners produced about 603 million tons of coal valued at almost $3.8 billion in 1970. It was the first year since 1947 that production had exceeded 600 million tons.

Underground mines produced 339 million tons valued at $2.5 billion and surface mines 264 million tons valued at $1.3 billion, Mr. Bagge said in releasing a 1970 economic and production analysis prepared by NCA economists.

"Aside from the increase in production and the significant economic impact of the coal industry, the point that really stands out in the figures prepared by our staff is the great contribution being made by the surface mining industry to the totals," Mr. Bagge said. "Without surface-mined coal our industry simply would be unable to meet the demands now being placed upon it by the electric utility industry, which is by far the largest single customer for coal and the biggest user of surface-mined coal."

The NCA study was made in preparation for hearings before the Mines and Mining Subcommittee of the House Interior Committee next week on proposals for Federal regulation of strip mining. NCA has previously announced that it is not opposed to legislation requiring surface-mine operators to meet Federal standards in land reclamation, but wants to leave the primary job of developing specific regulations to the states because of climatic and topographical variations.

Mr. Bagge said the study, based on preliminary figures, shows that in 1970:

1. There were 111,517 production and related workers in coal mines, 89,445 working underground and 22,072 in surface operations.

2. The addition of supervisors and on-site office workers brought total employment in bituminous and lignite mines to 127,794.

3. The total payroll was $1.2 billion, of which $954 million went to underground workers and $248 million to surface miners.

This is the breakdown, based on preliminary figures for 1970, for the seven principal coal producing states:

West Virginia--production, 144 million tons, with 116 million underground and 28 million surface; total value, $1,142 million, with $939 from underground operations and $203 million from surface operations; employment, 41,452, with 36,403 in underground operations and 5,049 surface; payroll, $379 million, with $344.5 million underground and $34.7 million surface.

Kentucky--production, 125 million tons, 62.61 million underground and 62.69 million surface; total value, $712 million, with $422 million underground and $289 million surface; employment, 22,418, with 16,659 underground and 5,759 surface; payroll, $194 million with $143 million underground and $51 million surface.

Pennsylvania--production, 80 million tons, 55 million underground and 25 million surface; total value, $585 million, $450 million underground and $135 million surface; employment, 20,936, with 16,101 underground and 4,835 surface; payroll, $211 million, with $159 million underground and $52 million surface.

Illinois--production, 65 million tons, 32 million underground and 33 million surface; total value, $320 million, with $171 million underground and $149 million surface; employment, 8,284, with 5,391 underground and 2,893 surface; payroll, $87 million, with $55 million underground and $32 million surface.

Ohio--production, 55 million tons, 18 million underground and 37 million surface; total value, $262 million, with $98 million underground and $164 million surface; employment, 8,207 with 4,168 underground and 4,039 surface; payroll, $84 million, with $41 million underground and $43 million surface.

Virginia--production, 35 million tons, 28 million underground and 7 million surface; total value, $246 million, with $213 million underground and $33 million surface; employment, 11,077 with 9,423 underground and 1,654 surface; payroll, $96 million, with $82 million underground and $13 million surface.

Indiana--production, 22 million tons, 2 million underground and 20 million surface; total value, $102 million, with $12 million underground and $90 million surface; employment, 2,105 with 572 underground and 1,533 surface; payroll, $23 million, with $6 million underground and $17 million surface.

[From Natural Resources Journal, Vol. 6, No. 1, January 1966]

STRIP MINE RECLAMATION AND ECONOMIC ANALYSIS

DAVID B. BROOKS*

It was proved conclusively that the stripping had no near or substantial relationship to the public health, safety, morals or general welfare.

—Edwin R. Phelps[1]

With strip mining and its companion, the auger-mining process, the shades of darkness moved close indeed to the Cumberlands.

—Harry M. Caudill[2]

It has almost become a cliche to describe strip mining for coal as "rape of the land." Strip mining is a surface method in which large power shovels—some of them the largest in the world—"strip" off the soil and rock overlying coal beds, dump it to one side, and then load the underlying coal onto trucks.[3] An extremely productive method of mining,[4] it nevertheless evokes strong reactions because the unwanted soil and rock are turned into long, successive ridges of unsorted, ugly, and unproductive waste as "strip" after parallel "strip" of earth is mined. These man-made badlands extend over large areas, each ending in a deep pit, the last strip mined out, beside

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* Economist, Resources for the Future, Inc., Washington, D.C. I acknowledge with thanks the assistance of Robert K. Davis, Jack L. Knetsch, Allen V. Kneese and Edwin H. Montgomery, all of whom contributed to the paper through numerous discussions as well as by their comments on an earlier draft.

1. E. R. Phelps, *Current Practices of Strip Mining Coal*, in Proceedings of Symposium on Surface Mining Practices 8 (Univ. of Ariz. College of Mines 1960).

2. H. M. Caudill, Night Comes to the Cumberlands 305 (Atlantic-Little, Brown 1963).

3. The word "strip" is used both as a verb indicating the removal of overburden and as a noun describing the long, thin plan of the areas mined out in each stage of advance. Many discussions of strip mining are available: O. E. Kiessling, F. G. Tryon & L. Mann, The Economics of Strip-Coal Mining (Economic Paper No. 11, U.S. Bureau of Mines 1931); H. D. Graham, The Economics of Strip Coal Mining (Bull. No. 66, Bureau of Economic and Business Research, Univ. of Ill. 1948); University of Ariz. College of Mines, Proceedings of Symposium on Surface Mining Practices (1960), especially E. R. Phelps, *Current Practices of Strip Mining Coal*, *id.* at 1.

4. In 1962 the average productivity at bituminous coal and lignite strip mines in the United States was nearly 27 tons per man per day. The average at underground mines was 12 tons. The absolute difference between the two rates has been increasing. 2 U.S. Bureau of Mines, Minerals Yearbook, Fuels 71, 86 (1962) [hereinafter cited as Minerals Yearbook, Fuels].

which is a cliff called the highwall. With "area stripping," used in relatively flat terrain, the entire surface area is turned into giant washboards. With "contour stripping," used in mountainous areas, the strips resemble looped shoestrings as they follow the sinuous outcrop of a coal seam, leaving a gash of one hundred feet or so in the hillside. Finally, with "auger mining," a relatively new technique, drills as large as seven feet in diameter bore into a seam (often into a high-wall left by stripping) from the surface, leaving it perforated by a series of holes from which the coal has been removed.[5] Any of these methods may cause extensive pollution and erosion damage downslope and downstream of the mine site unless the mine is carefully managed.[6]

Strip mining for coal in the United States will be one hundred years old in 1966, but during much of this time it was not an important method. Since the 1930's, however, strip mining has grown to account for one-half of all anthracite and nearly one-third of all bituminous coal and lignite mined in this country.[7] It has recently been estimated that operating and abandoned strip pits now occupy 500,000 acres in the Appalachian and Midwest coal fields.[8] Since the 1930's, coal strip mining has been attacked—and defended—in literally hundreds of emotional articles, speeches, and political

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5. Minerals Yearbook, Fuels 98-101. See also W. A. Haley & J. J. Dowd, *The Use of Augers in Surface Mining of Bituminous Coal*, in Report of Investigations 5325 (U.S. Bureau of Mines 1957). The average productivity at auger mines in 1962 was about 35 tons per man per day; *cf.* note 4 *supra.*

6. Among the many descriptions of the effects of strip mining on landforms, watercourses, and land use, the following, which do not agree in all respects, were found particularly useful: G. S. Bergoffen, A Digest: Strip-Mine Reclamation (U.S. Forest Service 1962); C. R. Collier et al., Influences of Strip Mining on the Hydrologic Environment of Parts of Beaver Creek Basin, Kentucky, 1955-1959 (Professional Paper No. 427-B, U.S. Geological Survey 1964); G. F. Deasy & P. R. Griess, *Coal Strip Pits in the Northern Appalachian Landscape*, J. Geography, Feb. 1959, p. 72; A. Doerr & L. Guernsey, *Man as a Geomorphological Agent: The Example of Coal Mining*, Annals of the A. of American Geographers, June 1956, p. 197; L. Guernsey, *Strip Coal Mining: A Problem in Conservation*, J. Geography, April 1955, p. 174; G. A. Limstrom, Forestation of Strip-Mined Land in the Central States (Agricultural Handbook No. 166, Central States Forest Experiment Station 1960); Tenn. Dep't of Conservation and Commerce, Conditions Resulting From Strip Mining for Coal in Tennessee (1960); TVA, An Appraisal of Coal Strip Mining (1963).

7. Minerals Yearbook, Fuels 84-86, 172. A brief history of surface mining is presented by J. W. Feiss, Surface Mining—Minerals, Men, and Divots, Paper Delivered to the Conference on Surface Mining conducted by the Council of State Governments, Roanoke, Va., April 13, 1964, p. 6 (mimeo.).

8. TVA, *op. cit. supra* note 6, at 4. An estimate made five years ago concluded that, "on the average, some two acres of every square mile in the Northern Appalachian Coal Fields, and a slightly smaller acreage of every square mile in the Eastern Interior Coal Fields, consist of strip pits." Local concentrations are, of course, much higher. Deasy & Griess, *supra* note 6.

campaigns. During the same period scientific knowledge about the effects of strip mining has been developed from a variety of sources. Both science and emotion are represented in current opinion and in the body of legislation that regulates strip mining in the important producing states.[9]

As yet, however, little effort has been devoted to subjecting these questions to economic analysis.[10] The purpose of this article is to indicate what economics has to say about coal strip mining and attendant efforts to protect other natural resources. More explicitly, I will argue that the private profit signals to which coal stripping firms must and should respond to maximize their profits are not adequate guides for maximizing social welfare. In many situations private market decisions can be relied upon to yield an approach to maximizing social welfare, but this is not the case whenever there is a divergence between private costs and social costs, like the situation presented here. The essence of the strip mining problem is that substantial costs resulting from the process of stripping are imposed on other individuals and are not reflected in the accounts of the coal mining firms.

It will be convenient to use the term "reclamation" to mean efforts devoted to controlling the use of land while it is being stripped as well as efforts devoted to bringing back to use land that was stripped in the past. The term "regulation" will refer to a legal enactment to accomplish one or both of these goals. In popular statements both reclamation and regulation are commonly called "conservation."

I

THE UNIQUENESS OF COAL STRIP MINING

Why has coal strip mining attracted more attention than other mineral commodities mined in open pits? The answer lies in a combination of reasons. First, coal strip pits are common in the wooded and agricultural areas of the populous eastern half of the country, not in the remote and semi-arid West. Second, compared with other non-metallic minerals mined in large quantities in the East, coal

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9. In 1962 bituminous coal and lignite stripping was practiced in 22 states. However, six states—Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia—accounted for about 85% of the tonnage produced. These states and Maryland have laws regulating strip mining. R. G. Meiners, *Strip Mining Legislation*, 3 Natural Resources J. 442, 443 (1964).

10. Bergoffen, *op. cit. supra* note 6, at iii.

stripping requires the production of much larger amounts of waste.[11] Third, compared with open pit metal mines, coal strip pits are very short-lived. The coal is mined from an area within a year or a few years, while iron or copper pits often remain in existence for half a century or more. Fourth, coal mines (not only strip mines) present certain problems not common to other mines. Coal, both in place and in dumps, is inflammable. Some 220 fires are burning in underground seams today and about 500 more burn in waste piles.[12] Many coal seams also carry iron sulfide minerals that react with air and water to form sulfuric acid, thus producing the widespread acid mine drainage that is toxic to fish and vegetation and which causes extensive corrosion damage.[13]

Finally, there are factors that are less definable. Coal mining is a symbol of the industrial revolution and carries with it a congeries of impressions for some people: impersonality, monopoly capitalism, absentee ownership, etc. To these, stripping adds the following: wholesale and rapid change in land use; serious deterioration in a familiar landscape; and extensive stream and valley pollution. It has also been suggested that stripping offends most seriously not by creating ugliness per se, but by creating ugliness in areas where one least expects to find it.

Given this complex of issues—partly rational, partly mystical, but always strongly felt—it is more apparent why individuals with otherwise diverse interests—sportsmen, farmers, conservationists, and even underground miners—could unite in their opposition to strip mining.[14] During the past several decades, therefore, strip mining has been generally and popularly regarded as an evil, mitigated

11. Typically the ratio of waste to coal is 12:1. The ratio of waste to usable product is much higher in low-grade metal mines, but the great bulk of the waste is not produced at the mine but at mills and smelters where it can more easily be handled. Feiss presents an outline comparing the physiographic effects of different mining methods; *op. cit. supra* note 7, at Fig. 1.

12. U.S. Dep't of the Interior, Annual Report of the Secretary for the Fiscal Year 397 (1962); R. W. Stahl, Survey of Burning Coal-Mine Refuse Banks 1 (Information Circ. No. 8209, U.S. Bureau of Mines 1964).

13. The following are useful introductions to the acid mine drainage problem: G. P. Hanna et al., *Acid Mine Drainage Research Potentialities*, 35 J. Water Pollution Control Federation 275 (1963); G. D. Beal, Common Fallacies About Acid Mine Water (Sanitary Water Bd., Pa. Dep't of Health 1953) (mimeo.); and any of the papers by S. A. Braley appearing in mining journals during the 1950's.

14. Indications of both open and hidden attacks by underground miners on the lower cost strippers can be found scattered through the mining literature. Rather more surprising is the fact that the TVA, once the delight of conservationists, is being cast by them in the villain's role for allegedly ignoring the effects of strip mining to purchase cheap coal for low-cost thermal power.

only in part in its high productivity. But this was not the only dilemma that it posed. Conservationists looked with disgust upon the resulting landscape, yet they had to admit that strip mining recovered a greater proportion of the coal than did underground mining.[15] Agronomists emphasized the loss of arable land to strip pits, yet they had to admit that poor farming practices resulted in a far greater loss.[16] Social scientists worried about effects of stripping on local communities, yet they had to admit that stripping not only provided much needed employment in coal towns but also had a far better safety record than underground mining.[17]

Thus, to most people any judgment of the social value of coal strip mining has always been a matter of balance. And it is just this kind of balancing, of choosing among alternatives when there are real and difficult conflicts, that economic analysis is designed to handle.[18] Economic analysis does this by providing a *rational and operational* set of rules for determining whether the benefits from any action outweigh the costs. Moreover, in situations like strip mining, where private costs are not equal to social costs, *all* costs can, at least in principle, be incorporated so that the general goal of public policy, to maximize net social benefits, can be pursued.

The remainder of this paper is divided into three sections. The first is a review of how approaches to strip mine reclamation have changed during the past several decades. The second is a series of conclusions pertinent to economic analysis that I have drawn from the literature, from interviews, and from field observations. Then, in the third section tentative suggestions are made about the application of economic concepts to policy problems.

A final note before proceeding. The emphasis in this paper is on the effects of strip mining on natural resources. There is reason to think that the more immediate problems may relate to the people

15. Strip mines recover 90% or more of the coal in place whereas underground mines seldom recover more than 50%. This conflict is typified in an article by W. C. Bramble, *Strip Mining: Waste or Conservation?*, American Forest, June 1949, pp. 24-25.

16. See, *e.g.*, H. R. Moore & R. C. Headington, Agricultural Land Use as Affected by Strip Mining of Coal in Eastern Ohio 34 (Bull. No. 135, Ohio State Univ. Agricultural Experiment Station 1940) (mimeo.).

17. In 1959 the accident frequency rates at underground bituminous mines were 1.02 fatal and 42.71 nonfatal accidents per million man-hours. The rates at strip mines were respectively 0.46 and 20.69. At auger mines the rates were 0 and 21.20. D. Drury, The Accident Records in Coal Mines of the United States 96-97 (Dep't of Economics, Univ. of Ind. 1964).

18. P. A. Samuelson, Economics: An Introductory Analysis 1-7 (5th ed., McGraw-Hill 1961); R. A. Dahl & C. E. Lindbloom, Politics, Economics and Welfare 18-28 *passim* (Harper & Bros. 1953).

who live in and move out of strip mined areas. Indeed, a large proportion of strip coal comes from the poverty-stricken region defined as Appalachia.[19] Human resources and natural resources are related, of course, and I could not disagree if it were stated that the first emphasis in these areas should be placed on education rather than on reclamation.[20]

II

CHANGING APPROACHES TO THE PROBLEM

Beyond noting the few articles in economics journals, the purpose of this section is not to review the extensive literature on strip-mine reclamation and regulation.[21] Rather, it is to point out the decided change in both tone and content discernible in serious considerations of the subject.

A. Agriculture and Agricultural Journals

Scattered articles on the effects of strip mining and on the minor reclamation efforts of the time began to appear in the 1920's.[22] Discussion warmed considerably in the following decade but focused less on the ill-effects themselves than on the amount of land that was taken, probably permanently, out of agricultural production. The arguments were not well supported and tended to reflect agrarian values.

During the late 1930's, two forces initiated a change in the tenor of discussion. The first was the research interest that state agricultural experiment stations and the Central States Forest Experiment Station of the United States Forest Service began to show in strip mine reclamation. (In the case of acid mine drainage, state engineer-

19. President's Appalachian Regional Comm'n, Appalachia 42-44 (1964).
20. This is surely a major theme of Harry Caudill's book, *Night Comes to the Cumberlands* (Atlantic-Little Brown 1963), especially pp. 305-24. It is also the principal conclusion in M. J. Bowman & W. W. Haynes, Resources and People in East Kentucky 244-46 (Johns Hopkins Press for Resources for the Future, Inc. 1963). These two books should be acknowledged as the source of my interest in these problems.
21. The pamphlets by Limstrom and Bergoffen, note 6 *supra*, include reviews of the literature. Three bibliographies have been prepared: G. A. Limstrom, A Bibliography of Strip-Mine Reclamation (Misc. Release No. 8, Central States Forest Experiment Station 1953); K. L. Bowden, A Bibliography of Strip-Mine Reclamation 1953-1960 (Dep't of Conservation, Univ. of Mich. 1961) (mimeo.); D. T. Funk, A Revised Bibliography of Strip-Mine Reclamation (Misc. Release No. 35, Central States Forest Experiment Station 1962).
22. These early activities were usually reported in the *Journal of Forestry*.

ing experiment stations and the United States Public Health Service served in a similar relationship.) The experiment stations viewed problems created by mining like they did those problems created by farming: they saw damages; they analyzed their nature; and they sought ways of coping with them.[23] Moreover, they financed or inspired studies by individuals in related fields—ecologists, fish and wildlife biologists, hydrologists—so that many disciplines have contributed to our present knowledge of strip pits.

Strip mine legislation was the second force. West Virginia passed the first regulatory law in 1939,[24] and other states followed suit. As state agencies were established to administer the law and carry out reclamation activities, a demand was created not only for researchers but for foresters and agronomists who could put findings into practice over large areas. But perhaps the main contribution of the state laws was a shift of emphasis from cure to prevention, from post-mining reclamation to regulation designed to avoid damages. Moreover, as the postwar agricultural revolution muted the argument that stripped land was needed for food production, the public-oriented perspective of state agencies encouraged them to further shift their emphasis toward recreational use of stripped land.

B. Mining Industry and Journals

For the most part during the prewar years the strip mining industry denied legal or moral responsibility for the effects of stripping. However, as the first results of reclamation research became available, a few companies did experiment with reforestation. Also, several statewide associations of strip mining firms—usually the larger ones—were formed to carry out reclamation programs.[25] Gradually the prevailing attitude shifted from do-nothing to one that could be called "industry *oblige*." But so long as voluntary reclamation was held to be the appropriate policy, strippers fought every state law.[26] Organized efforts were devoted to opposing bills introduced in state legislatures and, when passed, fighting them in the courts. Never-

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23. Much of this work was published in the *Proceedings* of the state academies of science rather than in an official publication.

24. W. Va. Acts 1939, ch. 84.

25. A. L. Toenges, *Reclamation of Stripped Coal Land*, in Report of Investigations 3440 (U.S. Bureau of Mines 1939); L. E. Sawyer, *Reclamation and Conservation of Stripped-Over Lands: Indiana*, Mining Congress J., July 1946, pp. 26-28.

26. For a recent statement that reflects the earlier opposition to any compulsory reclamation, see W. H. Schoewe, *Land Reclamation*, Mining Congress J., Sept. 1960, pp. 92-97, and Oct. 1960, pp. 69-73.

theless, some laws were passed and, with the exception of a poorly drafted Illinois statute, upheld by the courts as a legitimate use of the police power to protect the general welfare.[27]

Today state regulation is no longer opposed by the strip mining industry as a whole. Indeed, one often hears a call for stricter enforcement.[28] There remains some opposition to extending legislation to states which do not now regulate strip mining,[29] but the more broadly supported industry position is to oppose: (1) federal investigation of any kind,[30] and (2) state laws placing responsibility on the industry for lands stripped and abandoned before existing legislation went into effect.[31]

Articles on strip mine reclamation have appeared regularly in the mining press since about 1946.[32] Most articles have been written by officials of the now very active reclamation associations set up by the strippers. These organizations, staffed by foresters and agronomists, were better equipped to utilize the techniques developed by the experiment stations than were mining companies. Their professional attitude is probably the suorce of the most recent shift in the industry attitude. The goal of "industry *oblige*" was to reduce opposition to stripping, much as institutional advertising might improve the public image. But agronomists and foresters, like miners, are interested in production; they shifted the emphasis from public relations to gaining income from mined-out land through commercial forestry, grazing, or (increasingly) charging user fees for recreational use.[33]

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27. Meiners, *supra* note 9, at 445. G. D. Sullivan, Presentation Before the Mineral and Natural Resources Law Section, American Bar Association, Chicago, Aug. 12, 1963 (mimeo.).

28. A. E. Lamm, *Surface Mine Reclamation—Why and How*, Mining Congress J., March 1964, p. 25; D. Jackson, *Strip Mining, Reclamation, and the Public*, Coal Age, May 1963, p. 94. Interstate groups like ORSANCO are also favored over federal regulation; see W. A. Raleigh, *Acid-Drainage Curbs Are Here*, Coal Age, April 1960, pp. 80-84. There are two "ulterior purposes" that are at times alleged to be of influence in the call for stricter enforcement: (1) an attempt to take the steam out of efforts to strengthen existing laws, and (2) an attempt to force the smaller stripping concerns out of business.

29. Schoewe, *supra* note 26.

30. Lamm, *supra* note 28; Meiners, *supra* note 9, at 460. This position is somewhat inconsistent with complaints that reclamation requirements in one state are more expensive than those in another.

31. West Virginia is alone in having a fund into which strip miners pay a fee for reclamation of land mined in the past. Meiners, *supra* note 9, at 458. The ORSANCO rules for control of acid drainage define no responsibility for abandoned mines.

32. Most of these articles appear in *Coal Age* or *Mining Congress Journal.*

33. L. Cook, *A New Approach to Strip Land Reclamation*, Mining Congress J., Aug. 1963, p. 68, and *Reclaiming Land for Profit*, Coal Age, Oct. 1963, p. 94; Jackson, *supra*

C. Economics Journals

It is surprising that during three decades of widespread interest only four articles on strip mining have appeared in economics journals.[34] Of these, only one considers strip mining in a framework explicitly separating private and social values.[35] Another essentially proposes application of a social rate of discount to strippable farm land to retain it in agriculture.[36] A third presents a useful critique of strip mine legislation.[37] And the fourth, written by a geographer, describes the effects of strip mining in a semi-arid region.[38] As a matter of fact, the work of several geographers deserves substantial credit for today's more rational climate of opinion and comes close to providing, albeit qualitatively, the kind of analysis urged in this paper.[39]

The comments above should not be taken to imply that economic considerations are absent in other studies, for information on reclamation cost is given in many articles. However, the data presented are typically very general or very specific. More important, cost is reported as if reclamation were a production process in which private costs could be simply tabulated against private returns. In short, economic data have sometimes been reported, but economics has not been used as a decision framework incorporating social as well as private values.

III

ECONOMIC OBSERVATIONS

To formulate public policy for strip mining with the objective of increasing the net benefits to society, the place of strip mining in our

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note 28. In 1963 a national organization, the Mined-Land Conservation Conference, was formed in Washington, D.C., to coordinate and publicize the work of state associations. The "Voluntary Industry Program for Surface Mined-Land Conservation" of the Conference would be ideal if it were actually practiced. See Mined-Land Conservation Conference, Surface Mine Land Conservation 1-4 (undated) (mimeo.).

34. In addition, strip mining in the context of establishing "safe minimum standards" for conservation practice has been discussed by S. V. Ciriacy-Wantrup, Resource Conservation: Economics and Policies 264-65 (Univ. of Cal. 1952).

35. H. W. Hannah & B. Vandervliet, *Effects of Strip Mining on Agricultural Areas in Illinois and Suggested Remedial Measures*, 15 J. Land & P.U. Econ. 296 (1939).

36. C. L. Stewart, *Strategy in Protecting the Public's Interest in Land with Special Reference to Strip Mining*, *id.* at 312.

37. Meiners, *supra* note 9.

38. A. H. Doerr, *Coal Mining and Changing Land Patterns in Oklahoma*, 38 Land Econ. 51 (1962).

39. See especially G. F. Deasy & P. R. Griess, *Coal Strip Mine Reclamation*, Mineral Industries, Oct. 1963, p. 1; Guernsey, *Strip Coal Mining: A Problem in Conservation*, *supra* note 6.

socio-economic system must be described. The following conclusions, drawn from a variety of sources, seem relevant to an analysis of strip mining in this context.

(1) The day of depletion of the coal minable by surface methods is not at hand, as some have suggested. Technologic advances, manifested in the pit by mammoth shovels, are making it possible to move larger and larger amounts of overburden to reach underlying coal. Furthermore, in thermal generation of electricity, the most important use of coal today, the lower quality coal usually produced at strip mines can be burned as efficiently as the more expensive, higher quality coal produced at underground mines.

(2) Under existing economic arrangements coal strip mining is the highest use of most land stripped or sought by strippers. That is, the present value of the time stream of private net revenues from coal production is greater, usually considerably greater, than the market price of that land for any other use.[40] Not only are the per acre returns from coal higher than from other commodities, but they accrue within such a short time that their present value is not greatly diminished by discounting the future. The difference in capital values is indicated by the active market existing for strippable land.

In other words, both strip mining firms and land owners appear to be making appropriate decisions in terms of the private costs and returns that each must consider.[41] In this framework the long standing argument whether or not strip mines consume land of good, average, or marginal agricultural quality is irrelevant.[42] The same analysis applies whatever the quality of land is involved, though coal companies will presumably have to pay more for higher quality.

(3) By private standards the strip mining industry is acting in an

40. Graham, *op. cit. supra* note 3, at 29-31, 46-51; Guernsey, *Strip Coal Mining: A Problem in Conservation*, *supra* note 6, at 178.

41. This is not to say the market is working in ideal fashion. First, the bargaining advantage lies with the coal companies because they have the drilling records. Graham, *op. cit. supra* note 3, at 50; Guernsey, *Strip Coal Mining: A Problem in Conservation*, *supra* note 6, at 178. Moreover, while some farmers may welcome stripping as a way to get their capital out of the farm, others who would prefer to continue farming may be forced to sell because the area loses economies, perhaps in marketing or in the supply of factors, when too much land is withdrawn from farming. Fear of such diseconomies could set up a chain reaction that in effect lowers property values. Guernsey casts some light on these possibilities; *id.* at 179-81. See also G. H. Walter, *Agriculture and Strip Coal Mining*, Agricultural Economics Research, Jan. 1949, pp. 26-28.

42. Coal operators have generally held that the land stripped was of marginal quality, whereas others have held that it was of higher quality. Evidence indicates that land stripped is neither largely good nor largely poor land for agricultural purposes. Graham, *op. cit. supra* note 3, at 43-44; TVA, *op. cit. supra* note 6, at 5.

efficient manner. Like the exploitation of many other natural resources, the difficulty with coal strip mining is that private standards are not sufficient to define social efficiency. This market failure results because the decisions of strip miners impinge upon other individuals in the economy and affect the miners' production and consumption decisions in ways that are not reflected in their cost calculations. These effects are what economists call technical externalities or external costs. They are of interest not only because they are tangible or intangible costs imposed on others by the mining operation, but more importantly because there is no compensation for such costs and, therefore, no need for the coal operator to control them. They are outside his market calculations—hence the name, external costs—even though they are significant costs to society.

Through the years an almost endless number of ill-effects have been attributed to strip and auger mining. Upon closer examination many of these accusations have been found to be untrue. Other damages, those affecting the sales value of land held by coal companies, should come to be reflected in private decisions. But there are external costs that are real enough, and they form the heart of the strip mining problem. Inasmuch as these costs have been the subject of most of the nontechnical articles about stripping, they need not be discussed here in any detail,[43] but they should be reviewed briefly.

(a) Air pollution is a relatively minor problem, confined to dust at some pits and to smoke from burning waste piles or coal seams.[44]

(b) Water pollution, resulting from acid drainage or sedimentation, or both, is much more serious than air pollution. Acid drainage (actually a greater problem with deep mining) occurs as direct runoff from pits and as seepage from auger holes. It is responsible for caking in boilers and for corrosion of boats and bridges at considerable distances downstream from its point of origin. Acid drainage is also responsible for long reaches of some streams that are permanently devoid of fishlife or vegetation and for occasional fish kills in other reaches. Sedimentation, a more serious problem with contour stripping, results from the erosion of spoil banks, denuded hillsides,

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43. For varying appraisals of the importance of these costs, see references cited note 6 *supra*; also Hannah & Vandervliet, *supra* note 35. Graham, *op. cit. supra* note 3, at 52-61, emphasizes the effect of strip mining on tax collections. Several admittedly biased but nevertheless vivid pictorial reviews have also been published. See, *e.g.*, *Kentucky's Ravaged Land*, Louisville Courier-Journal, Jan. 5, 1964 (special supplement).

44. E. Hall, *Air Pollution From Coal Refuse Piles*, Mining Congress J., Dec. 1962, p. 37.

and access roads. Sediment in streams destroys fish habitat, erodes bridges and roadways, clogs culverts, and aids in undercutting stream banks. It shortens the life of flood control and water storage projects. Both acid drainage and sediment contribute to increased treatment costs for downstream users.

(c) Land problems go hand-in-hand with those of watercourses. The land downslope or downstream of a strip mine may receive eroded material from the mine area. It may become devegetated. In some cases sediment and coal fines have choked stream valleys until the fields become swampy and useless for agriculture. There is some evidence that choked stream beds and the bursting of sediment-built dams are responsible for increased flood damages.[45] Forest development is often altered and wildlife habitat destroyed; stagnant pools commonly develop in old strip pits, and there are cases in which coal fires have set forest fires.

(d) Intangible or less measurable effects derive from aesthetic and cultural values that are not directly tied to markets. Important aesthetic effects result from the loss of a natural environment, whatever its original character. Other aesthetic effects result from the absence of vegetation for years on some spoil banks and from the debris remaining after mining. Aesthetically speaking, the small proportion of land actually consumed by strip pits is of less importance than the much larger area over which its effects are visible.[46] Such intangible costs are imposed not only on residents but on visitors traveling through the area. Equally important are the effects on communities near stripping areas. The character of many may be adversely affected by the transient nature of coal strip mining. Tax burdens for those who remain in the area may rise while the level of, or access to, public services declines because people move away or routes of communication are disrupted. Finally, the highwall itself presents a safety problem near built-up areas.

Some of the external costs discussed above are incurred directly by existing producers of products other than coal and by consumers.

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45. Collier, *op. cit. supra* note 6, at B-1, B-18. However, W. G. Jones argues that presently used methods of backfilling after strip mining contribute to flood control. He claims that the strip pits themselves act as terraces to prevent rapid runoff and that the backfill is more porous than natural soils and holds more water. Jones, *Land Conservation in Pennsylvania Open Pit Mines*, Mining Congress J., Oct. 1963, p. 53.

46. The point that stripping consumes a small proportion of the total land surface was relevant when the community was worried about the destruction of agricultural land. It obviously has no relevance when the effects in question occur away from the site of mining. And it is almost equally irrelevant when many recreational uses of land are considered.

The remainder are represented by local income lost because additional productive opportunities are reduced by stripping.[47] There is no question that income from fishing, tourism, and other recreational activities is reduced while stripping is in progress, and that such income may remain low for years after abandonment of the mine. More questionable are the effects of strip mining on potential industrial development. It is considered important by the Area Redevelopment Administration,[48] and at least one power company has engaged in a reclamation program in the hope of increasing industrial development within its market area.[49]

(4) Less widely recognized than the external costs of coal strip mining are certain external benefits. That is, in some cases stripping confers benefits on individuals or on the community at large for which the coal company is not recompensed. For example, it has been claimed that men employed in strip mines learn skills more widely used in other industries than are those learned in timbering or in underground mining.[50] Other effects are more tangible. When stripping occurs over old underground mines, the process often collapses the roofs and seals openings so that the flow of acid mine water from the deep mines is reduced or eliminated.[51] It has already been noted that some flood control benefits are claimed. In other cases, strip mining can be an effective way of extinguishing fires in coal seams.[52]

(5) It is now rather widely held that technologic problems associated with reclaiming strip-mined land have been solved, and that today's problems relate to managing land and making it more pro-

47. It is not necessarily true that local income losses are net losses to the economy. They may simply be transfers from one region to another. However, given the depressed conditions in many strip mining areas, a case can be made for considering them as net losses.

48. The same approach is implicit in the Appalachia program. The less optimistic side of the argument is carefully presented by Bowman & Haynes, *op. cit. supra* note 20, at 135-59.

49. *Program Drawn To Enhance Landscape*, Electical World, Sept. 17, 1962, p. 94. No doubt this motive also underlies in part the TVA's recent interest in strip mine reclamation.

50. Graham, *op. cit. supra* note 3, at 41-42.

51. Jones, *supra* note 45, at 54, states that strip mining in areas once mined by underground methods has been the greatest single factor in controlling acid drainage in Pennsylvania; see also Jackson, *supra* note 28, at 89.

52. The Carbondale, Pennsylvania, program is the best known example of controlling a fire by strip mining. However, this case does not qualify as an external benefit because the purpose of fire control was fully recognized in the contract signed between the city and the coal companies. *Towns Built Over a Furnace*, Business Week, May 4, 1963, p. 98.

ductive.[53] As a general statement, this is no doubt true. However, there are areas in which further technical research would probably significantly lower the cost of reclamation. Most of our reclamation knowledge pertains to the relatively flat terrain stripped in Indiana, Illinois, western Kentucky, and elsewhere. Smaller but still large amounts of strip coal come from the contour mines in the hills of West Virginia, Pennsylvania, eastern Kentucky, and eastern Ohio. These areas are also the home of the auger mine. But there is little research and still less experience to guide reclamation efforts in mountainous terrain.[54]

Additionally, only a small part of the research on reclamation has treated the method of mining as a variable. It has been shown that the tandem system—a method in which a dragline on the edge of the pit removes and segregates the soil and overburden while a shovel in the pit digs the coal—produces better reclamation results but raises the direct cost of mining.[55] However, there have been no systematic studies of the relationships existing between mining methods, reclamation results, and total costs. This probably results from thinking of mining and reclamation as separate stages of production. In contrast, German coal operators have for years incorporated reclamation practices directly into their mining methods.[56] The same approach is being followed at phosphate mines in Florida.[57] In both cases substantial costs savings are claimed over procedures that divorce reclamation from mining.

(6) Useful information on the cost of strip mine reclamation and control of acid drainage is not readily available. What has been published is often of little meaning because there is no indication of what is included in the cost figures. Such reported "costs of reclamation" may include anything from piles of spoil bulldozed against the

53. G. S. Bergoffen, A Digest: Strip-Mine Reclamation 22 (U.S. Forest Service 1962); R. F. May, *Surface-Mine Reclamation: Continuing Research Challenge*, Coal Age, March 1964, p. 98.

54. Bergoffen, *op. cit. supra* note 53, at iv, 12; Feiss, *op. cit. supra* note 7, at 9. Actually, much the same statement might be made about reclamation in semi-arid areas, which is not a problem today, though it might become one if lignite is ever mined in large amounts. See Doerr, *supra* note 38.

55. Bergoffen, *op. cit. supra* note 53, at 26; Limstrom, Forestation of Strip-Mined Land in the Central States 26 (Agricultural Handbook No. 166, Central States Forest Experiment Station 1960).

56. W. Knabe, *Methods and Results of Strip-Mine Reclamation in Germany*, 64 Ohio J. Science 75 (1964).

57. U. K. Custred, *New Mining Methods Rehabilitate Florida's Strip Mines*, Mining Engineering, April 1963, p. 50; *Land Reclaimers Plan for '68*, Chemical Week, Nov. 14, 1964, p. 55. Of course, reclamation in level and semi-tropical Florida is simpler than in the Appalachian or Midwest coal fields.

highwall to the development of fields and forests. Moreover, costs vary with the nature of the terrain, with local employment conditions, and with the purpose for which the land is being reclaimed. Grading costs, perhaps the major variable, are reported to range from 1¼ cents per ton to 43 cents per ton (over $1000 per acre).[58] Nor is it always clear whether "per acre" figures refer to acres actually stripped or acres affected in other ways. Finally, it is impossible to dissociate costs of mining from costs of reclamation in many reported instances.

Despite the problems of generalizing about reclamation costs, it is nevertheless useful to have some idea of the magnitude of the costs involved. The most frequently cited cost figure is fifty dollars per acre. This amount is supposed to include a very little grading, some soil preparation, simple erosion control, and planting of tree seedlings; it presumes reasonably flat terrain. In rougher terrain the same figure may be used with the understanding that no grading or soil preparation is included but that greater precautions are taken to ensure correct drainage. Reclamation for purposes other than reforestation is generally more expensive.

It is likely that the figure of fifty dollars per acre represents a minimum program serving to avoid the worst effects, rather than an average cost of reclamation. The other extreme is represented in the estimates prepared by a special committee appointed by the Secretary of Agriculture when it was proposed to open a wooded, mountainous area of a national forest to stripping. The committee estimated that the cost of "restoring" mined land to something like its original contour and original forest cover would be $1800 to $3000 per acre, plus $800 to $1500 per acre for land that was disturbed but not actually mined.[59]

The minimum figure can apparently be borne by the coal industry, but the higher figure—assuming the full costs are to be paid by the coal company—would preclude mining. Between these extremes one can find cited almost any cost figure that he considers more repre-

58. TVA, An Appraisal of Coal Strip Mining 9 (1963). Cost figures for strip mine reclamation are usually reported in terms of cents per ton or in terms of dollars per acre. One can be converted to the other by assuming that coal weighs 75 pounds per cubic foot, so that one acre of coal one foot thick (one acre-foot) contains 1600 short tons of coal. If a stripping seam is 3 feet thick, a reclamation cost of $50 per acre is roughly equivalent to 1 cent per ton. Typically divergent views on costs in relatively flat terrain can be found in L. Guernsey, *The Reclamation of Strip Mined Lands in Western Kentucky*, J. Geography, Jan. 1960, p. 11, and in J. Hyslop, *Some Present Day Reclamation Problems: An Industrialist's Viewpoint*, 64 Ohio J. Science 157, 159-64 (1964).

59. S. T. Dana, *The Stearns Case: An Analysis*, American Forests, Sept. 1955, p. 44.

sentative. My own impressions are that costs of $50 to $250 per acre are appropriate for reforestation and pollution control on relatively level land; and that costs in the mountains are unlikely to be less than several hundred dollars per acre, despite claims to the contrary.[60]

(7) Although time has provided considerable experience, it does not appear that strip mine reclamation has been privately profitable.[61] In the majority of cases the net monetary return to a coal company would be greater if the company could avoid performing any reclamation activities at all. This does not mean that the returns (from harvesting timber, leasing, charging user fees, etc.) are insufficient to recoup the direct costs of maintaining and paying taxes on the land. But it does mean that the private returns are insufficient to recoup these costs plus the initial investment in reclamation if any reasonable interest rate is charged for the funds. In short, granting that for one reason or another coal companies have decided to reclaim land, they have made the best of the situation;[62] but the costs and returns are not usually such that an outside investor would look at strip mine reclamation as an attractive venture.

This is in contrast to the position of the reclamation associations and the large coal companies that reclamation is privately profitable.[63] No doubt in special sets of circumstances it is profitable. How-

60. This impression is corroborated by experiments carried out in Pennsylvania. See H. B. Montgomery, *Conscientious Coal Stripping*, Coal Age, July 1962, p. 87. Additional evidence is found in the fact that costs of establishing timber stands in California after burns or harvesting run close to $100 per acre. See J. R. McGuire, *What Are All the Costs of Stand Establishment?*, in Economics of Reforestation 3 (Proceedings of the Annual Meeting of the Western Reforestation Coordinating Comm. 1963). The costs reported by the TVA are much lower, but there seems to be an inconsistency between the amount of coal produced and the acreage mined. TVA, *op. cit. supra* note 58, at 10.

61. As a generalization this conclusion is not common. However, it is supported by many studies on particular projects: G. H. Deitschman & R. D. Land, *How Strip-Mined Lands Grow Trees Profitably*, Coal Age, Dec. 1951, p. 95; P. N. Seastrom, *United Electric Coal Companies Land-Use Program*, Mining Congress J., Dec. 1963, p. 27; H. Kohnke, *The Reclamation of Coal Mine Spoils*, in Advances in Agronomy, vol. 2, at 341 (1950); *Symposium of Strip-Mine Reclamation*, 64 Ohio J. Science 98, 146 *passim* (1964).

62. Thus, recognizing that coal strip mining is a land use generally incompatible with farming, the companies have turned in most instances to commercial forestry or commercial grazing. In England, where a very different land situation exists, reclamation of open pit mines has been directed toward the production of cereals. See the series of three articles by W. M. Davies, *Bringing Back the Acres*, Agriculture, March, April, May 1963.

63. See Mined-Land Conservation Conference, *op. cit. supra* note 33, at 3. In support of the industry position, it is often pointed out that reclaimed strip land is worth more, or is more productive, than adjacent non-stripped land. Such statements are evidence of successful physical reclamation but are irrelevant economically because

ever, most statements about the "profits" are found on closer examination to include only a comparison of revenue and direct cost, not revenue and total cost. In other cases hidden subsidies are involved, as when a company "loans" the use of its earthmoving equipment to the reclamation project or charges off costs for the replacement of soil as an expense of mining. Rarely is reclamation recognized as an investment process on which discounted net returns should amount to at least a normal profit if reclamation is to be regarded as privately profitable. In the few cases for which there are sufficient data to roughly compute and discount net returns, the results run to less than three per cent per year.[64]

(8) Although it is likely that the net private returns from strip mine reclamation are less than a firm could earn from other investments, there is good evidence that over some range the net social returns are high. Social returns include all the benefits from some action, no matter to whom they accrue, whether or not they can be marketed (as social costs include all the costs of some action, no matter who pays them or whether there is a market for them). To restate my conclusion, the direct returns from reclamation, which could be collected by a public body rather than by a private one, *plus* the tangible and the intangible returns accruing to others will often considerably exceed the costs of reclamation. Because these latter, non-direct returns—largely but not entirely represented by external costs avoided—are not collectible in the ordinary sense, strip mine reclamation can be socially, but not privately profitable. However, like private investment, social investment must be justified in incremental amounts. It is not enough to know merely that investment in strip mine reclamation is worthwhile in an overall sense. The benefits and the costs of reclamation vary from place to place —and not always in the same direction. Before investing, one should also know where and in what amount investment will yield the greatest net return. The problem presented by comparison of the social benefits of reclamation with the social costs of reclamation is discussed in the next section.

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considerable money was spent on the stripped parcel of land, whereas none was spent on the other parcel. Therefore, the time stream of costs as well as of returns is different, and it is not immediately obvious that the stripped land is the more profitable.

64. But one much-quoted figure of $3.71 profit per year from reforestation implies a return of 6 or 6½%. The figure was apparently estimated by Professor L. A. Holmes and first published in Strip Mine Investigation Comm'n, Report to the 63rd General Assembly of Illinois 24 (1942).

IV

THE APPLICATION OF ECONOMICS

A. Benefit-Cost Analysis

The main burden of this paper is that benefit-cost analysis offers the most useful framework for making decisions about strip mine reclamation. Benefit-cost analysis is essentially the same sort of decision-making process that is used in ordinary market calculations. However, it can be used in situations in which for one reason or another private market calculations do not produce good results, *e.g.*, external costs in strip or auger mining. In either benefit-cost or private market calculations a comparison is made, in monetary measures, between (1) the gains to be realized if some action is taken, and (2) the things that have to be given up in order to take that action. The action is justified if the benefits exceed the costs or, more accurately, if the benefits exceed the costs by a greater amount than for any alternative action.

The same benefit-cost principles apply whether operating strip mines are being regulated or abandoned pits are being reclaimed. However, it is simpler to illustrate the latter case. Consider a limited budget of, say $1000 available for recreational development at three pits. Pit *A* is near a city; pit *B* is on rolling farmland well out from the city; and pit *C* is in the mountains. Because of differences in the availability of construction equipment, in terrain, and in the types of development proposed (playgrounds in the city park, trails in the mountains, etc.), the costs of reclamation, assumed constant at each pit, vary among the pits as follows:

Pit *A*—$200/acre, Pit *B*—$100/acre, Pit *C*—$300/acre.

Benefits do not remain constant but vary with the amount of land developed. Ignoring for the moment how gross benefits are determined, assume that for three successive acres in each case they are:

	Pit A	*Pit B*	*Pit C*
1st acre	$600	$250	$600
2nd acre	550	150	400
3rd acre	300	100	200

By subtracting the per acre reclamation cost for each of the three acres at each pit, the net benefits are:

	Pit A	*Pit B*	*Pit C*
1st acre	$400	$150	$300
2nd acre	350	50	100
3rd acre	100	0	-100

Costs are lowest for pit *B*. The "three-acre benefit-cost ratio" is highest for pit *A*. Neither is a sufficient criterion for optimizing investment. The greatest net social gain can be won by developing the first acre at pit *A*, the second also at pit *A*, the third at pit *C*, and so forth. Thus, some pits may receive extra reclamation funds while others are not reclaimed at all.

What are the benefits, and what are the costs of strip mine reclamation? As emphasized above, the main benefits of both regulation and post-mining reclamation are represented by external costs avoided. When corrosion of boats or silting of ponds and streams can be reduced, this is a benefit. In addition, there are benefits from making the land productive. Represented by profits from grazing or tree harvesting, and in recent years, from orchards, homesite construction, or recreation fees, these benefits have often been captured by private owners. Other productive uses are likely to lie within the public sector. Use of strip pits for sanitary dumps is among these.[65] Also with the public sector are certain recreational uses and the production of fish and wildlife, particularly when they are treated as primary products of reclamation, rather than by-products.[66] It has even been suggested that strip pits themselves be used as tourist attractions.[67]

The costs of strip mine reclamation appear in two stages. Some are incurred after mining is completed and are clearly associated

65. G. F. Deasy & P. R. Griess, *Strip Pits and the Sanitary Landfill Process*, Mineral Industries, Nov. 1960, p. 1.

66. The best example of the use of strip mined land for public recreation is Kickapoo State Park in Indiana, part of which was built on strip land. (Indeed, almost every brochure on strip mine reclamation carries a picture of people fishing at Kickapoo Park.) Charles V. Riley of Kent State University has conducted pioneering studies on the use of strip land for wildlife production.

67. P. R. Griess & G. F. Deasy, *Economic Impact of a New Pennsylvania Tourist Facility*, 40 Land Econ. 213 (1964); K. L. Bowden & R. L. Meier, *Should We Design New "Badlands"?*, Landscape Architecture, July 1961, p. 226. Use of the unique character of pits is contemplated in Sweden where architects are making long range redevelopment plans for the iron mines; *id.* at 228. Similar proposals have been made but never implemented for the Lake Superior iron district of the United States.

with the reclamation program. When abandoned pits are being reclaimed, all costs are of this type. But operating pits also incur costs because of strip mine regulations and anticipated reclamation activities. Such hidden but, nevertheless, additional costs must also be counted against the benefits of strip mine reclamation.

By moving directly into illustrations of benefits and costs, an important step has been omitted. It has been implicitly assumed that by evaluating social benefits and social costs in terms of dollars, the social value of proposed actions may be approximated. It is not possible to justify this step here. It is sufficient to say that there is broad agreement that market prices or information on willingness-to-pay (which may consist of surrogate measures in the absence of markets) are socially valid indications of the desires of the members of a community for certain quantities of goods and services.[68] Moreover, prices and willingness-to-pay data provide rational and operational guidelines for investment decisions that will maximize society's gain from the use of its resources. By the same token, public intervention in the market is justified when something interferes with the maximization process. This implies that intervention is costless, which is of course not true; however, in the case of strip mining the costs are probably not excessive when compared with the costs imposed by unregulated market operation. As reflected in benefit-cost analysis, prices provide the tools for making public decisions about strip and auger mining that cannot be provided by such nonoperational slogans as "full reclamation."

B. The Role of Public Policy

The first requirement for the systematic use of benefit-cost analysis in public policy toward strip mining is an explicit statement of the social optimum being sought. The appropriate criterion for a social optimum involving strip mining activities is that all costs associated with an optimum level of mining be minimized. This criterion will not be satisfied whenever strip mining imposes costs that are not included in the coal operator's calculations, nor will it be satisfied if

68. An extended discussion of the theory underlying benefit-cost analysis can be found in J. V. Krutilla & O. Eckstein, Multiple Purpose River Development 3-77 (Johns Hopkins Press for Resources for the Future, Inc. 1958). A shorter treatment is presented by Allen V. Kneese, Water Pollution: Economic Aspects and Research Needs 18-20 (Resources for the Future, Inc. 1962). R. K. Davis offers a useful discussion of some "conceptual weeds," such as the notion that economic valuation implies commercialization, which can readily be expanded from recreation planning to strip mine reclamation. Davis, *Recreation Planning as an Economic Problem*, 3 Natural Resources J. 239, 241-44 (1963).

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cheaper solutions to some problems are feasible but are not open to individual operators. These two conditions, external costs and economies of scale, to use the economist's terms, are the most important general rationales for public intervention.[69]

Given the criterion for a social optimum, what is the role of public policy when there are uncompensated externalities? Its main role is redistribution of costs in a manner ensuring that those who are responsible for external costs have an incentive to take them into account. Only when costs can no longer be shifted to others in the economy will private costs correspond with social costs and the social optimum be realized. For example, in many areas strip mine operators have no incentive to prevent mine wastes from being picked up and carried off by streams. Because the miner has free use of the water, a valuable resource, his costs are understated. Simultaneously, a farmer downstream has lower profit from his land because acid and sediment are in the stream. Hence, the farmer's costs are overstated. If the downstream losses are greater than the costs of control at the strip mine, there is a net social loss and society is receiving less from the use of its resources than it could. But if costs are redistributed so that the mine operator must pay compensation to the farmer for damages, this net loss cannot occur.[70] The operator will have an incentive to control the release of sediment and acid to the point at which the added benefits from further control are no longer worth the added expense. If damages remain, it will be cheaper (and socially appropriate) for him simply to compensate the farmer. Once again, net social returns are being maximized. Moreover, they are being maximized by the normal market process in which a private resource owner attempts to minimize his costs. The only difference is that social costs are now made equal and are reflected in his private costs.[71]

There are several things about this process of cost redistribution that deserve further attention. First, not all external effects are eliminated. To do so would be as much a waste of society's resources

69. F. M. Bator, The Question of Government Spending 76-120 (Harper & Bros. 1960); see also Kneese, *op. cit. supra* note 68, at 29-32.

70. In some states, notably Kentucky, there are legal qualifications to the responsibility of coal operators to pay for damages. *Kentucky's Ravaged Land, supra* note 43, at 8-9; H. M. Caudill, Night Comes to the Cumberlands 74-75, 305-09 (Atlantic-Little, Brown 1963). These qualifications, upheld by the courts, derive from the contracts by which coal companies obtained mineral rights to the land around the turn of the century. This legal principle does not invalidate the economic principle stated in the text.

71. This process of "internalizing" external effects is discussed at greater length and with more attention to the theoretical underpinnings by Kneese, *op. cit. supra* note 68, at 20-27.

as controlling none of them. The social costs of moderate control measures plus some damages will usually be less than the social costs of eliminating all external effects. Similarly, there will be some abandoned pits for which the external costs avoided plus the potential net returns with reclamation will amount to less than the cost of reclamation at that location, and such pits would not optimally be reclaimed. On the other hand, with cost redistribution the scale of mining activities, the "optimum level of mining," will also differ from what it would be with an unregulated market. There are some lands that can be strip mined profitably now because certain costs need not be considered by miners. If the miners of these lands had to bear all the costs of strip mining, the operation would not be profitable and the land would probably remain in its natural state. Finally, social benefits and costs must be computed in net terms. In the example above the social cost of crops lost by pollution is the profit expected from those crops, not their gross value. Similarly, the social benefits of a reclamation program include the profit from the crops saved plus any profit that can be earned from the reclaimed land itself.

Redistribution of costs is the major role that public policy can play in the strip mining problem, but that is not the only role of public policy. It also has a role whenever regional or multipurpose approaches to reclamation can capture economies of scale and thus yield cheaper solutions than could be obtained with mine-by-mine approaches. For instance, it has been shown that large multipurpose dams often achieve a significant reduction in damages from acid drainage through dilution of the acid,[72] though it is an open question whether this method is preferable to mine-by-mine methods. Again, better reclamation results can often be achieved by coordinated work in larger parcels of land than may be controlled by one operator. The importance of such economies of scale is indicated by the success of coal operators' conservation associations and local soil conservation districts in West Virginia, where the strip mine law permits the miner to contract with them to do his required reclamation.[73] Regional or multipurpose projects introduce additional questions about sharing the costs of the program. For example, it is not obvious how the costs of a regional program for replanting strip

72. C. S. Clark, Mine Acid Formation and Mine Acid Pollution Control, Paper Delivered to the Fifth Annual Symposium on Industrial Waste Control, Frostburg State College, Frostburg, Md., May 7, 1964 (to be published in the *Proceedings* of the Symposium).

73. E. Leadbetter, *There Oughta Be a Law*, Soil Conservation, Sept. 1957, p. 36.

land in a depressed area should be distributed among mining firms, direct beneficiaries, and the general public.

Finally, the time dimension of strip mine reclamation deserves mention. Many of the damages from strip mining are temporary. An important aspect of benefit-cost analysis is to determine when the costs imposed by temporary losses or temporary ugliness are greater than benefits that may become negligible in a fairly short time. If a strip mine will reforest itself in five or ten years, it would no longer be correct to assign benefits to the reclamation program after that time. Should reclamation be left to nature in such a case? In some cases this might be appropriate action, but if this were the only area near a city for fishing or hiking, then even a temporary loss might impose large costs. Acid mine drainage presents a particular problem in this regard because its effects are so persistent. It has been reported that a stream may require thirty months for restoration after concentrated acid has flowed for barely one hour.[74] That is, the damages are much less reversible than are damages from other pollutants. Consequently, the importance of keeping acid out of streams or of maintaining adequate dilution flows at all seasons of the year becomes critical.

The reclamation program can also be designed to serve varying purposes during the passage of time. It has been persuasively argued, for example, that too much emphasis has been placed on reclaiming land in ways that lead directly to marketable products. A socially preferable procedure may be to make the initial goal one of obtaining cover on the bare soil and eliminating the ugliest aspects of the scar. Later phases of the program may then be devoted to commercial forestry or other profitable pursuits.[75] In any event, the sequence of reclamation activities is another variant in the search for the optimal reclamation program.

C. *Evaluation*

Thus far statements about benefits and costs have been made as though it were possible to evaluate them simply and accurately. This is, of course, far from the truth. They can be exceedingly difficult to evaluate. However, there are many benefits and costs whose market prices can be directly incorporated into the analysis. Value of timber

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74. G. D. Beal, Common Fallacies About Acid Mine Water 4 (Sanitary Water Bd., Pa. Dep't of Health 1953) (mimeo.).

75. Bergoffen, *op. cit. supra* note 53, at 21-22; F. W. Collins, Triple-Phase Strip-Mine Reclamation (Div. of Strip Mine Reclamation, Ky. Dep't of Conservation) (undated).

produced, cost of seedlings, and fees collected are a few of those regularly used in evaluating government projects. There are other benefits and costs that can be evaluated indirectly, though no market exists for the particular benefit or cost in question.[76] In these cases values can be imputed by substituting market prices that do exist. For example, in a Public Health Service study, the amount of money spent each year because of mine acid-induced corrosion of boats and marine structures, caking of boilers, and added treatment by industries downstream was calculated. The annual value imputed to acid drainage control was then the amount of these costs that would be avoided each year.[77] Flood damages, erosion damages, and other costs imposed by strip mining could be evaluated in the same way. Moreover, there are still other costs and benefits, once thought to be unmeasurable, that are proving at least partly tractable to analysis. Recreation is the most important of these.[78] It would seem entirely feasible today to use one of these techniques and the information available on the costs of different types of recreational sites to make a benefit-cost calculation of the net benefits of reclaiming strip land for recreational use.

There will remain, however, benefits and costs that are presently unmeasurable, and whose absolute values may be in principle unmeasurable. But this does not mean that these effects must be completely excluded from benefit-cost analysis. Kneese has suggested that the best way of handling "socially valid goals for which for one or another reason there are no values commensurable with the values pertaining to other elements of the system" is to treat them as explicit requirements in any proposed program.[79] Referring to water pollution control programs, he states:

> This can be done by initially treating these goals, expressed in physical terms, as limits or constraints upon the cost minimization objective . . . . Conceivably this would require a very different combination of units with different operating procedures than a system designed without the constraints. Presuming the constraints are effective, *i.e.*, not automatically met if costs are minimized, they would result in a

76. A. V. Kneese, *Socio-Economic Aspects of Water Quality Management*, 36 J. Water Pollution Control Federation 257 (1964).

77. U.S. Public Health Service, *Acid Mine Drainage Studies*, in Ohio River Pollution Control 973-1023 (Supplement C to Part II, 1944).

78. J. L. Knetsch, *Outdoor Recreation Demands and Benefits*, 39 Land Econ. 387 (1963); Davis, *supra* note 68.

79. Kneese, *Socio-Economic Aspects of Water Quality Management*, *supra* note 76, at 258.

> higher cost system than could otherwise have been achieved. The extra cost represents the limitation which the constraint places upon the objective.[80]

For example, it might be decided that for aesthetic reasons stripped land will remain denuded for no longer than one year. To accomplish this it may be necessary to save and replace topsoil, to do more soil preparation, or to avoid mining in certain sites. All of these procedures would increase the cost of the mining-reclamation process.

This method of making social goals explicit has the further advantage that it permits us to calculate their minimum value. It has been stated by Kneese:

> One useful way of stating the results of variation of constraints which represent goals . . . not valued directly by, or imputable from, the market . . . is in terms of what they must 'at least be worth.' . . . [By] comparing the optimum system with and without the constraint, it is possible to indicate what the *least* value is that must be attached to the increment of pleasure in order to make that level of control procedures worth while.[81]

In short, we are in fact putting a monetary valuation on aesthetic or social goals whether or not we like to think of it that way.

Actually this point is quite general and worth emphasizing. Any restriction or regulation that is placed on the processes of strip and auger mining (or anything else) implies an evaluation. Each has an economic cost that can be made explicit, and one must be able to argue that the social benefits to be gained by imposition of the requirement are worth *at least* this much.

D. Methods and Techniques

In the two preceding sections some principles of benefit-cost analysis and its application to strip and auger mining have been discussed in general terms. The final step in this preliminary assessment of the role of economics is to offer suggestions about how one might actually base decisions on benefits and costs. At this point it becomes convenient to separate the problem of regulating existing strip mines from that of reclaiming abandoned ones.

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80. Kneese, Water Pollution: Economic Aspects and Research Needs, *op. cit. supra* note 68, at 32-33, 42-44.

81. *Id.* at 34-35.

What methods are available for making benefit-cost calculations for reclamation of abandoned strip pits? The most promising approach is the method now coming into use for determining the social value of soil conservation projects.[82] These techniques require careful estimation of expected returns over time and clear recognition of the principle that reclamation must be justified on investment criteria. The data needed, but not presently available, to make these analyses include expected returns from different types and different sequences of reclamation activities on strip mined land of varying qualities and different locations. (Changes in land values may be a clue here.) Additionally, it would be essential to systematically collect data on the external costs of strip mining and to estimate the present value of future damages avoided. Some information of this type may come out of the cooperative study on acid drainage in several river basins in the northern coal fields of West Virginia recently begun by the United States Public Health Service and the West Virginia Bureau of Mines. In the same project various methods of coping with acid drainage will be compared, careful cost accounts being kept for each. The same approach could be fruitfully applied to an area in which the whole set of problems associated with strip mining is at issue.

With such data in hand it would be possible to adapt the techniques applied in soil conservation projects (which already include both direct returns and external costs avoided as benefits) to strip mine reclamation proposals. The problem is essentially no different. Moreover, the method is flexible. It would be possible to use a lower rate of interest for funds loaned in a depressed area; in areas where aesthetic valeus are high, limits on the depth or location of strip mining could be imposed as constraints on cost minimization.

When one turns to the more difficult problem of regulating existing mines, he finds that none of the seven state laws presently in force are adequate to handle the range of problems presented by strip and auger mining.[83] Most laws do not recognize that condi-

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82. A. J. Coutu, W. W. McPherson & L. R. Martin, Methods for an Economic Evaluation of Soil Conservation Practices (Tech. Bull. No. 137, N.C. Agricultural Experiment Station 1959); R. N. S. Harris, G. S. Tolley & A. J. Coutu, Cropland Reversion in the South 61-69 (Agricultural Economics Information Series No. 100, N.C. State College 1963). See also certain of the papers in *Economics of Reforestation, op. cit. supra* note 60.

83. Detailed comment on these laws is given by Meiners, *Strip Mining Legislation*, 3 Natural Resources J. 442 (1964), and a summary of their provisions is given by Bergoffen, *op. cit. supra* note 53, at 26-42. The laws of individual states are generally reviewed in detail in law journals shortly after passage or amendment.

tions vary, hence that external costs vary, within the state. Nor do these laws recognize that both reclamation costs and potential benefits vary with location and terrain conditions. The differences between area stripping and contour stripping are usually ignored. Regulations are applied across-the-board. For example, almost all of the laws impose a single standard for the grading of stripped land and spoil piles. Actually, the appropriate kind and degree of grading depends upon the terrain, adjacent land use, and proposed use of the reclaimed land. Professors Deasy and Griess have specifically urged laws designed to foster

> selective and local modification of the terrain, without major remodeling of the entire surface, [thereby permitting] development, at reasonable cost, of the widest variety, frequently aesthetically most pleasing, and on the whole economically most profitable types of highly specialized land usage—recreation, education, water conservation and waste disposal.[84]

On the other hand, a useful feature of some laws is their provision for substitution of land. Rather than reclaim land now being mined, an operator may elect to reclaim an equal number of acres of land not previously reclaimed. Although open to possible abuse, substitution does permit the reclamation effort to be concentrated on land that will return greater net benefits. It is not difficult to think of other techniques for concentrating the effort, possibly making it more efficient physically as well as economically.[85]

There is no need to belabor the point. The few instances cited indicate that much could be done to make existing strip mine legislation and its enforcement a more effective tool for reducing social costs by requiring certain practices of strip miners and by creating conditions under which socially more profitable reclamation procedures can be followed.

Perhaps there has been altogether too much reliance on control of strip and auger mining by legislative regulations. For existing

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84. Deasy & Griess, *Coal Strip Mine Reclamation, supra* note 39, at 1. On the other hand, Meiners, *supra* note 83, at 449 *passim*, attacks the laws for being too flexible. He seems to view every permissible relaxation of regulation as an unwarranted gift to the strip miner. But in economic terms rigid restrictions, rigidly enforced, may have no more to offer than administrative simplicity. However, Meiners is certainly correct when he argues that whatever the flexibility permitted by law, it is poor practice to allow the mining company alone to determine the degree to which the law will be applied, as is done in some states.

85. The West Virginia practice of allowing soil conservation districts to contract with coal operators to perform required reclamation is one such technique.

operations other techniques may be applicable. In the field of water quality management, techniques such as zoning, effluent standards, and effluent charges have been successfully used to redistribute external costs.[86] Effluent standards are implied by Pennsylvania's "Experimental Rules and Regulations for the Operation and Maintenance of Strip Mines."[87] The rules provide that acid in drainage shall be reduced as close to zero as possible in the outflow and that the iron content shall not be so high that it precipitates as "yellow boy" on the stream bottom. The rules also suggest that hillsides be zoned so that certain areas, notably water courses, be left unstripped. Similarly, the *Stearns* case decision, in which a specially convened board refused to permit stripping in Cumberland National Forest, was a zoning decision.[88] The *Stearns* decision was based not on the fact that the land was public land, but upon the hilly and forested character of that land. It was pointed out that the social costs of stripping would be much greater than the net value of the coal produced. And there was no reason to think that the coal under this land was of any greater value than coal that could be mined without such large social costs. Thus, this decision is not in conflict with other decisions permitting stripping in other national forests where conditions differ. Although rather broadbrush zoning to prevent stripping has been held unconstitutional,[89] there is no reason to think that zoning based on an evaluation of social costs would be so held.

The bonding system, common to all seven state laws, shows great promise as a device to redistribute costs to bring private and social costs in line. These bonds are required of strip miners before they begin operations and are released upon the completion of specified reclamation activities. Unfortunately, there is little evidence that the bonding system is being used as a device to direct reclamation along the socially most efficient path. Rather it is viewed only as a

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86. A. V. Kneese, *Water Quality Management by Regional Authorities in the Ruhr Area, with Special Emphasis on the Role of Cost Assessment*, in Proceedings of the 1962 Meeting of the Regional Science Association (in press). See also other papers by Kneese for elaboration on the use of these techniques.

87. Sanitary Water Bd., Pa. Dep't of Health, Experimental Rules and Regulations for the Operation and Maintenance of Strip Mines to Prevent Pollution of Waters of the Commonwealth (1952) (mimeo.). The ORSANCO acid drainage control program is similar; see Raleigh, *Acid-Drainage Curbs Are Here*, Coal Age, April 1960, p. 80.

88. Dana, *supra* note 59. There was an additional legal question in this case involving mineral rights reserved when the land was taken into the national forest. However, the board was instructed not to consider this question but only to evaluate the long term public interest.

89. G. D. Sullivan, Presentation before the Mineral and Natural Resources Law Section, American Bar Association, Chicago, Aug. 12, 1963, pp. 11-12 (mimeo.).

club over the heads of the operators, and with lax administration it need not be a very heavy club. First, the amount of the bond is usually fixed by law. It is not varied with the character of the land, the proposed method of mining, the nature of the reclamation problem, or the past performance of the coal operator. Second, there is no attempt to use the bonds as a device to gather blocks of land into planned reclamation areas. One strip pit could be reclaimed for forest, the adjacent pit for meadow. Third, in many cases the bonds are set so low that it is cheaper to forfeit than to perform any reclamation. Finally, the bond is usually returned on the basis of certain activities, not on the basis of certain accomplishments. The fact of seeding, not of growth, is sufficient to have the bond released. In short, there is little economic rationale for the amount of the bonds or for their terms as they are used today. If, instead, the bonds were set according to some benefit-cost guidelines taking into account the nature and beauty of the terrain, proximity to urban areas, the time required for natural revegetation, and alternative uses of the land, among other things, the net benefits to society from the whole strip mining process would be significantly increased.

All of the methods suggested to achieve a socially preferable allocation of resources would require more complex administrative procedures than do the current across-the-board rules. Public intervention is never costless. The justification for the added administrative costs lies in the social gains that can justifiably be expected from the application of economic concepts to the problems created by strip and auger mining. Finally, there is every reason to think that the strip mining industry could accommodate itself to a new regime. It is a remarkably resilient industry that has taken many other problems in its stride. Wtih further research it may appear that the socially optimal position is not so privately expensive after all.

CONCLUSION

This is an opportune time to review the problems associated with strip and auger mining for coal. Public concern is high, and this concern derives increasingly from the desires of numerous individuals and groups residing in urban areas, rather than from those few whose interests are directly affected. The legislatures of a number of states have considered new or amended strip mine laws in the past year or two. Such legislative proposals invariably generate even broader public interest. The chairman of the mineral law section of the Pennsylvania Bar Association noted that the 1963 amendments to the strip mine laws of that state were "the single, most controversial piece of legislation of the past decade."[90]

With passage of the Appalachian Region Development Act of 1965,[91] strip mining has become for the first time an explicit concern of the federal government. This federal concern is potentially the most important development for solution of the problems of strip and auger mining. The act authorizes the spending of funds to cope with the effects of both surface and deep mining. Indeed, President Johnson, upon the insistence of Governor Scranton, agreed to substantially more funds than had originally been proposed.[92] Additionally, Senator Lausche's perennial bill to authorize a federal study of strip mining, which in other years had aroused vehement opposition and had never passed out of committee, was incorporated almost completely in the act as one of the few sections made applicable to the entire country rather than solely to Appalachia.[93] The importance of this new federal involvement in relating the problems of local and Appalachia is reflected in the strong positions taken outside of government. At one end are those who see an expanding coal industry, largely by means of strip and auger mining, as the key to Appalachian redevelopment. At the other end are those, like Harry Caudill, who claim that the social costs of strip mining in the mountains are so high that it should be completely prohibited.[94]

With interest focused on strip mining from a number of sources, there is danger that the desire for action will foster uneconomic or

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90. D. B. Dixon, *Report of the Mineral Law Section*, 34 Pa. Bar Ass'n Q. 456, 457 (1963).

91. 79 Stat. 5 (1965) [Pub. L. No. 89-4, 89th Cong., 1st Sess. (March 9, 1965)].

92. Washington Post, April 23, 1964, p. A-6, col. 1, and April 29, 1964, p. A-11, col. 1.

93. Pub. L. No. 89-4, § 205(c), U.S. Code Cong. & Ad. News, March 20, 1965, pp. 100-01.

Struck by the inconsistency of proceeding simultaneously with reclamation and with a study of how best to go about it, Senator Lausche succeeded in having the Appalachian Bill amended to provide that no federal funds be spent to restore privately owned strip land, pending completion of the study. Immediate reclamation of public land is permitted. Pub. L. No. 89-4, § 205(d), *id.* at 102. (This amendment to the bill was one of two passed on the floor of Congress. Washington Post, Feb 2, 1965, p. A-4, col. 2.)

Some work on the application of benefit-cost analysis had already been started in the Department of the Interior. Interview With E. H. Montgomery, Resources Program Staff, Dep't of the Interior, June 3, 1964.

94. H. M. Caudill, *Appalachia: Path From Disaster*, The Nation, March 9, 1964, p. 240. The special supplement to *The Courier-Journal* stated that such a prohibition would be ideal, but that it was unattainable. *Kentucky's Ravaged Land*, Louisville Courier-Journal, Jan. 5, 1964, p. 13 (special supplement). See also Knabe, *supra* note 56, at 141-42.

inconsistent programs. The problem is basically one of allocation of resources. An unregulated market will not produce a socially optimal allocation because of technical externalities. The purpose of this paper has been to indicate that a rational public approach to this problem, based on benefit-cost analysis, is within the capabilities of our analytic methods. Three different but interrelated goals have been implied, goals that may complement or oppose the others.[95] The first goal is national productivity, maximization of the net value of output from the resources that society puts into production. This goal is presumably approached by firms operating through the market system in response to free consumer choice. However, it is also this goal that requires government intervention to minimize the total of all costs associated with an optimum level of strip and auger mining whenever (1) costs associated with mining need not be considered by miners, or (2) a regional or multipurpose reclamation program would be more efficient than a mine-by-mine approach.

The second goal includes cultural and aesthetic values that cannot, for one reason or another, be put directly into the cost minimizing calculation. They are represented by constraints on the ssytem forcing it away from the minimum cost point. The implication is that added benefits received are greater than added costs incurred. The importance of this quality of the environment goal is increasing. A substantial proportion of the public seems to be opting for beauty, or at least for the absence of ugliness.

The third goal for programs of strip mine reclamation is redistribution of income to individuals in stripped areas whenever these areas fall within the scope of the poverty program. For our purposes, this goal can be narrowed to local employment. If local employment in certain areas is accepted as a benefit, it follows that the "cost" of certain reclamation projects will be reduced to the extent that men who would otherwise be unemployed will secure jobs. On the other hand, if action directed to other goals reduces the amount of mining in some areas, an important conflict that must be resolved develops among the goals. Again, this goal of redistribution of income is real because the public seems to be opting for the elevation of poverty stricken areas.

The three goals of national productivity, quality of the environment, and local employment together represent a rationale for pub-

95. Bowman and Haynes outline policy criteria for eastern Kentucky in terms of a set of goals, and I have drawn upon their formulation. Bowman & Haynes, Resources and People in East Kentucky 259-66 (Johns Hopkins Press for Resources for the Future, Inc. 1963).

lic policy on strip and auger mining. By the use of benefit-cost analysis conducted under constraints, an explicit and flexible framework becomes available for considering both regulation of existing surface mines and reclamation of the "orphan pits" abandoned in earlier years. Unfortunately, we are still a long way from having the data necessary to make such analyses. If the primary purpose of this paper is to emphasize the applicability of economic analysis to strip and auger mining, its secondary purpose is to indicate the lack of appropriate data and to stimulate the collection of it.

[From Natural Resources Journal, Jan. 1971]

A MEASUREMENT OF THE EXTERNAL DISECONOMIES ASSOCIATED WITH BITUMINOUS COAL SURFACE MINING, EASTERN KENTUCKY, 1962-1967

HERBERT A. HOWARD†

The purpose of this article is to suggest an approach in measuring both the assumed external diseconomies arising from surface mining and the internal expenses incurred by firms to reduce such social costs. These internal expenses are associated with reclaiming the surface-mined land. The term "external diseconomies" or social costs as used herein refers to all of those damages and harmful effects sustained by others as a result of productive processes, and for which the private firms are not held accountable; in addition, such costs must be avoidable and shifted to other persons or society in general. The various types of external diseconomies arising from each of the several sources within the mining site are calculated separately; charges to be incurred in future years are discounted to the year in which surface mining takes place. When further reclamation is performed, the average internal expenses and the average external costs are computed and compared.

For the purpose of exploring this approach, an examination is made herein of the internal expenses and assumed external diseconomies associated with the eastern Kentucky bituminous coal surface mining industry during the 1962-1967 period. The changes over this six-year period in the Kentucky law and regulations concerning the reclaiming of land disturbed by such surface mining[1] caused significant reductions in external costs imposed upon society in the form of damages from acid run-off water, silt and sediment material, landslides, losses by owners of the land surface only, and loss of aesthetic values. The more notable alterations in the reclamation provisions and their enforcement occurred in 1964 and 1966. These revisions changed the magnitude of each external cost source and its duration. In addition, the changes in reclamation requirements and enforcement procedures increased the mining firms' internal mining expenses.

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1. Unless otherwise indicated, the term "surface mining" as used herein refers to eastern Kentucky bituminous coal surface mining (auger plus strip).

External cost decreases and internal mining expense increases for the 1962-1967 period are computed and compared both on a per-disturbed acre and a per-ton-mined basis. This period is chosen in order to determined such annual costs before and after the 1964 as well as the 1966 revisions in reclamation procedures and enforcement. The specific external costs examined are:[2]

Damages from acid run-off water
Damages from silt and sediment materials
Loss of aesthetic values
Losses incurred by owners of the land surface only
Losses caused by landslides

The calculated internal costs of the mining firms to perform the land reclamation include:

Direct reclamation costs (land regrading and revegetation).
State surface-mining permit and acreage fees.
Performance bond fees.
Other administrative costs.

The approach utilized herein may be useful in analyzing the costs and benefits associated with surface mining other than bituminous coal.

I
THE METHOD OF MEASUREMENT

A. *Types and Sources of External Costs*

The basic objectives of the Kentucky reclamation requirements are:

1. Reduction of external diseconomies caused by acid-run-off water.

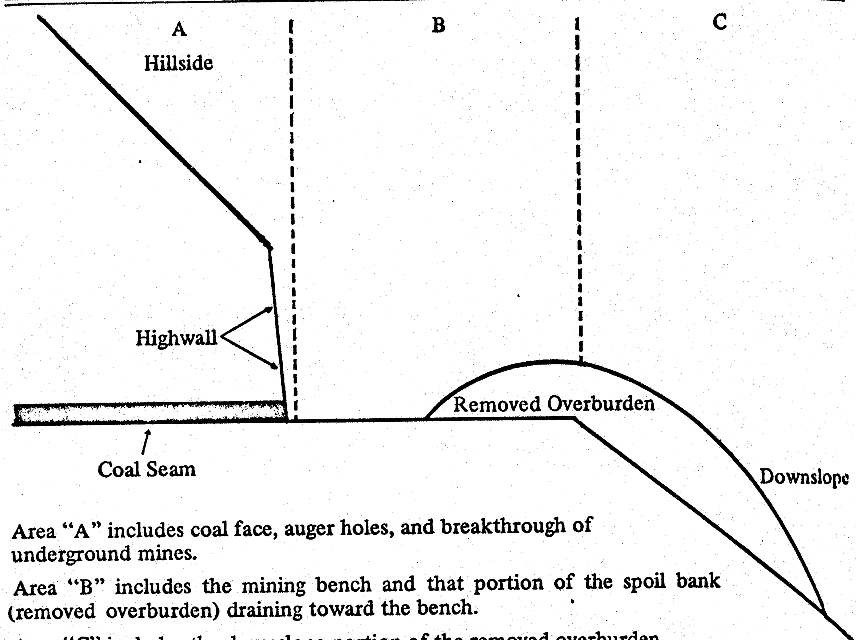
Sulfuritic minerals in the material in and around the coal seam are exposed during the mining process. These substances are carried from the mining site by storm run-off water. The pollution of streams and

2. It is recognized that other external costs exist such as the damage to society by dust arising from the mining operations and from coal truck traffic, and damages to public roads and bridges by coal trucks above their share of road taxes. However, these external costs are not within the purview of the state law. In addition, the creation of some comparatively level land in the mountaineous terrain of eastern Kentucky may be considered as an offsetting benefit arising from surface mining. These other possible damages and benefits are not measured herein. In addition, the lower industrial accident rate may be cited as a benefit of surface compared to underground mining; however, the difference would not correctly be included as a benefit in this analysis. These differential accident rates would appropriately be considered in an examination of the comparative costs and benefits of all sources of fuel -coal, oil, gas, nuclear, hydro, and solar.

rivers by these minerals corrodes bridge supports, increases the cost of processing water for both domestic and industrial use, kills fish, and decreases the aesthetic values of streams and lakes. Acid water originates in three different areas of a contour mining site in eastern Kentucky. These areas are labeled "A" "B" and "C" in Figure 1.

FIGURE 1

Sources of Acid Water and Silt Pollution Where the Contour Method of Bituminous Coal Surface Mining is Utilized



Area "A" includes coal face, auger holes, and breakthrough of underground mines.

Area "B" includes the mining bench and that portion of the spoil bank (removed overburden) draining toward the bench.

Area "C" includes the downslope portion of the removed overburden.

2. Reduction of external diseconomies caused by sediment material flowing from the mining site.

Silt material is carried from the mining site by run-off water into surrounding streams and bodies of water. This sediment reduces the water-carrying ability of streams and the storage capacity of lakes and reservoirs.[3] The basic sources of this silt material are areas "B" and "C" in Figure 1.

3. Reduction of other external diseconomies.

Surface mining removes the vegetative cover of the land and causes

3. At the same time, it is recognized that a reduction of the water run-off rate in some tributaries may be beneficial.

some loss of aesthetic values. Owners of the land surface only may receive from the mining firms a relatively reduced amount of compensation because of the provisions of the broad form land deed.[4] The mining process may entail additional external charges such as damages from landslides.

B. Acres Disturbed by Surface Mining

In the years prior to 1966, the land measurements submitted in surface mining permit applications were not computed according to any common standard. Such measurements were probably more accurate from 1964 than in earlier years, since commencing in this year the mining areas were surveyed by professional engineers. However, in 1966 and 1967 the acreage was determined by a standard formula promulgated by the Kentucky Reclamation Division (Kentucky Department of Natural Resources). Comments by personnel of the Division in 1968 indicate that the actual acreage disturbed by surface mining was grossly understated in permits issued in earlier years. Therefore, the acres disturbed in 1966 are used herein as a standard for the calculation of such acreage in other years. Table 1 shows the acres considered disturbed during 1962-1967 and also an example of the method of acreage calculation utilizing the 1966 permitted acreage as a standard.

C. Discounting of Specific External Costs

The procedure for measuring some external costs involves the deduction of the share originating in eastern Kentucky surface mining sites from the total of such costs which arose from all bituminous coal mining in the Appalachian region. The total cost figures utilized are those estimated by the U.S. Public Health Service (references are shown in Table 2). Other costs are those contained within eastern Kentucky, such as those imposed upon land surface owners only. All costs are assigned on a per-disturbed-acre basis, and some costs are further allotted to each part of the mining site, such as acid run-off water from only the downslope of the removed overburden. Costs from all sources are summed and computed for the year of mining and future periods. Costs incurred in future years are discounted to the year of mining.

The suggested measurements include:

> the external costs originating from a period's surface mining operations—this period's charges plus those of future periods;

4. This type of land deed, used extensively in eastern Kentucky, separates the surface and the mineral rights. Several aspects of this land deed are further discussed below.

TABLE 1

Data Utilized in the Determination of Actual Acres of Land Disturbed by Bituminous Coal Surface Mining in Eastern Kentucky, 1962-1967

(1) Year[1]	(2) Average Seam Thickness Stripped[2] (ft)	(3) Average Seam Thickness Augered[3] (ft)	(4) Average Seam Thickness[4] (ft)	(5) Tons Per Acre[5]	(6) Total Surface Production[6]	(7) Total Acres Disturbed[7]	(8) Tons Per Acre Disturbed
1962	3.5	4.1	3.8	6,840	6,390,836	3,364	1,900
1963	3.7	4.2	3.95	7,110	6,993,194	3,541	1,975
1964	4.0	4.2	4.1	7,380	7,626,482	3,720	2,050
1965	4.3	4.3	4.3	7,740	9,587,626	4,459	2,150
1966	4.4	4.4	4.4	7,920	9,711,238	4,414	2,200
1967	4.5	4.4	4.45	8,010	11,352,004	5,102	2,225

NOTES: [1] Calendar years.

[2] and [3] Average seam thickness for 1965 is from U.S. Bureau of Mines Information Circular 8345, W. H. Young, *Thickness of Bituminous Coal and Lignite Seams Mined in 1965*, (August, 1967); seam thicknesses for 1962 through 1964 determined by interpolation (utilizing data for 1960 and 1965); seam thicknesses for 1966 and 1967 determined by extrapolation and estimates by mining engineer, Kentucky Department of Mines and Minerals.

[4] Average thickness determined by an average of the strip and auger thicknesses, since approximately one-half of eastern Kentucky surface tonnage is produced by each method of mining.

[5] Calculated on the basis of 1,800 tons per acre foot of coal and 100 percent recovery.

[6] Data from *Annual Reports* of Kentucky Department of Mines and Minerals for the period covered.

[7] Actual acres disturbed including coal-haul roads according to the standard used in 1966 by the Kentucky Reclamation Division. The acres newly permitted in 1966 plus the acres renewed in 1966 minus the acres renewed in 1967 equal 4,414 acres, the number considered disturbed in 1966. The total production for 1966, divided by 4,414 acres equals 2,200 tons produced for each acre disturbed. The tonnage from an acre of coal in 1966 equals 7,920 and divided by 2,200 equals 3.6 acres disturbed for each acre of coal. Using this standard of 3.6 acres, the total acres disturbed for any other year may be determined. For example, in 1963: total production of 6,993,194 tons divided by 7,110 tons equals 983.57 acres of coal; the acres of coal multiplied by the standard of 3.6 equals 3,541 acres disturbed.

changes in these external costs caused by natural forces and by land reclamation requirements.

The specific costs for the 1962-1967 period, symbolically, are:

The amount of external costs from surface mining operations in time period t caused by acid run-off water,

A_t^c = from the coal face, auger holes, and breakthroughs of underground mines.

A_t^m = from the mining and fill bench.

A_t^s = from the downslope of the removed overburden (spoil bank).

$$A_t = A_t^c + A_t^m + A_t^s$$

The amount of external costs from surface mining operations in time period t caused by silt material,

S_t^m = from the mining and fill bench.
S_t^s = from the downslope of the removed overburden (spoil bank).
$S_t = S_t^m + S_t^s$
B_t = The amount of external costs from surface mining operations in time period t caused by the loss of aesthetic values at the mining sites by the general public.
O_t = The amount of external costs from surface mining operations in time period t imposed upon owners of the land surface only.
L_t = The amount of external costs from surface mining operations in time period t caused by landslides. These costs are in addition to any additional acid water and silt damages caused by landslides.

The total external costs from surface mining operations in time period t,

(1) $E_t = A_t + S_t + B_t + O_t + L_t$

is a product of the number of acres disturbed and the charge per acre. For example:

N_t = The number of acres disturbed in period t.
C_t = The dollar amount of external cost per disturbed acre from surface mining operations in time period t, caused by acid run-off water from the coal face, auger holes, and breakthroughs of underground mines.

(2) $A_t^c = N_t C_t$

Even if no changes in the land reclamation requirements take place, it must be recognized that nature causes some of the external costs to change over time. For example, the acids in the overburden leach out over time, fallen material from above the coal seam may gradually cover the face of the coal seam, and vegetation spreads to disturbed land from the surrounding area. Thus, the physical amount of acid pollution, for instance, may decrease over several years. Therefore, C_t must also reflect any changes in costs resulting from natural causes.

(3) $C_t' = C_t^o (a_{ot} + a_{lt} + \ldots a_{nt})$

$= C_t^o \sum_{i=0}^{n} a_{it}$ (n = number of the year in which $a_n = O$) .
= Total external costs per disturbed acre for acres disturbed in

period t and including costs arising in future years (but not discounted).

The value of the coefficient "a" is assigned for each time period. For example, the total costs from this source for the mining which took place in 1963 is computed by assigning the following values to the coefficients.[5]

$a_0 = 1.0 \quad a_2 = .4 \quad a_4 = .2 \quad a_6 = 0.0$

$a_1 = .6 \quad a_3 = .3 \quad a_5 = .1$

$$(4)\ C'_{1963} = \$4.59\,(1. + .6 + .4 + .3 + .2 + .1 + 0) = \$11.934$$

And where $N_{1963} = 3{,}541$ acres,

$$(5)\ A^{c}_{1963} = \$42{,}258.29 \text{ (not discounted).}$$

The purpose of reclamation requirements is to reduce the amount of the external diseconomies; therefore, these restraints have the objective of reducing the values of the coefficients. For example, more complete coverage of the coal face and auger holes would reduce the value of "a" for each time period. In addition, the time span may be shortened and cause a_t to become zero at an earlier period.

Future costs associated with any period's coal production should be discounted to the base period. But what rate of discount should be used? If the mining firm is forced by law to incur all external costs, it could either pay these costs as they occur each year or establish a sinking fund. In the former case the future costs should correctly be discounted at a rate appropriate for a mining firm. The U.S. Department of Interior recommends a rate of twelve percent to represent mineral industry expectations for normal risk undertakings.[6] The use of this rate would assume that the firm earns twelve percent on its funds and pays the external costs in each future period. The second possibility would assume that the firm establishes in the period of mining a sinking fund of a sufficient amount to cover all future costs. If such a fund is invested in Government bonds, for example, the appropriate discount rate should be utilized.

5. The values of the coefficients and the time spans were determined in consultation with personnel of the Kentucky Reclamation Division, Kentucky Reclamation Association, Water Resource Center, Indiana University, and others.

6. U.S. Bureau of Mines, Div. of Economic Analysis, Economic Advice No. 15, Economic Valuation of Mineral Resources (1968).

An alternative to these two methods of calculating the present value of future costs is to assume that each other firm or segment of society incurring these external charges has its own discount rate. The present value of future charges would then be calculated using a multitude of discount rates. Thus, firm "A" which incurs certain costs due to acid water pollution would be reimbursed an amount in the year of mining to cover all of its future costs from this source of pollution. In this case, the present value of these future costs would be discounted at the rate appropriate for firm "A" and not the mining firm. An additional alternative would be that the mining firm would place funds in some other economic endeavor which would return more than twelve percent. In this case, the external charges would be discounted at this higher rate. However, we must assume that the mining of coal represents the best opportunity available to the firm for the investment of its funds, otherwise, it would be engaged in the other economic activity with the higher return.

The intent of the Kentucky reclamation law and regulations is to reduce or eliminate these external charges by prescribing certain land reclamation, rather than by requiring direct reimbursement to other parties or public agencies. However, either method would minimize losses of these external parties. Reimbursement may be considered as the estimated maximum net cost chargeable to the mining firm. Therefore, the rate of twelve percent is considered appropriate for the calculation of the present value of future costs.

Equation (5) must therefore be extended to include the discounting of future costs.

r = discount rate.

$$(6)\ C_t = C_t^o \sum_{i=0}^{n} \frac{a_{it}}{(1+r)^i}$$

$$= C_t' \text{ discounted.}$$

Thus, the present value of the total external cost from Source A^c arising from the 1963 surface mining operations, where r=12 percent,

C_{1963} = \$10.336

A^c_{1963} = \$36,599.78 (Instead of the undiscounted amount of \$42,258.29.)

II
EXTERNAL COSTS

A. Source A–Acid Run-Off Water

Table 2 depicts the data for the computation of the external costs arising from this type of water pollution. The cost of \$11.466 per

TABLE 2

Data Utilized in the Determination of Total External Costs Arising From Acid Mine Run-off Water From Eastern Kentucky Bituminous Coal Surface Mining; 1962-1967

When the Base Year (t) is:	(C_t) Cost Per Acre Disturbed (Present Value in Base Year)	*The Time Periods* *The Value of the Coefficients* Dollar Value Discounted to Base Year at 12 percent a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7
For A^c (From Coal Face, Auger Holes, and Breakthroughs)		1.	.6	.4	.3	.2	.1	0	
1962 and 1963	$10.336	4.590	2.459	1.464	0.980	0.583	0.260	0.000	–
1964 and		1.	.2	0					
1965	5.410	4.590	.820	0.000					
1966 and		.5	0						
1967	2.295	2.295	0.000						
For A^m (From Mining Bench)		1.	.7	.4	.2	.1	0		
1962 and 1963	4.921	2.290	1.429	0.730	0.326	0.146	0.000		
1964 and		1.	.4	.1	0				
1965	3.291	2.290	0.818	0.183	0.000				
1966 and		.7	.2	0					
1967	1.914	1.603	0.311	0.000					
For A^s (From Downslope)		1.	.8	.6	.5	.3	.1	.1	.1
1962 and 1963	13.274	4.590	3.279	2.195	1.634	0.875	0.260	0.233	0.208
1964 through		1.	.7	.5	.2	.1	.1	0	
1967	10.494	4.590	2.869	1.830	0.653	0.292	0.260	0.000	

SOURCES: The total costs imposed upon society in 1960 from acid mine water from the Appalachian Region was stated to be $9,570,000 by the U.S. Public Health Service, *Water Pollution Control and Abatement,* Hearings before a Sub-Committee of the Committee on Government Operations, House of Representatives, 88th Congress, 1st session (1964). Twenty-five percent of such damage comes from surface mining in Appalachia ($2,392,500) and Eastern Kentucky contained 6.976 percent of such mining in this region. In 1960 there were the equivalent of 14,556 acres newly surface mined in Eastern Kentucky. This equals $11.466 per disturbed acre (data for 1960 and 1961 not shown above). It is estimated that 2/5 of acid run-off water originates from the coal face and auger holes, 2/5 from the downslope, and 1/5 from the mining bench. The values of the coefficients, time spans, and proportions were determined in consultation with personnel of the Kentucky Reclamation Division (Kentucky Department of Natural Resources), Kentucky Reclamation Association, Water Resources Center, (Indiana University), and members of the industry.

acre disturbed was derived from data presented by the U.S. Public Health Service.[7] (The data are for 1960 and are utilized to determine the costs for each year during the 1960-1963 period—only the two years of 1962-1963 are shown in Table 2.)

The cost of acid mine water damages per disturbed acre of surface mined land in eastern Kentucky is calculated as follows. Only 25 percent of acid mine water originates at the surface mining operations; the remaining 75 percent arises from underground mining. Data presented by the U.S. Department of Interior[8] indicate that approximately seven percent of the surface mining in Appalachia took place in eastern Kentucky in 1960. Considering the number of acres newly surface mined in that year, plus such acreage in the preceding ten years, it is estimated that the equivalent of 14,556 acres were newly surface mined in eastern Kentucky in 1960. The amount of damage from acid water drainage thus equals \$11.466 per newly disturbed acre.

This cost was incurred during each year of the 1962-1963 period when relatively little reclamation was accomplished. Two-fifths (\$4.59) of this per acre cost is considered to arise from Source A^c (coal face, auger holes, and breakthroughs of underground mines); one-fifth (\$2.29) from Source A^m (the mining bench); and two-fifths (\$4.59) from Source A^s (the downslope of the removed overburden).

1. Source A^c

During the 1962-1963 period the Kentucky reclamation law and regulations required coverage of the coal face and auger holes, and the sealing of breakthroughs. This work was not always accomplished, due to lax enforcement by the state agency. Nevertheless, partial coverage after mining, plus fallen material from above the seam, are considered sufficient to have caused a decrease and final halt of the flow of acid water from this source over the following six

7. *Water Pollution Control and Abatement*, Hearings Before a Subcomm. of the House Comm. on Government Operations, 88th Cong., 1st Sess. (1964). The annual damages from acid mine water from the Appalachian Region for 1960 was estimated to be \$9,570,000 by this Government agency. This estimate includes damages to: domestic water supplies, industrial water supplies, steamboats and barges, power plants, river and harbor structures, and floating plant, all damages occurring in the smaller streams in Appalachia, and the loss of aesthetic values in the area. While this estimate is a projection of a survey made in 1940, Tybout, in *An Economic Framework for Evaluation of Acid Mine Drainage*, Water Quality and Recreation in Ohio, Proceedings, Second Annual Symposium on Water Resources Research 229 (1966), states that these damages are "... probably as great today," and further that, "... the overall magnitudes cannot have changed radically except for steamboats downward and probably for power plants upward. The suggestion on the basis of information now available is that the total magnitude of the problem remains similar now to what it was in 1940," *id.* at 232.

8. U.S. Dep't of Interior, Study of Strip and Surface Mining in Appalachia 23-24 (1966).

years. This decrease is indicated in Table 2 by the decline in the values assigned to the coefficients over the six-year period (a_0 through a_5). In 1964-1965, the coverage of the coal seam and auger holes was extended to two feet above the seam. Enforcement of this requirement halted the flow of this acid water in the second year after mining. In 1966-1967, coverage of the coal seam was further heightened to four feet above the seam. In addition, a shortening of the time period between coal removal and the accomplishment of this reclamation requirement gave rise to relatively less pollution from this source during the period of mining. Thus, the coefficient a_{0t} is reduced to 0.5 when t is 1966 and 1967 (Table 2).

2. Source A^m

In the 1962-1963 period, little regrading of the mining bench was required, coverage of acid producing materials was not effectively enforced, and a minimum of revegetation was accomplished. Water pollution from this source is considered to have continued for an average of five years, but in declining amounts (Table 2). Normal leaching of the soil plus some natural re-seeding of vegetation from surrounding areas caused such a decline. Regrading of material across the mining bench in 1964-1965, plus additional revegetation and coverage of toxic materials reduced the flow of acid water from the mining bench. This reduction is reflected in the values of the coefficients assigned this origin. A further reduction of water pollution originating at this source was accomplished in 1966-1967 by additional grading and revegetation. A shortening of the time span for the performance of reclamation is reflected in the decrease in the coefficient value for the period of mining, a_{0t} from 1.0 to 0.7 when t is 1966 and 1967.

3. Source A^s

The flow of acid water from the downslope continues for a longer time than from the above two areas. While natural leaching also takes place on the downslopes, some sliding of the material down the hillside exposes new material. The grading of some of this overburden across the mining bench reduced the pollution from this source commencing in 1964. Although additional grading and revegetation was required in 1966, no reduction of acid water flow occurred in this year. As a result of the bench-width restrictions imposed in 1966, mining firms merely stacked the overburden higher causing no net change in the amount of water pollution from this source (Table 2).

The total external costs arising from the three sources of acid run-off water from surface mining for the 1962-1967 period are shown in Table 3 together with other external costs. It is noted here, however, that the total of these costs decreased from about $96,000 in 1962 to about $75,000 in 1967, (or about 22 percent) although the number of acres disturbed by surface mining increased approximately 52 percent over the same period.

B. Source S–Silt and Sediment Materials

Surface mining in the steeply-sloping terrain in eastern Kentucky causes severe erosion of the soil material removed throughout the course of the mining process. During periods of heavy rainfall this material flows from the mining site into streams and other bodies of water. The water-carrying capacity of these streams is decreased and the storage capacities of lakes and reservoirs are reduced. On the basis of the U.S. Forest Service experiment in eastern Kentucky, the U.S. Department of Interior estimates that approximately 400 tons of soil per acre of newly disturbed overburden flow into streams and other bodies of water. This quantity compares to about one ton of material from the same area prior to disturbance by surface mining.[9]

The external cost imposed upon other parties or society in general from this silt and sediment material is calculated herein on the basis of the cost to remove such material from streams, lakes and reservoirs. A cost of $0.07 per ton is used as an estimated average for the removal of this material.[10] The spoil bank settles over time and becomes relatively more stable. This process reduces the amount of material flowing from the disturbed area. In addition, this reduction is accelerated by grading of the mining bench and by revegetation of the disturbed area. (Space does not permit the inclusion of the data used to calculate the total external costs caused by silt and sediment material from mining operations; i.e., data such as that in Table 2 for acid mine run-off water.)

The total annual cost imposed upon other parties by silt and sediment material, originating on the mining bench fell from about $37,000 to $26,000 between 1962 and 1967, although the number

9. *Id.*

10. During the first year, an estimated 400 tons of silt and sediment flow from each acre of mined bench and spoil bank combined. The downslope of the spoil bank contributes 300 tons and the mined bench 100 tons. The downslope comprises 1/3 and the mined bench 2/3 of each acre. For each acre mined, 3.6 acres are disturbed. For each 3.6 acres disturbed, there are 2 acres of mined bench and 1 acre of downslope. For each two acres of mined bench 300 tons of material flow, or 83.33 tons per acre disturbed. For each 1 acre of downslope 900 tons flow, or 250 tons per acre disturbed. The removal of silt and sediment material from streams, rivers, lakes, and reservoirs is estimated to cost an average of $0.10 per cubic yard of material. This material weighs an average of 105 pounds per cubic foot, or 2,835 pounds per cubic yard. Cost of removal equals approximately $0.07 per ton.

TABLE 3

Total External Costs Arising from Bituminous Coal Surface Mining in Eastern Kentucky From All Sources; 1962-1967

	Sources of External Costs										
Year	A_t^c	A_t^m	A_t^s	S_t^m	S_t^s	B_t	O_t	L_t	Total Cost	Per Acre Disturbed	Per Ton Mined
1962	$34,770	$16,554	$44,654	$37,115	$164,698	$3,364	$3,000	$4,450	$308,605	$91.74	$0.048
1963	36,600	17,425	47,003	39,068	173,364	3,541	5,000	4,700	326,701	92.26	0.047
1964	20,125	12,243	39,038	34,451	143,644	2,790	6,000	4,900	263,191	70.75	0.035
1965	24,123	14,675	46,793	41,295	172,180	3,344	7,000	5,900	315,310	70.71	0.033
1966	10,130	8,448	46,321	22,617	170,442	3,311	3,000	5,850	270,119	61.20	0.028
1967	11,709	9,765	53,540	26,143	197,009	3,827	3,000	6,750	311,743	61.10	0.027

SOURCES: Totals of each source of external costs are from data presented in the text. Annual tonnages for computation of cost per ton mined are from *Annual Reports,* Kentucky Department of Mines and Minerals, for period covered.

of acres disturbed increased about one-half. The annual external cost of the material flowing from the downslope, however, rose from about $165,000 to $197,000 during this six-year period. While some additional grading of the mining bench and revegetation were required starting in 1966, total bench-width restrictions induced mining firms to stack the overburden higher. The reclamation requirements imposed upon the surface mining firms were relatively more effective in reducing external costs due to the silt and sediment material given off from the mining bench than from the downslope of the removed overburden. These costs are shown with other external charges in Table 3.

C. Source B–Loss of Aesthetic Values

The U.S. Public Health Service included the loss of aesthetic values in its valuation of total losses from acid mine water. The external costs from the silt and sediment material in streams and bodies of water include the associated aesthetic values. These two costs have been considered above. The aesthetic values of the land surface lost during mining incurred by the land surface owner is considered below. However, it may be claimed that the general public also suffers a loss when the scenic values of the nation's countryside are destroyed.

The hills of eastern Kentucky are covered with a growth of trees and other vegetation which most people would consider beautiful. This beauty is disturbed and interrupted by the strips of bare earth and rock exposed by surface mining. The exposure is greater where more than one coal seam is mined along the contour of the hills. Here, the overburden from one mining shelf flows downward and contacts the area exposed by mining operations at the lower altitude. Comparatively larger areas are denuded of vegetation when the entire upper portions of hills are removed during the mining process.

It is reasonable to assume that the general public is somewhat affected by the environment, and therefore recognition should be made of the loss of aesthetic values caused by surface mining in eastern Kentucky. Such a recognition is considered appropriate, since the reclamation requirements have reduced this loss. This charge upon society, however, must be valued at a relatively low level. Eastern Kentucky is not thickly populated, and is comparatively isolated from the surrounding areas. A higher value would appropriately be assigned to aesthetics in thickly populated regions.

For the 1962-1963 period, the loss of aesthetic values at the mining site by the general public is assigned a value of $1.00 per acre disturbed. This amount is considered to include the loss during the year of mining and all future years discounted at the rate of twelve percent. The regrading and comprehensive revegetation requirements of the mined areas were commenced in 1964. This action not only ensured that more of the mined areas would be revegetated, but also shortened the time span necessary for relatively more complete coverage. Therefore, the loss of aesthetic values at the mining site is valued at $0.75 per disturbed acre for the 1964-1967 period. The annual totals of this external cost are combined with other external costs in Table 3 (Source B).

D. Source O—Losses Incurred By Owners of the Land Surface Only

Eastern Kentucky mineral rights were sold in the late 1800's and early 1900's by the landowners when surface mining methods were unknown. The broad form deed was used for the transference of these rights, and conveys all the coal and,

> ...the privilege to use and operate the surface in any and every manner that may be deemed necessary or convenient for mining, and therefrom removing...and in the use of said land and surface thereof by the grantee shall be released from liability for damages.[11]

The separation of the land surface and mineral rights does not occur in all states. For example, in Indiana and Illinois a landowner may lease to a mining firm the right to exploit the minerals, but this lease or sale does not separate the mineral rights in perpetuity from the surface rights. Incidences of personal hardship involving some surface mining also are unique to eastern Kentucky; some cases of personal distress have occurred solely as a result of these separate ownerships. Some situations involving personal hardships are recounted by Harry M. Caudill.[12] At the same time, it must be noted that not all eastern Kentucky land has separate owners of the mineral and surface rights. The annual proportion of total disturbed land represented by acreage with separate owners has varied from about one-fourth to one-half during this six-year period.

Approximately 97 percent of all acres surface mined during 1962-1967 was disturbed by mining firms which had leased this right from the minerals owner who received a royalty for each ton of coal

11. U.S. Dep't of the Interior, Surface Mining and Our Environment 103 (1967).

12. H. Caudill, Night Comes to the Cumberlands (1962). In addition, some protests by owners of the surface only were voiced in connection with the passage of the 1966 revisions in the Kentucky reclamation law. Although some of this dissent against surface mining was made in response to damage or the threat of damage to the surface owner's property, a share of these remonstrances was made on other grounds. The mountaineer of eastern Kentucky has for generations feared and distrusted the outsider. The surface mining firm is considered an intruder.

extracted. If this owner also owned the surface rights, i.e., fee ownership, he also incurred the cost of any damage to the land surface—destruction of trees and loss of aesthetic values. Therefore, rational calculation by the owner would have included this cost in the royalty payments for which he contracted.

However, when the land has separate owners of the minerals and surface rights, the coal royalty is paid only to the mineral rights owner. In addition, if other factors are equal—coal quality, type and depth of overburden, transport costs—the royalty is equal to that paid to an owner of the land in fee. Thus, in this latter case, the owner of the surface does not share in the coal royalty. It would therefore appear that this surface owner receives no compensation for any damages caused by surface mining.

Nevertheless, eastern Kentucky surface mining firms leasing mineral rights on land with separate ownerships do pay the surface owners an "access fee." This payment is approximately $0.25 per linear foot of land as measured along the highwall of the contour mining site. The amount per ton of coal varies widely, of course, depending upon the width and thickness of the coal seam strip mined and whether the auger method is also employed. While the owner of the surface rights only is somewhat compensated for damages to the surface, he lacks the necessary bargaining power to receive any economic rent which may be due because of the location of his land. Nevertheless, this access fee payment is considered to fully cover the surface owner's costs of temporary loss of the land use and the decrease in aesthetic values.

At the same time, the surface owners have clearly had some imposed external costs caused by the removal of the overburden; for example, large rocks rolling down the hillsides. Such damages have been associated with the operations of a minority of the mining firms. Personnel of the Kentucky Reclamation Division indicate that no more than 10 or 12 situations involving such damages occurred in the two years prior to 1966, and only about one-third as many since the law's newest revision became effective.

In 1964 and 1965 the disturbed acres with separate ownerships totaled 3,461. Assuming 12 cases of property damage during these two years, one damaging instance occurred per 288 acres (or fraction thereof) of disturbed land with separate ownerships. Estimated damages are $1,000 per case. We may apply this ratio of loss cases to acres disturbed in the years prior to 1964. However, due to the authority of the Reclamation Division to prohibit mining in areas where possible damage may result from such operations, the ratio for

1966 and 1967 is changed to one loss of $1,000 per 864 acres (or fraction thereof). The annual totals of this external cost imposed upon these surface owners are indicated in Table 3 (Source O).

E. Source L—Losses Caused by Landslides

The sudden movement of portions of the spoil bank down the hillside in the form of landslides causes several types of damage. Some of these costs are already included in the previously calculated external charges. For example, the costs caused by acid water and silt and sediment materials include the additional amounts of such damages brought about by landslides. In addition, the loss of aesthetic values at the mining site—landslides increase the barren area and inhibit the growth of vegetation—and the costs imposed upon surface owners include estimated charges arising from landslides.

Landslides, however, impose other costs upon society. In addition to increasing the flow of silt material from the mining area, a landslide itself may block or disrupt the water flow in a stream; the sliding material may cover a public road or highway. A comparatively massive landslide damages several acres of land below the mining area. At the same time, we must recognize that some landslides cause relatively little damage. The sudden sliding of removed overburden down the hillside in an isolated, uninhabited region may merely mean that the material now covers an additional acre of comparatively valueless undergrowth and scrub timber.

The Kentucky Reclamation Division reported in December, 1967, that approximately 135 landslides had occurred over the previous 12-month period.[13] Discussions with personnel of the Division concerning the cost of damages caused by landslides revealed that such costs are among the more difficult costs to estimate. As noted above, the locations and size of landslides are diverse. The estimated cost of the damage from a landslide may vary from almost nil to several hundred dollars. However, utilizing the data reported by the Division, approximately one slide occurred per 38 acres of disturbed land; and further, we may reasonably estimate an average damage cost of $50 per slide. The annual estimated totals of this external cost are shown in Table 3 (Source L).

F. Total External Costs

While the total external costs per acre disturbed decreased over this six-year period—from about $91.74 to $61.10—the aggregate external charges for eastern Kentucky rose from about $308,605 to

13. Hearings on New Reclamation Regulations in Kentucky, held in Frankfort, Kentucky, on Dec. 7, 1967 (unpublished transcript).

$311,743 (Table 3). The annual acreage disturbed by surface mining increased over this same period from 3,364 to 5,102 acres. Thus, an approximate 52 percent increase in annually disturbed acreage was associated with only about a one percent rise in the annual external costs arising from such mining. Relatively more comprehensive and effectively enforced land reclamation brought about this comparatively lower increase in aggregate external charges.[14]

Although the total annual eastern Kentucky surface-mined tonnage rose from 6,390,826 to 11,352,004 tons, or about 78 percent, over this six-year period, the total external costs per-ton-mined decreased from about $0.048 to $0.027 per ton, or about 44 percent, over the same period (Table 3). This decline in total external costs per ton of coal produced may be attributed to two factors. First, increased land reclamation requirements were instituted and enforced over this period; and second, the average number of tons mined per acre disturbed increased. The latter increase was due to a rise in the average thickness of the coal seams exploited by strip and auger mining methods in eastern Kentucky from 3.8 to 4.45 feet between 1962 and 1967. Therefore, even without changes in the extent of land reclamation, the external costs per-ton-mined decreased annually. But, the increases in the amount of land reclamation in the years of 1964 and 1966 accelerated this decline.

III
INTERNAL EXPENSES

Increases in the amount of land reclamation performed by the bituminous coal surface mining firms during 1962-1967 caused an increase in internal mining expenses. Such charges are divided into two components for the purpose of this survey, i.e., enforcement expenses and direct land reclamation expenses. The former category includes: state permit and acreage fees, court fines, performance bond fees, and other charges (land survey, map, and administrative expenses). None of these expenses contribute directly to land recla-

14. Two limitations of this analysis must be recognized here. First, the external costs shown in this examination are those arising from bituminous coal surface mining only in eastern Kentucky during the period surveyed. The external costs originating from the contour mining operations in adjacent regions, for example, would be different due to dissimilar definitions of "acres disturbed" and to the relative extent of surface mining in these other areas. Similar mining operations would probably impose comparatively higher external costs upon society in a more densely populated region. Second, the amount of any external charge is not considered to be exact. While some of these charges are based on the best considerations and projections of professional personnel and government agencies, these costs remain estimates—other appraisals are possible. Nevertheless, the relative magnitudes of the various external costs and internal expenses would not be substantially changed by other reasonable assessments of these charges.

mation. The second category, direct land reclamation expenses, includes those expenses associated with earth movement, revegetation of the mined area, and the construction of drainage ditches.

A. Enforcement Expenses

The total expenses to the mining firms to obtain a permit to surface mine bituminous coal in eastern Kentucky are indicated in Table 4. The permit and acreage fees, and court fines for violations of regulations are paid directly to the Kentucky Reclamation Division for its use in enforcing the law and regulations.

TABLE 4
Total Enforcement Expenses of The Kentucky Reclamation Law and Regulations Associated With Eastern Kentucky Bituminous Coal Surface Mining Incurred by The Mining Firms; 1962-1967

Year	Permit Fees	Acreage Fees	Court Fines	Performance Bond Fees	Map, Land Survey and Other Expenses	Total	Total Average Expenses Per Disturbed Acre
1962	$4,830	$20,950	–	$ 2,556	$ 815	$ 29,151	$ 8.67
1963	4,140	22,245	–	2,580	690	29,655	8.37
1964	6,960	53,815	$3,450	4,255	3,480	71,960	19.34
1965	9,810	109,075	2,375	10,038	4,905	136,203	30.55
1966	14,080	110,350	2,400	14,170	8,750	149,750	33.93
1967	22,750	127,550	9,190	20,903	11,375	191,768	37.59

SOURCES: Kentucky Reclamation Division files and regulations, and estimates made in consultation with members of the industry.

NOTES: Cost of permits is average of $30 per permit for 1962 through June, 1966, and $50 thereafter.

Performance Bond Fee is $12.50 per $1,000 bond, per year, Map, Land Survey, and Other Costs computed at following rates: 1962-1963, $5. per permit; 1964-1965, $15. per permit; and 1966-1967, $25. per permit.

Performance bond fees are paid to private bonding companies. The applicable fee–$12.50 per $1,000 bond per year–is regulated by the State of Kentucky. The estimated average expenses incurred by the mining firms to survey the mining site, to prepare and submit the required map, and other administrative expenses associated with a permit application are based on information obtained from members of the industry and the Reclamation Division. While the permitted acreage increased by about one-half between 1962 and 1967, the 1967 average enforcement expense per acre to the firm was over four times this expense in 1962. This rise is attributed to an increase in the acreage fee over this six-year period–from $10 to $25 per acre–and to an increase in the required performance bond per permitted acre–from $100 to $200 (minimum bond of $2,000 is required per permit).

B. Direct Land Reclamation Expenses

1. Regrading

During the 1962-1963 period relatively little regrading of the surface mined land was required and performed. Some earth movement was accomplished to cover the coal seam face and to bury toxic materials. However, a sizeable increase in the expenses of regrading, burying of toxic materials, and the construction of drainage ditches occurred in the 1964-1965 period. Additional coverage of the coal seam, plus the grading of some removed overburden back toward the highwall, caused an increase in both labor and machinery time. Since grading does not take place on the downslope of the removed overburden, all acres disturbed are not graded. For each 3.6 acres disturbed, only approximately two acres are actually graded. An estimated seven actual acres could be graded in eight hours during this 1964-1965 period at an average expense of $18 per hour for labor and machinery. However, the number of acres regraded in the 1966-67 period in eight hours was reduced from an average of seven to five actual acres. This decrease was due mainly to the requirement to cover the mining bench with at least four feet of material from the removed overburden. From 1962 to 1967 these expenses rose from an average of $2 per acre disturbed to $16 as shown in Figure 2.

Figure 2
Data Utilized to Compute Direct Land Reclamation Expenses Associated with Eastern Kentucky Bituminous Coal Surface Mining, 1962-1967.

Required Grading, Burying of Toxic Materials and Drainage Ditches.

Period

1962-1963–$2.00 per acre disturbed.

1964-1965–$11.43 per acre disturbed. (Required work on 7 actual acres completed in 8 hours, at $18. per hour, equals $20.56 per actual acre. Two actual acres graded, etc. per 3.6 disturbed acres).

1966-1967–$16.00 per acre disturbed. (Required work on 5 actual acres completed in 8 hours, at $18. per hour, equals $28.80 per actual acre. Two actual acres graded, etc. per 3.6 disturbed acres).

Revegetation

1962-1963–$15.00 per acre disturbed. ($18. per actual acre revegetated; three acres planted per 3.6 disturbed acres).

1964-1965–$25.00 per acre disturbed. ($30. per actual acre revegetated; three acres planted per 3.6 disturbed acres).

1966-1967–$30.83 per acre disturbed. ($37. per actual acre revegetated; three acres planted per 3.6 disturbed acres).

SOURCES: Estimates based on consultations with members of the industry, Kentucky Reclamation Division (Department of Natural Resources), and representatives of the Kentucky Reclamation Association which performs revegetation of mined areas.

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2. Revegetation

The revegetation of surface mined land during the 1962-1963 period involved an estimated expense of approximately $18 per acre planted. Since only three acres are planted per 3.6 acres disturbed, this involved an average expense of $15 per acre disturbed. Increases in revegetation requirements–planting and survival standards–caused a rise in this external expense over the 1962-1967 period.

The total average internal expense to the mining firms to perform the required direct land reclamation rose from $17 in 1962 to about $46.83 in 1967 per disturbed acre. These figures are set out in Table 5. During this six-year period the primary cause of the increase in

TABLE 5
Total Internal Expenses of the Eastern Kentucky Bituminous Coal Surface Mining Firms Incurred in Performing Land Reclamation; 1962-1967.

Year	Enforcement Expense Per Acre Disturbed	Percent of Total	Land Reclamation Expense Per Acre Disturbed	Total Per Acre Disturbed	Eastern Kentucky Annual Total	Total Expenses Per Ton Mined
1962	$ 8.67	34	$17.00	$25.67	$ 86,354	$0.014
1963	8.37	33	17.00	25.37	89,835	0.013
1964	19.34	35	36.43	55.77	207,464	0.027
1965	30.55	46	36.43	66.98	298,664	0.031
1966	33.93	42	46.83	80.76	356,475	0.037
1967	37.59	45	46.83	84.42	430,711	0.038

SOURCES: Kentucky Department of Natural Resources, and members of the industry. Annual production from the *Annual Reports*, Kentucky Department of Mines and Minerals.

land reclamation expense per disturbed acre was the 8-fold increase in grading expenses–from $2 to $16. Revegetation expenses per disturbed acre approximately doubled between 1962 and 1967–from $15 to about $30.83 (Figure 2).

C. Total Internal Reclamation Expenses of the Mining Firms

The total average internal expenses (enforcement fees and direct land reclamation expenses) rose from about $25.67 to $84.42 per acre disturbed between 1962 and 1967 (Table 5). During the same six-year period enforcement expenses comprised an increasing proportion of total average expenses per acre disturbed; rising from 34 to 45 percent. The total average expense per ton mined increased approximately 171 percent–from $0.014 in 1962 to $0.038 in 1967.

IV
CONCLUSIONS

A. External Costs and Internal Expenses Compared

Although the additional constraints contained in the 1964 and 1966 revisions of the Kentucky land reclamation statute and in the enforcement agency's regulations caused significant reductions in the amount of external costs imposed upon society, these decreases in external diseconomies were achieved only by larger internal expense increases, as shown in Table 6.

TABLE 6
Summary of Average Total External Costs and Internal Expenses Associated with Eastern Kentucky Bituminous Coal Surface Mining and Land Reclamation; Average Cost Per Acre Disturbed and Per Ton Mined; 1962-1967.

Period	Average Total Per Acre Disturbed	Average Change From Previous Periods	Average Total Per Ton Mined	Average Change From Previous Period
		EXTERNAL COSTS		
1962-63	$92		$0.047	
1964-65	71	- $21	0.034	- $0.013
1966-67	61	- 10	0.028	- 0.006
		TOTAL INTERNAL EXPENSES		
1962-63	26		0.013	
1964-65	62	+ 36	0.029	+ 0.016
1966-67	83	+ 21	0.037	+ 0.008
		ENFORCEMENT EXPENSES ONLY		
1962-63	9		0.004	
1964-65	25	+ 16	0.012	+ 0.008
1966-67	36	+ 11	0.016	+ 0.004

SOURCES: Summary of data appearing in other tables and in the text.
NOTE: All per acre costs rounded to the nearest dollar.

The external costs were reduced during 1964-1965 (compared to the 1962-1963 period) $21 per acre disturbed; however, the mining firms' average internal expense of land reclamation rose $36 in the same period. Similarly, a further average decrease of $10 per disturbed acre was achieved in the 1966-1967 period; this decline, however, added an average of $21 per disturbed acre to the firms' internal expenses. On a per-ton-mined basis, much the same relationship exists between the reduction of external costs and the increases of internal expenses. The latter exceeds the former charges.

The shares of the increases in total internal expenses represented by the rises in average enforcement expenses per disturbed acre are also indicated in Table 6. In the 1964-1965 period, for example, enforcement expenses comprised $16 of the total $36 rise of internal expenses. Without the enforcement expenses, the $21 decline in average external costs per acre disturbed would be associated with an increase of only $20 of internal expenses. Similarly, in the 1966-1967 period, without the $11 increase in average enforcement expenses per acre disturbed, the average $10 drop in external charges would be associated with an average $10 rise in internal expenses.

The amount of reduction in external costs, per acre disturbed, per dollar of increase in internal expenses during 1964-1965 amounted to only $0.583 and $0.476 in 1966-1967. Such a reduction, per ton mined, per one cent of increase in internal expenses, amounted to $0.0081 in 1964-1965 and to $0.0075 in 1966-1967. Therefore, additional internal expenses caused by the increases in reclamation requirements in eastern Kentucky have reduced external costs, but at a declining rate.[15]

While only the approximate amount of the increases of internal expenses represented by actual land reclamation costs (without enforcement charges) contributed to the associated decreases in external costs, eastern Kentucky surface mining firms could not be expected to perform the land reclamation without compulsions. Therefore, the expenses of enforcement cannot be avoided.[16] However, if the mining forms would have voluntarily performed the land reclamation, each dollar of the increase in internal expenses would have reduced external costs by approximately one dollar (per acre disturbed). This result, of course, raises the question of the desirability of requiring additional land reclamation. Except as

15. These conclusions may be reversed, of course, if one assigns higher values to the loss of aesthetic values. The assigned values are 1962-63: $1; and 1964-67: $0.75 per disturbed acre. Suppose, however, that the loss of aesthetic values per disturbed acre were designated as follows: 1962-63: $37; 1964-65: $21; and for 1966-67: $9. In this case, the average total of *all* costs per disturbed acre would increase to $128 for 1962-63; $91 for 1964-65; and $69 for 1966-67. With these valuations a $37 decrease in external diseconomies would be associated with a $36 increase in internal expenses between the 1962-63 and the 1964-65 periods. Similarly, a decrease of $22 would be associated with an increase of such expenses of $21 between the 1964-65 and the 1966-67 periods. In like manner, the conclusions on a per-ton-mined basis would also be reversed with these higher valuations of aesthetic losses. Such increases, however, also involve the assumptions that the loss of aesthetic values in the 1962-63 period increase from approximately one to 29 percent of the total of all social costs per disturbed acre; in the 1964-65 period an increase from about one to 23 percent; and in the 1966-67 period from about one to 13 percent. However, these proportions and dollar quantities which would be required to reverse the conclusions are deemed to be unrealistic in the present case of eastern Kentucky.

16. We may assume, however, that not all enforcement expenses are utilized for this purpose. The Kentucky Reclamation Division expends some funds for research connected with eastern Kentucky surface mining. Such research includes experiments concerning the growth and survival of various species of trees and other vegetative cover in different types of soil. Thus, perhaps a small share of the firms' internal expense increases should be considered research and development expenses instead of land reclamation expenses.

recommended in the following section, a solution for this dilemma will not be suggested here.

RECOMMENDATIONS

A. The State of Kentucky

Since the 1964 and 1966 revisions of the Kentucky bituminous coal surface mining reclamation law and regulations have caused greater increases in the mining firms' internal expenses than the decreases in external costs imposed upon society, the Kentucky General Assembly should carefully evaluate the present as well as any proposed additional land reclamation requirements applicable to such mining.

The Kentucky General Assembly might well turn its attention to other sources of external costs imposed upon society. For example, approximately 75 percent of the total acid water pollution originates from underground mining operations. Silt and sediment materials also flow from roads leading to these mines. Extensive erosion of the hillsides takes place where trees have been harvested. Legislation directed to reduce the external diseconomies originating from these sources could properly be considered.

B. Other Government Bodies

The experience of the State of Kentucky not only in enacting but enforcing more comprehensive surface-mined land reclamation requirements may influence the actions of other government bodies. Indeed, this may have already occurred. For example, such a law first became effective in late 1967 in the State of Tennessee. The existing statute in the State of Indiana was revised the same year. In addition, the U. S. Senate Interior Committee held hearings in June, 1968, on a proposed Federal land reclamation law. We may ask, however, whether the actions of the State of Kentucky should be followed.

But to evaluate the Kentucky experience, several guidelines are required for the particular actions to be followed by a government body in connection with the enactment of land reclamation provisions. Such actions should be based upon:

1. Recognition of the existence of external costs arising from the surface mining process.
2. Measurement of external costs.
3. Formulation of recommended procedures and regulations to internalize such costs within the industry, including estimation of necessary internal expenses.

4. Revision of recommended land reclamation requirements if internal expense increases exceed external cost reductions.
5. Institution of land reclamation requirements.
6. Measurement and comparison of actual cost increases and decreases after a trial period.
7. Further revisions of the land reclamation requirements.

The record of the Kentucky experience indicates that four of these seven items were considered; specifically,

1. Recognition by the State of certain external costs arising from surface mining was first made in 1954 when the original land reclamation statute was enacted.
3. Following the enactment of the original statute, the State formulated some procedures and regulations to require land reclamation following the surface mining of bituminous coal. Estimates of the internal expenses to perform the land reclamation were made upon the occasion of each revision of the state law. The projections by the Kentucky Reclamation Commission differed, however, from such industry estimates. For example, in 1964 the former projected costs of 5 to 10 cents per ton mined; the latter estimated costs of 60 to 90 cents per ton. (As shown herein the average expense was close to 3 cents per ton.)
5. If we equate the institution of land reclamation provisions with effective enforcement of such requirements, the State of Kentucky commenced the former in 1964.
7. Revisions of the land reclamation requirements were made almost every two years after the enactment of the original 1954 statute. The more significant revisions were made by the Kentucky General Assembly in 1964 and 1966.

The other three steps, numbers 2, 4, and 6 concern the measurement and comparison of costs–specifically–the need to calculate internal expense increases and external cost decreases. These computations and their comparisons were not accomplished.

Requirements to reclaim the land after the surface mining of bituminous coal are applied to all surface mining operations. While the expenses to perform the reclamation are similar for all firms,[17] the reductions of external charges upon society vary from area to area.[18] For example, the external costs arising from any given min-

17. Differences exist, however, on a per-ton-mined basis due to varying coal seam thicknesses.

18. That is, from area to area in eastern Kentucky. Different reclamation provisions do exist for such mining operations in western Kentucky where the contour method of mining is not used.

ing operation are higher in the relatively more densely populated areas. Acid mine water and silt and sediment material, for example, cause higher external costs in areas containing roads, bridges and bodies of water than in relatively isolated localities. Thus, while the increase in internal expenses per acre disturbed are almost uniform, the reductions in external costs will vary according to the location of the surface mining operations. These results might have been different if another approach had been used by the State.

Deviations from the prescribed land reclamation provisions are allowed in some cases in eastern Kentucky, but only when such exceptions cause higher rather than lower external costs. For example, if the acidity of the removed overburden is so high that vegetation cannot survive, the mining operator may be allowed to revegetate equal acreage of other unreclaimed mining sites. Thus, for any site with this high acidity in a given population density, an area causing relatively lower external costs may be substituted for one causing comparatively higher costs.

A higher total reduction in external charges may be achieved if the reclamation provisions were viewed as minimum rather than maximum standards. Selective deviations in the extent of required reclamation would then be made toward more instead of less external cost reductions.

A government body administering a land reclamation law should include all seven of the aforementioned steps in its administrative procedures. This inclusion will insure that recommended or instituted changes in surface mined land reclamation provisions are first assessed and compared with estimated and actual external cost reductions.

[From the Arizona Republic, Mar. 21, 1971]

Strip Mining and Black Mesa

A lasting impression that emerges from today's article about the Black Mesa mining operation, elsewhere in today's Republic, is the precautions Peabody Coal Co. officials are taking.

For example, the article says, "It might be said that the archeologists are running the mine." For early in negotiations with the Navajo and Hopi tribal councils, the company agreed to preserve Black Mesa's rich archeological heritage. It agreed to restore and reseed the land after it has stripped away the coal. Its agronomist and reclamation advisers are on guard to see that the land is not simply used and abandoned.

Anyone who is familiar with strip mining operations elsewhere knows that concern for the land has been largely nonexistent. The coal fields are gouged with deep scars, huge soil banks add to the defacement, the remaining arid and acidic soil won't sustain vegetation, and nearby streams are often contaminated by sediment and acids drained from the exposed coal beds.

No wonder then that, even at a time when the nation's power plants require the cheap coal that only strip mining can provide, a West Virginia congressman recently proposed federal legislation to ban strip mining entirely.

Obviously, that is not a realistic solution—not when America's energy demands are rising, and when strip mining tonnage, presently about 40 percent of total coal output, is rising. For strip mining is not only twice as productive per man day as underground mining, meaning that it holds down the cost of electric power, but it is also considerably safer.

What is needed is legislation similar to that President Nixon requested of Congress, the establishment of federal standards for states that refuse within the next two years to set standards for reclamation (usually grading and replanting) of abandoned strip mines.

It goes without saying that this added cost will be passed on to coal consumers. But it also bears repeating that the fight to preserve and enhance the environment, which opinion polls put at or near the top of every list of public concerns, requires more than merely a rhetorical commitment. It is going to require a financial commitment as well.

What Peabody has promised to do at Black Mesa far exceeds the proposed federal standards. And there is every reason to believe that the company is sincere—both because it has restored and reseeded in its Colorado coal fields, and because it has given repeated public assurances that it respects the Indian lands from which it will mine coal during the next 35 years.

As today's story points out, the Navajos and Hopis will receive $100 million in royalties during the lease period if the two power plants operate at the expected 85 percent capacity. That is a tremendous amount of money, particularly for tribes that have suffered from economic privation throughout their history.

Nevertheless, it would be hardly worth it if the Black Mesa mining operation left the tribes with slag heaps that defaced the land and rendered it useless for hundreds of years. That is why the environmental guarantees given by Peabody are every bit as important as the royalties the tribes will collect for the coal mined from their land.

[From the Arizona Republic, Mar. 21, 1971]

Coal Is Bringing Prosperity to Black Mesa—Salaries, Royalties for Indians Will Continue for Many Years

(By John J. Harrigan)

Black Mesa.—Leo Frank, a young Navajo from Lukachukai, is a contradiction both as an Indian and by job description.

As a typical Navajo male, he should be earning less than $3,000 a year, but his pay is well in excess of $10,000.

His job title at Peabody Coal Company's Mine No. 1 is "oiler" but he is never seen with an oil can. The term is a throwback to the days of more primitive diesel equipment that required constant oiling.

He is mechanically responsible for a self-lubricating, $2.5 million, gargantuan dragline boasting 180 feet of boom and a scoop that will remove 35 yards of dirt, about 50 tons, in a single bite. He is more mechanic, welder and operator trainee than oiler.

No one is probably more aware than he of the unpleasant fact of life that you cannot efficiently move 13 million tons of coal a year from depths of 55 to 110 feet without bothering some of the land, or overburden, above it. But you won't hear him or any of his fellow 66 Indians and 16 companion caucasian workers complaining.

There is little doubt, he would acknowledge, that coal mining has begun in earnest on Black Mesa. Deep black canyons surrounded by mountains of overburden on this year's 525-acre mining plot attest to it. And mining will move forward at the rate of about 400 acres a year, with the previous 400 acres being continuously replanted as it goes along.

Ecologists worried about whether Peabody Coal Company's intentions with Mother Earth are honorable will just have to wait and see. It's too early to tell.

The first load of coal was hauled April 25, 1970—by trucker Leroy Arnold who said he drove like crazy to get it to the nearby crushing plant.

Ecologists and Navajos like Frank who have lived near here all their lives have the assurances of Peabody that the mining company has a full-time agronomist and the support of a half dozen other agencies to handle reclamation.

The company reassures in its official brochures that it will stick with its agreement with the Hopi and Navajo tribes to return Black Mesa "to as good a condition as received, except for ordinary wear, tear and depletion incident to mining operations."

Foremen, superintendents and employees in conversation, however, claim that the land will be better than when they started. Five deep wells, more than 3,000 feet, will be turned over to the Indians. Small lakes and ponds are expected to fill pits engineered with gentle slopes to allow cattle to drink safely from them.

Thirteen different grass varieties are being tested to find the best possible replacements for the present, overgrazed stands. The company also promises replanting of other landscaping to replace the pinyon and juniper now being bulldozed.

A 35-year coal mining lease here covers 65,000 acres, or an area roughly 12 by 16 miles, on land designated as Navajo-Hopi joint use area by presidential order of 1882. Of the 64,858 acres in the lease, only 14,000 have coal.

Present mining appears minimal from the air but massive from the ground. It represents a mere toe-in-the-door. Mine No. 1 will strip 24.5 million tons of high-grade coal over a five-year period for the Mojave generating plant near Bullhead City.

Peabody reduces the coal to chunks two inches and smaller. Conveyor belts transport it to nearby Black Mesa Pipeline, Inc, It is then pulverized, mixed with water and pumped at 4 miles per hour through a 275-mile pipeline to the Mojave plant under 800 pounds per square inch of pressure.

A second mine will open soon on the north end of the Mesa to provide coal for the Navajo generating plant at Page. Work will begin in a month on a railroad to transport it from here to Page.

Eventually the mines will produce 13 million tons of coal a year, eight for Navajo and five for Mojave.

Some of the Indians who have lived all their lives on these rolling, grass-covered hills are alarmed at the destruction, however, temporary. Most are the Chee and Yazzie descendants of a single family—Manymules. Others have accepted the reality and are benefiting from it.

Of the 78 Navajo families within the lease area, 53 have their homes over coal deposits. They will be temporarily relocated at the company's expense.

They are well remunerated for their trouble, sometimes in more ways than one. The company in one case is not only paying a father for moving from his ancestral hogan but has hired three of his sons. They bring home combined incomes of more than $3,000 a month.

Stan Begay, one of Peabody's best Caterpillar operators, is one of the company's highest paid employees, often earning more than $1,200 a month. His brother, Wally, drives a company supply truck. They both grew up on the mesa they are now helping to dissect.

While reconstruction of the landscape and its possible success is still a question mark, the company has recognized the mesa's rich archeological heritage. It is sponsoring research by archeological teams at Prescott College. It provides summer mobile home quarters for student archeologists and often assists them by bulldozing large earth masses.

It might be said that the archeologists are running the mine. No strip mining will be done where major archeological finds have been located. So far, they have located 138 sites, of which 29 have been considered valuable enough to excavate.

Ruins date back to a Pueblo people, the Kayenta Anasazi Indians, who farmed there between 600 A.D. and 1200 A.D.

Aside from cultural pluses, the mine will be a boon to Indians and the tribes for years. The tribes will receive $100 million in royalties during the 35-year anticipated lease period if the two power plants operate at an expected 85 per cent capacity. The $3.25 million-a-year royalties are based on a 25-cents-a-ton commission, "a higher royalty than had ever been negotiated for coal developed on Indian or public lands," Peabody said.

Some Indians—usually off in far-away Window Rock or Chinle—have complained that the 25-cent-a-ton commission was too small. They see traders selling back their coal at $3 a hundred pounds to them.

But local Indians here enjoy another fringe benefit—free coal. The company doesn't advertise it. It neither encourages nor discourages local Indians from loading up their pickup trucks and driving away.

Company officials report they seldom see the same pickup trucks twice— a testimonial to the high bituminous thermal unit rating of the anthracite. It is rated at 11,000 BTU per pound, with an ash content of 8 per cent—which will be the generating plants' filtering problem—and a sulfur content of 0.5 per cent, which is considered low.

Apparently one pickup load of the 11,000 BTU fuel will last one family a year or more.

Almost all of the workers at Peabody earn more than $10,000 a year, including laborers. It is not uncommon for an Indian with no more than a sixth grade education to walk home with a paycheck of more than $1,000 for a two-week pay period with some overtime. Understandably, there is a backlog of some 300 applications from Indians and non-Indians alike for jobs.

Eventually, the plant will hire 250 with about 75 percent of them Indians. Potential employees must be qualified, either by experience or by trainability. The company has been unable to locate qualified Indian electricians and diesel mechanics.

The highly skilled jobs mean big checks and big checks cause their own problems: Local traders don't have the financial resources to cash them.

Loren Crank a Navajo employee here sent out a recent letter to the editor that insisted, "The opportunity is here for the people who would just open their eyes and start a business of their own, such as banks, laundromats, grocery stores, good garages, trailer and car sales, theater, etc. (in nearby Kayenta) . . .

"I've heard so much of sheep, cattle and land. We had these since the beginning of time but so far I haven't seen anyone become self-supporting with it except anglos off the reservation, but they have them in large quantities, not just two or three hundred sheep, cows, but thousands . . ."

[From Mining Congress Journal, March 1971]

Effect of Wilderness Policy on Exploration Activities—An Industry Viewpoint

(By J. H. La Grange, Land and PR Coordinator Bear Creek Mining Co.)

President Johnson signed the Wilderness Act at a special ceremony in the White House rose garden on September 3, 1964, bringing to a successful conclusion one of the nation's longest and most controversial battles. After more than 8 years of study, public hearings, debates, and controversy, the Wilderness Bill became the law of the land.

The congressional mandate is concise. Wilderness areas of the National Wilderness Preservation System shall be administered for the use and enjoyment of the American people. The wilderness character of these areas will be left unimpaired for future use and enjoyment as wilderness. Thus, the Wilderness Act provides a statutory base for preserving the remainder of the American wilderness as we know it today. These areas lie within our national forests, national parks and monuments, and the national wildlife refuges and ranges.

Fifty-four of the existing Wilderness, Wild and Canoe areas have been placed in the National Wilderness Preservation System established by the Act. Thirty-four Primitive areas of the national forests are to be included in the System during the 10-year period following the Act. Such inclusions are to follow a series of public hearings and reviews by the Secretary of Agriculture. During this 10-year period, roadless portions of over 70 national parks, national monuments, wildlife refuges, and wildlife ranges are to be reviewed by the Secretary of the Interior for possible inclusion in the Wilderness System.

40 TO 50 MILLION ACRES SUBJECT TO REVIEW

The Act set a schedule under which recommendations for one-third of these areas were to have been presented to Congress by the President within 3 years. Two-thirds are subject to his recommendations for inclusion under the Act within 7 years—the remaining areas by the end of the tenth year. All together, this procedure can apply to 40 to 50 million acres of wilderness lands which are subject to review. These lie within preservation areas, units of the national park system and the wildlife ranges and refuges. By comparison, the total area of the national forests administered by the Forest Service is less than 190 million acres. Units of so-called "de facto" wilderness may also be included in the Wilderness System under the provisions of the Act. Such units could add still more acreage. A "de facto" wilderness, by popular definition, is a roadless area of wilderness quality not yet designated as Primitive or Wilderness. The Lincoln Back Country in Montana and the White Cloud mountains area in Idaho are examples of "de facto" wilderness.

INFORMATION GATHERING PERMITTED IN WILDERNESS

The Act permits prospecting and gathering of information on minerals in the established wilderness. Such activities must be conducted in a manner "*compatible with the preservation of the wilderness environment.*" The Secretary of the Interior is directed by the act to develop and conduct recurring surveys of areas proposed for inclusion in the Wilderness System. The results are to be available and submitted to Congress. There is nothing in the Act to indicate that recommendations to delete areas from Wilderness classification due to mineral character will be followed.

The Act states that surveys will be conducted in a manner "*consistent with the concept of wilderness preservation.*" The Act and the applying Rules and Regulations specifically prohibit temporary or permanent roads, aircraft landing strips and heliports or helispots. Use of motor vehicles, motorized equipment, motor boats, or other forms of mechanical transport is prohibited. You may not land aircraft or drop materials, supplies or persons from aircraft. Structures or installations and cutting trees for non-wilderness purposes is prohibited. There is an exception where these purposes existed prior to the designation of the National Wilderness Preservation System. However, persons with *valid* mining claims or other valid occupancies wholly within the Wilderness are permitted access. Access is limited to that "*consistent with the preservation of the forest wilderness.*" Consider how you might build a road consistent with preservation. Now go a little further and consider the ramifications of the word "valid" with reference to an unpatented mining claim.

Permits may be issued for access. The permits prescribe routes of travel to and from the area surrounding claims or occupancies. They also prescribe the mode of travel and other conditions reasonably necessary to preserve the wilderness. Mining development or timber cutting is permitted on a valid claim. However, there are certain specifications requiring that the Forest Service be furnished with operating plans before a permit is issued. An operating plan must be submitted and approved before a permit will be issued to construct an access road. There is a provision whereby special request may be made for use of motorized equipment and to land aircraft during prospecting. However, in practice, such permission is not normally granted except on a valid claim.

LOCATIONS BANNED AFTER 1983

Claims may be located under the mining laws or the mineral leasing laws until December 31, 1983. Mining rights acquired prior to that date will be honored. Prospecting other than on valid claims, and the location of claims, is permanently banned thereafter. Exploration work done on the claims is subject to restoration as nearly as practicable to the original surface contour upon completion of the work.

To understand the effect of Wilderness Act policy on exploration activities, we must determine what that policy is. A broad-scope analysis is necessary to identify all of the elements which determine this policy with regard to mining.

There are four primary sources of Wilderness Act policy having an impact on mining. The first source is Congressional intent as expressed in the Act itself. The second source is the Department of Agriculture, particularly the Forest Service.

Those agencies are responsible for the management of the wilderness areas and the implementation of the Act. Rules and regulations were promulgated pursuant to the Act by the Secretary of Agriculture. In addition to directives contained in the rules and regulations, policy is being continually determined and altered by the ongoing Forest Service administrative experience. The third major source of wilderness policy is public opinion as expressed by the various, more or less powerful, wilderness recreation and preservation interest groups such as the Sierra Club. Such organizations are constantly applying pressure on the Forest Service to take actions and establish policies which hinder the activities of mining companies. These organizations are dedicated to a single use principle of absolute preservation of the pristine forest untrammeled by the works of man. The fourth source is, of course, the mining interests who seek Forest Service action or cooperation with respect to lands under Forest Service jurisdiction.

CONGRESS RECOGNIZED MINING AS PRIORITY LAND USE

The policy of Congress in enacting the Wilderness Act is to, in effect, recognize mining as a priority use of wilderness lands. There are, of course, very important limitations as mentioned previously. Development and operation of a mining property is obviously in conflict with the fundamental concept of the Wilderness Act—that is, preserving wilderness. Yet the Act allows mining development indefinitely with the limitation that new prospecting and claim location must cease after 1983. This is clear policy. Furthermore, it is a reasonable interpretation that the limitations on human activities are to protect the wilderness as much as possible. However, such limitations should not effectively prohibit mining.

The Forest Service, as the direct implementing agency of the Wilderness Act, is faced with a difficult task. How does one manage a program which attempts to provide for mutually exclusive uses of the same area? One or the other use must come out on the short end, and to date, it seems to be mining.

In addition to the restrictive rules and regulations established by the Secretary of Agriculture, another level of rules and policy making must be considered. In promulgating rules and regulations, the Secretary of Agriculture asked the Forest Service to prepare individual plans for the implementation of the Act in each of the 54 established wilderness areas. These plans were to include whatever special regulations or restrictions were deemed necessary due to local circumstances to protect the area involved. Consequently, before going into any wilderness area, the prospector or miner must determine what special rules he must comply with in addition to those contained in the Wilderness Act.

The policy of the Forest Service supervisor who administers rules and regulations under the Act is necessarily affected by interdepartmental directives and memos. He is further affected by general unwritten departmental policy, vocal special interest groups and even some personal prejudices. Lower echelon interpretation of the rules and regulations may vary widely from place to place.

USE PERMIT REQUIRED FOR PROSPECTING

Written permission in the form of a Special Use Permit is required for virtually every type of prospecting and exploration activity other than walking. Access theoretically may not be denied. In fact, it may be denied or prohibitively delayed for any number of reasons, including lack of discovery. Due to administrative slowness, negotiations for Use Permits usually require a lead time of from 3 to 6 months.

The problem of what constitutes a valid discovery is not within the scope of this discussion. It should be noted, however, that permission to use powered equipment and perform many modern exploration activities in Wilderness areas is contingent upon the existence of a valid claim. The Forest Service has the option of disagreeing as to whether a discovery has actually been made.

The supervisor has the problem of satisfying many interests. He must satisfy his supervisors who are influenced by the Congress and special interests groups. He must satisfy the local populace with whom he must live and maintain good day-to-day relationships. He must fulfill the desires of the prospector. The supervisor's decisions must lie within the law, yet will almost always involve a compromise among all interested parties. It would appear the Forest Service will try to avoid blanket rulings from Washington headquarters. This is effected by making decisions and rulings on a local level as much as possible. This, of course, resolves itself into a policy of "play it by ear" for the prospector. He cannot expect any guarantees that he can explore in the most efficient manner at his command, nor can he be free from threats of administrative restraints that may be thrown over his operations.

RESTRICTIONS WOULDN'T HAVE BOTHERED OLD-TIME PROSPECTOR

To comprehend the aggregate effect of these elements of Wilderness Act policy, one must understand the nature of modern minerals exploration. The various restrictive Wilderness Act rules and regulations would not have appreciably affected the old-time prospector with essentially unlimited time resources. He required only individual initiative, primitive means of transport, and no mechanized devices to prosecute his exploration program. The modern exploration effort, by contrast, requires a large amount of capital and is extremely complex. It utilizes a variety of scientific devices to determine or predict the presence of mineralization. It employes as many labor-saving and time-saving mechanical devices as possible.

An exploration program often commences with a time-consuming evaluation of large areas. This is to determine the location of zones containing anomalous amounts of valuable minerals. These mineralized zones may have very little surface expression and may outcrop only sporadically. Profitably locating the zones themselves and exploration targets within these zones requires a very efficient, highly mechanized and extremely flexible program. These mineralized areas or targets may be located by recognizing surface or subsurface alteration products. Certain trace elements normally occur near or within known ore bodies. Anomalous electrical conditions of both a regional and a very local nature or an unusual concentration of various elements in soil or water are also indications of mineralized areas.

One of the most efficient and expeditious methods of regional sampling and mapping in roadless or remote areas is by helicopter drop of men and equipment. Drop locations are decided as a given exploration program progresses and utilizes information and ideas developed from the program itself. Long-term preplanning as to drop points and sampling points is practically impossible. A high degree of unfettered mobility is required during this stage; aircraft and powered surface vehicles are essential.

Once a target is located, further geochemical and geophysical methods, as well as detailed surface mapping, are employed to decrease its size. This makes the prospect amenable to evaluation as to tonnage, continuity and probable extraction costs based on present and projected economic conditions. The information for many such evaluations is normally obtained from diesel or gasoline-powered drilling equipment or a variety of powered devices for tunnel driving or shaft sinking. Generators are usually necessary to provide an electrical power source for geophysical equipment or campsites.

LIMITATIONS AFFECT EFFICIENCY OF PERFORMANCE

Several years ago, an exploration project in the Absaroka Wilderness required some unusually time-consuming and complex planning. This was due to pressure on the local Forest Service by recreationists, resort owners and packers. A joint public announcement describing exploration plans was requested by the Forest Service. This is normally a serious breach of security because it invites competition to share the ideas and benefit of extensive and expensive reconnaissance. Stipulations in the prospecting permit required that helicopter flight operations to spot and service drill rigs be limited to hours between daybreak and 9 a.m. Flights were required to be at altitudes greater than 1000 ft, except when landing on claims. Off-claim landings were not permitted at all. Transport of drilling equipment to various locations on the claims was necessarily restricted to the hours of permitted use.

The purpose of these restrictions was to avoid scaring horses and disturbing the Wilderness solitude. Except for emergencies, five days notice was required for deviations in permitted flight patterns. No personnel could be transported in the aircraft. Such limitations certainly do not allow for efficient use of personnel and material.

OPPOSITION TO DEVELOPMENT USUALLY TO BE EXPECTED

Once it is apparent that a Wildenress prospect may be developed, some formidable opposition will usually arise. General public interest may be focused by preservation-oriented individuals or organizations dedicated to the prevention of wilderness development. Present concern for the environment and the popular public reaction of objecting to any kind of new industrial development serves to aggregate the situation. The general pattern of attack is to flood large-circulation newspapers and national periodicals with stories of the natural attributes of the area. How the area will be destroyed by mining is usually described vididly. Support for such preservation programs is mustered from state and federal legislators and persons of national stature. This support is enlisted through influential organization members and by letter writing campaigns. Attempts may be made to pass punitive laws or zoning regulations which are directed toward severely encumbering or prohibiting mine development.

Kennecott Copper Corp. has mining property under development in the Glacier Peak Wilderness area in Washington. Several years ago, it was awarded a great deal of uncomplimentary publicity both nationally and locally. This resulted from a drive by preservationists to establish a 1.5 million acre North Cascade National Park. Mining development was cited as a prime example of what could happen if the area was not preserved as a national park. Some of you may remember the "Open pit that could be seen from the Moon" as publicized in a full-page ad in the Wall Street Journal.

PROBLEMS OF EXPLORATION MANAGER ARE NUMEROUS

Think about some of the problems an exploration manager must consider before committing scarce company funds to exploration in a Wilderness area:

The Forest Service may contest the validity of unpatented claims based on lack of discovery.

The Forest Service may refuse a Special Use Permit or use of motorized equipment on the grounds that the proposed activities or the use of such equipments is not consistent with wilderness preservation or compatible with the wilderness environment. Where there are no clear grounds, a permit can be delayed by holding public hearings. This is to obtain expert and lay opinion as to the interests and effects of the permits. Very often some serious objection to granting the permit or some reason for further investigation and delay can be generated by such a hearing. Experience of American Smelting and Refining Co. in the White Cloud mountains in Idaho is an example.

If the Forest Service grants a Special Use Permit without a hearing, individuals or interested groups can call for reconsideration. Hearings will then be held on the grounds of an unconsidered interest or danger.

Local zoning can be asserted to prevent development where existing codes can be so interpreted, or new zoning can be established. Such zoning probably would not be upheld in court, but could result in time-consuming litigation.

Individuals or groups can take advantage of every opportunity afforded by law to review, study and reconsider decisions of the controlling government agency. An example would be the delay encountered on building of the Trans Alaska pipeline.

If all else fails, individuals or groups may prosecute a Class Action Suit on behalf of all interested parties (Wilderness recreationists, etc.). Such action could temporarily or permanently enjoin road building or mining activity. Presumably, when the law does not grant an unqualified right to pursue the opposed activity, a court can issue such an injunction on a variety of temporary or permanent grounds.

The power of condemnation is always open to the federal government. It is entirely conceivable that the government would be willing to condemn a mineral property and pay its fair market value to prevent a mining operation.

It is an exploration manager's responsibility to minimize the commitment of exploration funds and to obtain maximum probability of success in locating an ore body. An integrated reconnaissance program involving men, aircraft and geophysical or equipment contractors requires large sums of money. There are severe financial penalties for poor timing. When large development funds are committed, land control and unimpeded progress toward profitable production must be guaranteed. The specific rehabilitative and environmental control measures required need to be defined. Uncertainty in any of these matters greatly increases the already high risk of no return from exploration expenditures.

LEGAL UNCERTAINTIES INCREASE RISKS

We in the mining industry have an obligation to maintain a healthy domestic mineral industry—an industry which can continue to supply a large portion of the raw materials so essential to our economy. This is becoming more essential than ever because of the growing tendency of foreign governments to impose difficulties in the way of U.S. companies in developing sources of minerals. The intent of Congress to continue mining rights is clearly expressed in the Wilderness Act. We should have the right to give Wilderness areas the exploration attention Congress allowed. However, we are finding it difficult to do so because of unpredictable risks occasioned by unduly restrictive regulations inconsistently administered. The risks are increased by legal uncertainties generated by the activities of special interest groups.

There are only 13 years remaining to exercise Congressional intent under the Wilderness Act. So far, we've let seven go by without much effort. Many of the situations I have described may very likely extend to all areas of federal lands in a short time. It's long past time for the mining industry to cooperate, organize and make a positive effort to cope with this serious problem.

RECLAMATION

[From the Wall Street Journal, May 24, 1971]

Hiding the Scars—Some Strip-Mined Land Now Is Being Reclaimed, But Task Is Enormous

TODAY'S MASSIVE MACHINERY MAY BAR FUTURE RECOVERY; TOUGH LEGISLATION URGED

How to Make Indian Mounds

(By Everett Groseclose)

Gene Lanning, a maintenance supervisor for Ohio Ferro Alloys Corp., likes nothing better than to see Friday afternoon roll around. As soon as the whistle blows at the factory in Philo, Ohio, he jumps into his camper and roars out into the sticks.

In southeastern Ohio, weekend camping is as common as strip mining for coal—and that's really common. One thing, however, sets Mr. Lanning apart from outdoorsmen in other parts of the country, and that is his favorite camping ground.

"To look at this," Mr. Lanning declares as he waves his hand to indicate the wooded hillsides and ponds that stretch for miles southward from the hamlet of Cumberland, "you might never know it's been strip-mined. Why, the way it is now, it's almost as good as it was before the miners came in." Streams and ponds are alive with fish; deer hunting rates as some of the best in the state; beaver and muskrat are trapped during the winter.

It hasn't always been that way. Barely 20 years ago the valley that yawns southward from a small mountain known as Windy Hill looked more like a moonscape than a landscape, the handiwork of miners in pursuit of coal. Hundreds of acres, often as far as the eye could see, were chewed up and spit out by giant power shovels, leaving a terrain of jagged rock, deep trenches and mountains of raw, desolate earth.

Environmental Destruction Continues

Throughout the Appalachian coal belt, thousands of acres, laid waste by miners as soon as they had scooped out the last chuncks of coal, are still the way the countryside near Cumberland once was. Moreover, such environmental destruction is still going on, because strip mining for coal, one of the cheapest of industrial fuels, continues to grow. Thus, the coal-mining industry is booming, particularly in states such as Ohio, Pennsylvania, Kentucky and Tennessee.

But changes are clearly in the wind. Two counties in Kentucky have outlawed strip mining. In West Virginia, the state legislature has enacted a two-year ban on strip mines in 22 counties so far untouched by them. In 33 other counties, strip mining remains legal, but efforts to outlaw it are believed to be gaining support. And in Ohio, a bill backed by powerful conservationists would, among other things, require strip miners to restore land to its original contour.

In addition, President Nixon recently proposed federal regulations that would require all states to set standards for reclamation within two years. But Rep. Ken Hechler, a West Virginia Democrat who calls the Nixon proposal "toothless," wants faster and more decisive action. He introduced a bill that would ban strip mining for coal within six months after enactment and provide federal funding of reclamation in a limited number of instances.

The Havoc of Strip Mining

Whether legislation to control strip mining and force reclamation of old sites will ever get through Congress remains to be seen. But a visit to southeastern Ohio, where two of the country's largest strip-mine operators have been working and reclaiming some land for years, gives an observer a fairly good picture of the havoc brought by strip mining and what a certain amount of land might eventually

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look like if stiff reclamation laws are passed. It also helps explain why many students of strip mining are convinced that reclamation of land currentlv being stripped by mammoth machines may be impossible.

"The first thing that hits you when you get into strip-mining country is the mind-boggling immensity of the problem," says Richard L. Lancione, a lawyer in Bellaire, Ohio. He heads a group called Citizens Concerned About Strip Mining, which is sponsoring the Ohio law. "Literally thousands and thousands of acres have been turned upside down, destroyed for all practical purposes," he says.

The kind of devastation Mr. Lancione is talking about is much in evidence about 10 miles west of Cumberland, where Ohio Power Co., a unit of American Electric Power Co., operates what is said to be the world's largest power shovel. Known as "Big Muskie," the machine's boom is so long the operator frequently can't see the 220-cubic-yard shovel in the early-morning fog. The shovel, operating from the bottom of a trench, is capable of stripping off soil—called overburden—to a depth of more than 160 feet to expose a layer of coal. Once the overburden is stripped off, it is called the "spoil bank"—a term critics say is extremely accurate.

Surrounding the shovel are hundreds of acres of devastated earth and jagged rock. Trudging along the bottom of the trench, Walter Smith, a young forester who is superintendent of reclamation for Ohio Power, says that "as soon as the stripping is finished, the bulldozers move in to grade the surface," in effect, shaving off cones of piled soil. After grading, Mr. Smith says, "we move in to plant seedlings."

The Tree-Planting Approach

Ohio Power's basic approach to reclamation involves planting trees, which the company hopes may someday be reaped as lumber. "We plant about 1,000 seedlings per acre, and we reclaim about 1,300 acres per year," Mr. Smith says. But even to the untrained eye, it is clear that areas mined in recent years can never regain their original appearance and vegetation, largely because mining machines in use today leave such devastation.

Areas mined years ago, generally with much smaller equipment that left much smaller scars, are usually the spots that companies point to with pride as having been reclaimed. And, indeed, some such areas are relatively attractive. For instance, the wilderness area frequented by Mr. Lanning of Ohio Ferro Alloys was mined with small equipment more than 25 years ago.

Trees that were planted then are now up to 40 feet tall and 18 inches in diameter. They help hide the ugly "final cuts"—trenches more than 50 feet deep on their uphill side left when the shovel made its final pass. How such areas would look today if larger mining equipment had been used is sheer guesswork. But critics familiar with the techniques of mining agree with 47-year-old Mr. Lanning, who has watched strip mining all his life, when he says he believes that "it would look absolutely terrible."

Nonetheless, such areas illustrate what can be accomplished in certain locations with reclamation. With its trees growing nicely, Ohio Power decided in 1964 to polish up its image by carving out primitive campsites in the reforested acreage south of Cumberland. Currently the company has 18 such campsites. Visitors, who must obtain a free permit from the company, can hunt on the property or fish in some of the 300 ponds the company has created—most of them by damming up final cuts every few hundred yards. "On the weekends during the summer, I'll give you a dollar for every pond you can find that doesn't have a fisherman on it," Mr. Smith says.

If Ohio Power's reclamation projects are partially successful, they are also partly "showcase" efforts. Others have gone even further. A striking example of showcase reclamation and what can be done if enough money and effort are pumped into the job can be found near the village of Cadiz, about 35 miles northeast of Cambridge, Ohio. There, Hanna Coal, a division of Consolidation Coal Co., has built a 400-acre public park. Called Sallie Buffalo, the park comprises a 27-acre lake, parking space for house trailers, a lodge for parties and facilities for picnicking and camping.

Thousands of lovers of the outdoors visit Sallie Buffalo each year, and long-time residents of the area are the first to say the park is a vast improvement. Walking along the shore of the lake as he flips a lure into the water and then retrieves it, Herman Eberling, a retired steelworker, tells how he has "lived around here all my life." Mr. Eberling adds: "This park is certainly a lot better than the way it was when the country was all torn up, but it's still old beat-up mining country."

PROVING IT CAN BE DONE

C. Arthur Wallace, general superintendent for land use and reclamation for Hanna Coal, estimates that Hanna has put $130,000 into the park and its facilities. "Yeah," he concedes, "it's awfully expensive—too expensive to do very much of it. We did it mainly just to prove it could be done, but I think it's worthwhile from everyone's viewpoint."

Hanna Coal has also been working on a far more economical approach to reclamation near Cadiz. The company has planted 12,000 acres of strip-mined land with a perennial legume called crown vetch. In certain types of soil, the legume grows well and cattle thrive on it.

Showing a visitor across the gently rolling pastureland stocked with registered Hereford cattle that the fussiest rancher would take pride in owning, Mr. Wallace says that Hanna Coal is "making a tiny profit" on its cattle operations. "The company keeps asking me what we're going to do with all this (stripped) land," Mr. Wallace declares. "My answer is that five years from now we're going to be in the cattle business in a big way."

In Hanna Coal's case, that may be true. But certainly it isn't true for many other coal-mining concerns. The reason: Hanna Coal is unusually fortunate. The overburden on much of the land mined by the company is mostly limestone. Unlike so-called acid sandstone, which covers most seams—or layers—of coal, plant life grows relatively well on limestone spoil banks. Says Mr. Smith of Ohio Power: "When you've got a spoil bank that's acid sandstone, you just plant your trees and pray."

The type of spoil created by strip mining is indeed a crucial factor in the difficulty of reclamation. Nothing will grow on soil that contains small chunks of coal or powdered coal. The earth directly above most coal seams is heavily acid. This type of material is sometimes the last to come out of the final cut; thus it is what occasionally goes on top of the spoil bank.

GETTING RID OF THE "GOB"

In addition, numerous companies have run into difficulty in disposing of a waste product from coal that is called "gob." Essentially, gob is inferior coal. In many cases, it is removed from mined coal before the fuel is shipped to its user. Companies have tried various means of disposing of gob, usually involving one kind of attempt or another at burying it in low-lying areas and covering it over with non-toxic soil.

Frequently burying gob works poorly. Hanna Coal's Mr. Wallace, for instance, says that attempts to bury gob on about 250 acres near Cadiz have been only partly successful. The problem is that rainwater tends to seep through the non-toxic overlayer into the gob, drain downhill and emerge at a lower terrain level, polluting both land and streams. Such seepage often results in drainage almost the color of blood. "That water will eat the nails right out of your boots," says Donald E. Richter, field director of the Ohio Reclamation Association, a group formed in 1945 by coal-mining concerns to handle much of their reclamation work.

Rugged terrain also sometimes makes it impossible for miners to reclaim strip-mined land. Particularly in mountainous Appalachia, experts say, the terrain is simply so rough that power shovels can make only one pass, throwing the spoil downhill. In many instances, the mountain is so steep that the spoil disperses itself as it tumbles downhill, leaving only the ugly final cut and no spoil bank to grade.

Most critics object the loudest to abandoning final cuts with little or no effort to reclaim the land. The reason, of course, is that the final cut is the most obvious and lasting scar. Even in countryside that isn't particularly mountainous, the final cuts are almost never filled. Instead, they are dammed up every so often, which allows the toxic materials left in the bed to be covered by water. Once these cuts are covered, the posionous effect of coal is contained. Fish, beaver and other forms of wildlife can thrive in such ponds.

THE COST OF FILLING

Still, critics decry the scars and generally contend that coal-mining companies should fill them in. Thus far, in most parts of the country, coal companies have successfully resisted drives to require them to fill final cuts. Their motivation is simple. "The cost of filling in the high wall is very, very expensive. That's why its not done," declares Mr. Richter of the Ohio Reclamation Association. Besides, he adds, "by knocking off the top of the high wall, you only ruin more surface area."

Still another major reason companies are reluctant to put money and effort into reclamation projects is that they plan to mine most areas again. Take Hanna Coal's crown-vetch pastureland, for example. "We're nowhere near through mining around here." Mr. Wallace says. With the development of larger equipment capable of digging ever deeper after one of the 12 seams of coal below the surface in Ohio, companies can reach coal that wasn't possible before.

Typical of what has happended and what is continuing to happen is Mr. Wallace's prized pastureland. It was first mined almost 40 years ago with an eight-cubic-yard shovel. Then came a 22-cubic-yeard machine. Later came longer-boomed shovels that would move 45 and 65 cubic yards in one bite. Currently a 105-cubic-yard Hanna Coal machine is operating in the area, and larger machines, such as Ohio Power's Big Muskie, are being developed.

A variety of other problems also make reclamation difficult; not the least of these is time. For many areas, planting trees is the most logical step. But a year-old tree usually is barely more than a sprig one foot to three feet tall. Ten-year-old trees usually have attained a height of only 10 to 20 feet, depending on the and the soil condition. Generally trees take 20 to 25 years to mature.

More mundane difficulties aren't unusual, either. A constant problem for operators attempting to grade strip-mined land is dispersal of huge chunks of rock, sometimes as large as a two-story house. "When you run into a rock so big you can't move it, you just pile dirt around it and call it an Indian mound," Mr. Wallace says.

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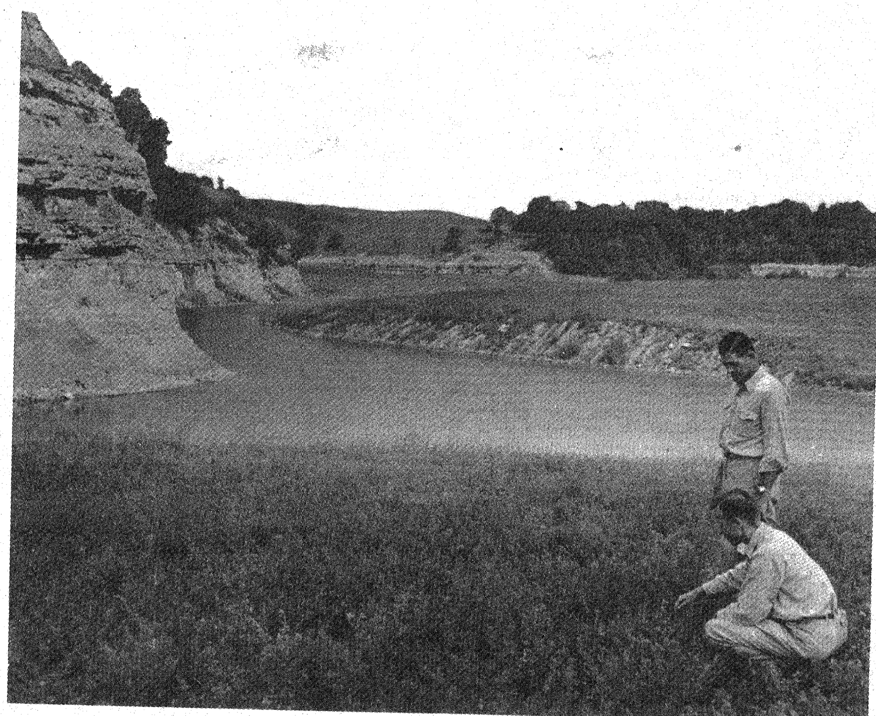
RESTORING SURFACE-MINED LAND



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TYPES OF SURFACE MINING

OPEN PIT.—Excavating for stone, sand and gravel, iron, or copper where a mineral deposit is found within a small area. Most quarries fall under this category. Some of these mines may be operated in one location for many years.

AREA STRIPPING.—Digging a series of parallel trenches in relatively flat or rolling terrain to get coal, phosphate, or other minerals. Spoil material is placed in the previous cut made; the mine resembles the ridges of a washboard with an open trench where the last cut was made.

CONTOUR STRIPPING.—Digging around a hillside in steep or mountainous country, usually for coal. It creates a shelf or "bench" bordered on the inside edge by a high wall that may be as much as 100 feet tall and on the outside edge by a rim and a very steep "outslope" covered by loose spoil material.

AUGER MINING.—Boring horizontally into a seam to get more coal after stripping is finished. A cutting head—as large as 7 feet in diameter—is drilled into the seam, and coal is scraped out along the auger threads.

DREDGING.—Removing sand and gravel, gold or other minerals from underwater or low-lying areas by a suction pump or digging device usually mounted on a floating barge. Spoil piles may resemble those from area stripping.

HYDRAULIC MINING.—Using a powerful jet of water to wash down or erode a bank to get gold or other precious metals. Ore is separated by differences in specific gravity as the material is fed through sluices or other devices.

RESTORING SURFACE-MINED LAND

By the U.S. Department of Agriculture

Introduction

A power shovel as big as an office building bites into the earth, piling up row on row of rock and soil to get at a vein of coal . . . .

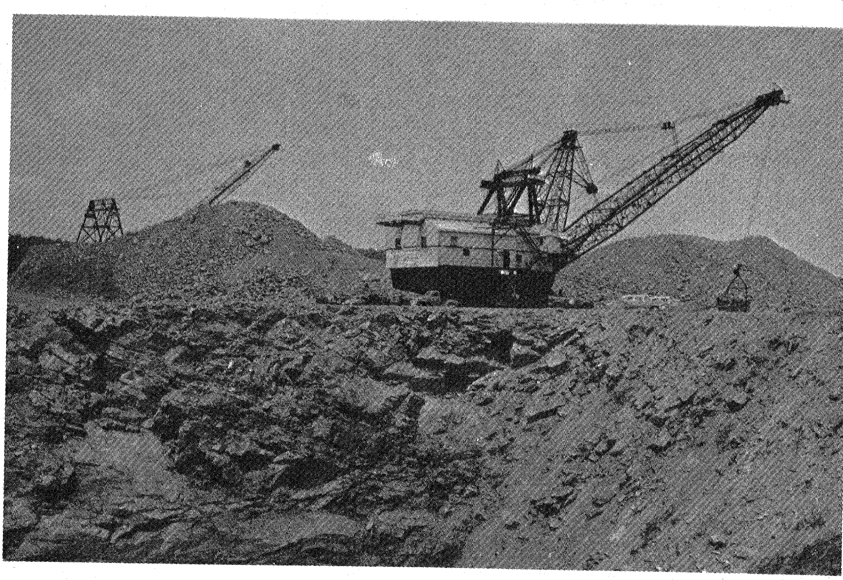
An auger with a 7-foot bit bores into a hillside, and coal works its way out like wood shavings . . . .

A floating barge dips its big chain-bucket into a streambed for a load of sand and gravel . . . .

An ore-laden train snakes its way out of a giant open pit . . . .

Through these and other operations man carries on the big activity of surface mining. He gets many minerals, fuels, and building materials that help our Nation grow and that provide jobs in rural America.

In the process, the land is changed—laid bare, rearranged into parallel ridges, or scooped out like a soupbowl. Properly treated and managed, it can be returned to safe and productive use, even become a greater asset to the community than it was before mining. Left alone, it may produce only



With today's large excavating equipment we can not only surface mine faster and cheaper but also reshape the landscape and rehabilitate the site easier.

TABLE 1.—*Land disturbed by strip and surface mining in the United States, by commodity, Jan. 1, 1965* [1]

[In thousands of acres]

Mineral	Strip mining			Into hillside	Quarry-open pit below ground level	Total	Dredge, hydraulic, and other methods	Grand total [2]
	Contour	Area	Total					
Coal [3]	665	637	1,302					1,302
Sand and gravel	38	258	296	82	371	453	74	823
Stone	6	8	14	100	127	227		241
Gold		8	8	1	3	4	191	203
Clay	10	26	36	22	44	66	7	109
Phosphate	28	49	77	13	93	106		183
Iron	7	31	38	30	96	126		164
All other	11	12	23	59	81	140		163
Total	765	1,029	1,794	307	815	1,122	272	3,188

[1] Acreage by method of mining estimated from random sampling survey.

[2] Compiled from data supplied by U.S. Department of the Interior; from Soil Conservation Service, U.S. Department of Agriculture; and from estimates prepared by the field study group.

[3] Includes anthracite, bituminous, and lignite.

stream-fouling sediment and acid and ugliness.

For many years the U.S. Department of Agriculture (USDA) has been helping private-land owners restore their surface-mined land as part of their regular programs of wise land use and conservation treatment. USDA also has done restoration work and research studies on the public land it administers. Its experience and skills range all the way from preplanning mining to prevent offsite damage to development of a mined area for highly intensive uses.

Through studies and experience and through participation in the 2-year National Surface Mine Study under Public Law 89-4, USDA has gathered a great deal of information about surface-mined-land conservation progress and needs. In this report highlights of the data are given as well as ideas for future action, suggested by research and experience, that can speed restoration of the surface-mined land that is intermingled with farm, ranch, forest, and other land in rural and suburban America.

SURFACE-MINED LAND—BY STATES.—An estimated 3.2 million acres of land—some in every State—had been disturbed by surface mining by January 1, 1965 (tables 1, 2).

DISTANCE FROM POPULATION CENTERS.—Surface-mined-land conservation is a *rural* opportunity. More than four-fifths of the mined land surveyed is at least a mile from communities with a population of more than 200. More than half are more than 4 miles from town. And 40 percent of the mined land cannot now be seen from any U.S. highway or passenger railroad. Most areas were close enough to communities, though, for a family to reach for an afternoon recreation outing. No urban growth was evident around two-thirds of them, which suggests that these areas are likely to continue in agricultural and related uses.

OWNERSHIP.—Ownership of the land and its minerals holds the key to use and conservation of these resources. Since most surface-mined land is privately owned, opportunity for improvement lies largely in local assistance programs of mutual interest and value to landowners and their neighbors—the kind of program already being carried on by the Nation's 3,000 soil and water conservation districts and by State forestry agencies with USDA help. Increased assistance through these going programs could do the job. And since the mining industry owns more than half of the surface-mined land, it has a challenge to restore its property to a useful state and to prevent offsite damages.

A survey of 693 surface-mine sites [1] in 1966 showed that many were scattered small acreages best treated as part of the total conservation management of the farm and other areas with which they are intermingled. Nearly 80 percent of the sites were in forest, farm, or grassland or reverting to forest at the time of survey. These same uses were being made of land adjacent to 86 percent of the sites. Less than 2 percent of the acreage had

[1] Sites were selected at random from mined land throughout the Nation to represent the surface-mining situation. Of the total, 180 sites were mined for coal; 149 for sand and gravel; 100 stone; 49 clay; 49 iron; 48 gold; 40 phosphate; and 78 for eight other commodities.