# Setting Priorities for Abandoned Mine Land Research (1987)

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Board on Mineral and Energy Resources
Commission on Physical Sciences, Mathematics, and Resources
National Research Council (U.S.).





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**COMMITTEE ON ABANDONED MINE LANDS RESEARCH PRIORITIES**

**KENNETH N. WEAVER, Maryland Geological Survey, Chairman**
**BUDDY A. BEACH, Consolidation Coal Company**
**GERALD J. McLINDON, Consultant, Baton Rouge, LA**

**Liaison Members**

**JERRY R. ENNIS, Office of Surface Mining, Casper, Wyoming**
**RICHARD L. JUNTUNEN, Department of State Lands, Helena, Montana**
**LYLE V. A. SENDLEIN, University of Kentucky**

**Staff**

**ROBERT S. LONG, Staff Officer**
**ELLEN TENENBAUM, Consultant**
**FLORENCE WONG, Project Secretary**

# PREFACE

In the legislation that transferred the abandoned mine land (AML) research program from the Office of Surface Mining (OSM) to the Bureau of Mines (BOM), Congress stipulated that BOM was to establish research priorities. In order to address this requirement and other related issues, which are new responsibilities for the bureau, the director of BOM in a letter of March 17, 1987, asked the Board on Mineral and Energy Resources of the National Research Council (NRC) to conduct a study of several issues central to the AML research program. Specifically, the director requested that the board make recommendations on research priorities and criteria for evaluation of research proposals dealing with reclamation of abandoned coal mine lands. In addition, the study group was asked to formulate recommendations regarding the development of an effective technology transfer program in the area of AML research. The director asked the board to submit its report to the bureau by September 30, 1987, so that BOM could incorporate the NRC's recommendations into the AML research program in time for the next funding cycle.

The NRC agreed to conduct the study and established the Committee on Abandoned Mine Lands Research Priorities. The six-member committee represents a broad range of many years' experience and expertise in dealing with abandoned mine land problems.

The committee held three meetings in Washington, D.C., reviewed the pertinent available written materials, held discussions with bureau management, conducted inquiries with critical groups regarding research priorities, and interviewed knowledgeable persons in the abandoned mine reclamation field, from both the research and the programmatic sides. Particularly valuable input resulted from the committee's written inquiries to five organizational groupings of experts in AML matters. A total of 136 letters were sent and 68 responses were received, an excellent 50 percent response rate.

In the following sections of this report the committee discusses the status of AML research (Chapter 1), assesses AML research needs and priorities (Chapter 2), discusses the central components of an

effective project-selection process (Chapter 3), and identifies the kinds of technology transfer mechanisms needed to transmit research results to the user (Chapter 4). The committee's recommendations were formulated after considering funding level expectations, time-dependent factors of the AML program, the AML priorities outlined in PL 95-87, and the types and geographic distribution of AML problems.

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APPENDIXES

# EXECUTIVE SUMMARY

In the Continuing Resolution for Federal Agencies (PL 99-591) enacted in October 1986 for fiscal year 1987, Congress transferred the abandoned mine land (AML) research program and $1.9 million in funding from the Office of Surface Mining (OSM) to the Bureau of Mines (BOM). Subsequently the director of BOM asked the Board on Mineral and Energy Resources of National Research Council (NRC) to conduct a study and to make recommendations on research priorities and criteria for evaluating proposals dealing with reclamation of abandoned coal mine lands. The study group was also asked to recommend an effective technology transfer program for AML research. The Committee on Abandoned Mine Land Research Priorities was established and set about the task of reviewing the status of abandoned mine land reclamation research (Chapter 1), establishing AML reclamation research priorities through a questionnaire process (Chapter 2), discussing the selection process for choosing successful AML research projects (Chapter 3), and discussing the technology transfer process as applied to AML research (Chapter 4).

A central focus of this study was the attempt to identify the highest-priority research problems through an inquiry letter sent to knowledgeable professionals throughout the country. One hundred thirty-six letters were sent to individuals representing five major groups--state AML program directors, state geologists, Mining and Mineral Institute directors, representatives of the coal industry and mining associations, and representatives of the American Society for Surface Mining and Reclamation. Sixty-eight responses were received, for a 50 percent response rate.

The following conclusions can be drawn from the responses to the inquiry:

- Water quality, subsidence, mine waste, and revegetation are ranked as the top four research priorities in all regions.
- Top research priorities tend to be similar across organizations within a specific region.

- Regional research priorities differ somewhat, but only in terms of relative rank and differing lower-priority problems.

- Although water quality is perceived as the highest priority in all regions, the top four priorities are ranked fairly evenly in the West; water quality is clearly highest in the East and Midwest.
- Subsidence and mine waste are ranked either second or third in all regions.
- Revegetation is of concern, as it comes out a clear fourth priority in the overall composite results as well as in each region.
- Landslides/slope stability, topsoiling, mine fires, and mine openings are subjects having higher than "background" interest among respondents.

A number of recommendations were developed from the study. Many of these recommendations are interrelated, so each should be viewed in the context of the others. Each of the recommendations is explained in the body of the report and summarized briefly below.

The first series of recommendations focus on AML research priorities:

Recommendation 2.1: The committee recommends that the Bureau of Mines use a broad rather than a restrictive interpretation of the legislative intent of the AML research program. All AML lands will not be reclaimed by 1992, and there will be a continuing need for well-founded, longer-term research into corrective measures.

Recommendation 2.2: The bureau would benefit from using the AML research priorities indicated by the committee's survey (Table 2.2) as guidance in setting priorities for future research project solicitations. Most of the funded research projects in the AML program fall within the identified high-priority topics, so only minimal fine-tuning of the existing process will be required.

Recommendation 2.3: It is recommended that the bureau conduct periodic surveys of experts (perhaps in two-year intervals), asking for their views on the highest-priority research needs. The survey conducted by the committee produced a broad consensus on the most important areas for research, offered many insights on specific research topics, and made the community of researchers feel involved in the priority-setting process. The query letter (Appendix B) might be expanded to ask respondents what research they believe would yield the greatest benefits or knowledge in relation to cost.

The following topics are recommended for consideration in subsequent AML research solicitations:

Recommendation 2.4: The committee recommends that BOM assess the cost-effectiveness of various current techniques of abandoned mine subsidence reclamation, e.g., subsidence insurance, remote underground backfill, reclamation of surface depressions with long-term maintenance, land use zoning, and remining. In the short term, certain methods may appear to be low in cost, but what is needed is a firmer idea of total costs for any technique.

Recommendation 2.5: BOM should assess the cost-effectiveness of abandoned mine highwall reclamation associated with contour mining, using an integrated approach as in the recommendation above, but also considering short-term environmental disruption during reclamation versus long-term reclamation benefits.

Recommendation 2.6: Acid mine drainage is perceived to be an urgent problem, but no long-term plan exists for ultimate control of this problem on abandoned mine lands. A long-term plan for control needs to be developed, incorporating all currently known techniques. Such a plan would includes strategies for research and implementation of the results over the next decade. Undoubtedly this problem will continue into the twenty-first century. The bureau should expand its research on use of wetlands to ameliorate acid mine drainage. OSM currently allows new and innovative techniques to be applied under Title IV of SMCRA. Possibly these experimental practices (e.g., wetlands treatment of acid mine drainage) could be combined with a research project on acid mine drainage.

Recommendation 2.7: Research on the long-term economics of reshaping the land is required to determine the expected life and future maintenance cost. Probably the most difficult aspect of reclamation of abandoned mine land is the prediction of the expected life after remedial treatment. In the case of land surfaces, natural geomorphic processes are constantly at work, leveling any oversteep terrain. If a problem on a steep slope is addressed without reducing the degree of slope, the problem might require perpetual maintenance. We need to determine how to apply this geomorphic knowledge to the long-term planning for abandoned mine land reclamation.

The following series of recommendations relate to the proposal review panel and the project selection process. The committee believes the process as it has evolved is well-thought-out. Its recommendations are for refinements to make the system more efficient and to reflect the highest-priority research needs.

Recommendation 3.1: The committee recommends that the bureau prepare a research plan with priorities identified, and that the key elements of the plan be incorporated into the call for proposals and scoring in the selection process. The AML research policy and research priorities are in transition as this report is being written. The previous policy expressed only vague goals and

objectives. The research effort was not focused on the solution of either short-term or long-term AML problems. The program was reactive, in that it did not identify specific research priorities but relied on the proposer to define the research direction.

Recommendation 3.2: The present system of informal peer review practiced by panel members within their own agencies should be formalized and expanded to include peers drawn from OSM, BOM, state agencies, academic and research organizations, and industry. BOM can establish a list of qualified people by discipline outside the agency who could review and comment on specific proposals; peer comments should be made available to the review panel for their timely deliberation. Methods for including peer review in the current selection process include several approaches. It would be possible to develop a peer review list based on specific research expertise, and then mail the proposals to at least two of these individuals with a request for review according to an accepted format. A second approach that might be more appropriate to the requirements of the law would be to add a sufficient number of peers to the panel, varying their expertise with the research priorities identifed or topics to be reviewed. In this way the panel could benefit from the technical expertise of the scientists, and the scientists could benefit from the practical aspects of panel members through discussion of the research topic proposed. Normal Bureau of Mines procedures involve review of the project activity with peers from within their organization, and such individuals are part of the current legislated panel, but it is advisable to include peers from outside government as well. Care should be taken to avoid conflict of interest.

Recommendation 3.3: It is recommended that the bureau establish an identifiable or specific research objective at the beginning of the research activity. Technical monitors will be able to follow the progress of the work, with the objective in mind, as it is being performed. There should be a follow-up program to ascertain the success or failure of the technology, and possible need for further research, engineering development, or modification of the system. If a concrete research objective is established at the beginning of the research activity, the effort will be provided with a measurable means of evaluating the effectiveness of the research. If the research provides the answer to a previously perplexing question, it has certainly been successful. If, on the other hand, the research reveals that the direction taken will not address the problem, this also can be a valuable and defined conclusion.

Recommendation 3.4: In view of the longer-term nature of some important research, the committee recommends that promising research projects be allowed to be amended, upon the selection panel's approval, rather than be required to undergo a complete submittal for funding every year. This would probably call for a change in the procurement process. Many new and promising research ideas are in

such an early stage of development that needed answers may not be developed in one or two years of work. Most new technologies require an evolution of progressive steps to reach field implementation. Last year's panel discussed the need for a mechanism to assist in this progression, instead of requiring a complete reapplication every year. It can generally be considered cost-effective for the most experienced researcher to continue with projects, thereby adding to existing experience. A system for easily amending highly innovative and especially exciting projects when needed could be beneficial if not overused.

Recommendation 3.5: The process for evaluating and selecting research proposals should have enough flexibility to consider proposals with unusual qualities. For example, an encouragement of some cooperative research projects should be built in to the proposal submission and evaluation process. If partial funding were to be provided by a mining company and the results of a particular project would be useful to AML reclamation and to active mining as well, the proposal could be given a certain priority or ranking within the overall selection process.

Recommendation 3.6: The committee believes that maximum utilization should be made of the talent in the Bureau of Mines and in the Mineral Institutes in addressing the priority topics. Because the bureau has had a great deal of experience in water quality and subsidence problems, these two areas should receive particular attention for BOM research funding. The bureau is line-item funded to carry out a wide range of scientific and technological research. A review of the publications issued by the Bureau of Mines in the period 1983 through 1986 reveals that the bureau publishes a considerable number of reports on the high-priority research topics identified in Chapter 2. Subsidence and water quality are the subjects treated in most of the papers. Revegetation, mine wastes, and slope stability are also prominent topics.

Many technology transfer systems are available for AML use within the Bureau of Mines to transfer knowledge from research laboratories and construction sites to new sites to accomplish AML reclamation in a more cost-effective and environmentally sound manner. The following recommendations will help the bureau put in place an effective technology transfer program for AML research.

Recommendation 4.1: Serious consideration should be given to assigning the AML technology transfer program to the Bureau of Mines. The Bureau of Mines has a well-established technology transfer program. It will require special planning, but the AML technology transfer needs can be met by the bureau's current program by adding some new elements and identifying new clientele. Thus, all of the elements of OSM's AML technology transfer activities can be moved to the Bureau of Mines for a comprehensive technology transfer program.

Recommendation 4.2: It is recommended that the bureau establish a task force to define and address the abandoned mine land technology transfer activity. This task force should identify the needs of the AML technology transfer program and link as many of these needs as possible to other established Bureau of Mines technology transfer programs. The bureau should consider including an OSM representative as a standing member of the task force in order to coordinate technology transfer between the two bureaus.

Other apsects of the problem to be studied by the task force should include:

- Data base development of bibliographic listings of mining and mineral resources as applied to abandoned mine lands.
- Development of linked series of information circulars, reports, and bibliographies categorized by subject.
- Continuation of joint federal and professional agency-sponsored seminars on abandoned mine land reclamation.
- Compilation and rapid distribution of technology from overseas.

Recommendation 4.3: A universal data base of state AML projects similar to the data base of state AML projects prepared by the Abandoned Mine Reclamation Bureau of Montana should be established within the Bureau of Mines technology transfer program. It may be possible to incorporate this in the bureau's MRMIS system and make it, and all other information not used for internal management purposes, available to the public.

Much of the research carried out by state agencies represents state-of-the-art reclamation practice, but it is virtually unknown to other states or researchers. The committee recommends that the bureau utilize the Montana file and incorporate it with its own research-in-progress index. The MRMIS, which currently is used only for internal purposes, and contains confidential data, should be redesigned for public access. The Mineral Institutes, state agencies, state geologists, and Federal Library Depositories will benefit from access to these sources.

Recommendation 4.4: The committee recommends that the bureau establish a "one-stop" information service capable of responding to questions from state AML agencies, Mineral Institutes, contractors, and others. A roster of "one-stop" experts by discipline area would be compiled for each coal region, to include bureau, laboratory, state agency, and university personnel willing to answer inquiries or to meet in the office or field, paid by the user where appropriate. This employs a vital personal component of technology transfer, one that has proven highly productive in other agencies.

Recommendation 4.5: A Generic Technology Research Center in Mining and Reclamation should be established at the earliest date, with affiliate universities located in those states with major AML problem areas. The Surface Mining Control and Reclamation Act authorized the creation and partial federal funding of state Mining and Mineral Resources Research Institutes, under the Generic Center Research Program. The concept of research centers is well-established, not only by the Stevenson-Wydler Act and by other congressional and executive measures, but also by the fact that BOM has already set up five generic centers. Greater benefit could be derived from establishment of a Center for Reclamation. This would serve as a reference center, a depository, and distributor of information on reclamation practices.

The selection of a generic research center for reclamation and affiliate universities should follow the bureau's normal procedure. In this instance, consideration should be given to proximity to areas of major AML concentrations, and to the presence and quality of supporting programs in mining engineering, chemistry, geology, civil and mechanical engineering, soil science, horticulture, forestry, wildlife, agriculture, and landscape architecture. An Agricultural Cooperative Service presence would be an advantage. The generic center should also be a designated Regional Federal Depository Library Center. The center, with its affiliated universities, would also be useful as part of the one-stop network.

Recommendation 4.6: It is recommended that the bureau host small professional seminars or conferences on information dissemination and technology transfer, particularly in the course of designing the AML technology transfer program. These sessions would include representatives of the bureau, OSM, and state agencies, editors of mining publications, and representatives of the Mineral Institutes and Generic Centers, NTIS, and the Federal Laboratory Consortium. Broad participation will allow the input of all federal and state entities having an interest in technology transfer. Currently, some agencies that are in place for the transfer of technology are not being utilized, and it is thought that a meeting of interested people would enhance the design of the AML technology transfer program.

Recommendation 4.7: The committee recommends that the Bureau of Mines incorporate the results of AML reclamation projects into technical guidance documents for use by agencies, mine operators, and contractors. Some manuals have been produced by OSM for other parts of its program, and these have been used extensively by coal mining companies. It is appropriate that this mechanism be utilized for this new clientele. These documents would summarize construction practices that have been used in other areas.

# Chapter 1

# THE STATUS OF ABANDONED MINE LAND RECLAMATION RESEARCH

## 1.1 AML RECLAMATION RESEARCH BEFORE 1977

Before the enactment of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), Public Law 95-87, no federal law governed coal-mined-land reclamation, although most states in which there had been extensive coal mining did have some form of laws or regulations in place prior to 1977. In some states there were two periods of reclamation. Regulations under the first period required leveling the tops of spoil piles left by the drag line or shovel. The first period began in the late 1930s and 1940s, with West Virginia being the first to enact a surface mining law in 1937, followed by Indiana (1941), Illinois (1943), Pennsylvania (1945) and Ohio (1947). Subsequent laws or regulations required the regrading of the mine spoils to a relatively level configuration and placing nontoxic spoil material on the surface. Most western states developed detailed surface mining regulations in the early 1970s, often modeled after the eastern states' regulations. Montana's law was first passed in 1970, and the amended law (1973) was closely modeled after the Kentucky legislation. Imhoff and others documented the status of state mining regulations in a 1976 U.S. Geological Survey Circular.[1]

A considerable body of knowledge was developed by reclamation research conducted by the federal government and universities prior to the enactment of SMCRA. Mining companies provided valuable assistance to the research through their practical knowledge of mining and reclamation and by providing land, materials, and services. The cooperation and interaction between the research community and the mining industry significantly influenced research priorities and accomplishments for many years.

The term "abandoned mine land" was inappropriate until state laws and regulations specifically identified responsibilities for reclamation. The term was not widely applied until the 1960s when laws became more stringent and enforcement practices improved.

Much of the early research did not focus specifically on abandoned mine land problems; rather, it related to active mine issues but was carried out on abandoned mine sites. Research often was unreported in

the general literature, because private companies conducted it on company-owned land, in some cases to improve that land for postmining uses such as grazing, forest products, and recreation. Some research, however, was reported in the open literature and in state and federal reports.[2] The number of reports of research on various reclamation practices has grown considerably over the past four decades. In the 1940s, it averaged about 5 per year; in the 1950s, about 8 per year; in the 1960s, 25 per year; and in the 1970s, annual figures were as high as 189.[2]

The Central States Forest Experiment Station of the U.S. Department of Agriculture's Forest Service provided leadership in early reclamation research. Individuals at universities in Pennsylvania, Ohio, Indiana, Illinois, and West Virginia made significant contributions. Much of this research focused on factors affecting the establishment of trees and shrubs on ungraded mine land. Species adaptability trials, planting methods, planting arrangement, and stock grading systems were evaluated. The effect of pH and other soil characteristics on seedling survival and growth was investigated.

In the eastern coal fields, where reclamation problems were particularly severe, practitioners from several states came together to visit abandoned mine land sites, discuss research progress, and evaluate new ideas. This form of research and technology transfer became more established, as it was able to focus on common problem areas. Research centers emerged in Illinois, Kentucky, West Virginia, and Pennsylvania, linked with specific researchers working in government, industry, and universities. Beginning in 1949, A. F. Grandt of Peabody Coal Company pioneered revegetation research in Illinois.[3] His work included planting of strip-mined land for pasturing cattle. W. D. Klimstra at Southern Illinois University inventoried the problems of abandoned mine land in Illinois, focusing on the development of wildlife.[4] In West Virginia, R. M. Smith, in 1945, classified spoil into three types according to the pH of the soil surface. He used lime and fertilizer to establish vegetation and showed that mulching and seedbed preparation and prevention of cutting or grazing also aid in establishing vegetation.[5] Later, W. R. Curtis of the Northeastern Forest Experiment Station published research on revegetation for reduction of sedimentation and runoff.[6] In the West, T. A. Gwynn of the Knife River Coal Mining Company reported on establishing game management areas on reclaimed strip mines.[7]

There was relatively little reclamation research in the West prior to 1970. However, much of today's subsidence control technology is a result of work sponsored by the Bureau of Mines and performed in Rock Springs, Wyoming, and northeastern Pennsylvania during the 1960s.

The initiation of the Surface Environment and Mining Project (SEAM) by the U.S. Forest Service in 1973 provided funds for a comprehensive research program. This project coordinated and

supported research by federal agencies, states, and universities. Although revegetation was emphasized, other aspects of reclamation and pollution control were funded.

Many of the most serious abandoned mine land problems recognized today were acknowledged as early as the 1940s and 1950s, but remained unresolved and little-researched. Acid mine drainage, burning in mines, gob and spoil piles, subsidence, unabated erosion, and stream pollution were not addressed in a manner that would add new knowledge and economic solutions to the problems. In some cases solutions were available, but the cost of correction was beyond the reach of the private and state entities that had responsibility for them. Some of these issues were addressed as research if they affected population centers.

During the 1970s the Bureau of Mines developed a microfilm mine map repository system with maps contributed by state mining agencies and industries. This system helped to gather together in a central data file mine maps from all over the United States and still represents a valuable data base for subsidence research.

Funding for the early research came from a variety of sources. The federal government supported most of the research through such agencies as the Department of Agriculture, the Department of the Interior, the Department of the Army, the National Science Foundation, the Appalachian Regional Commission, and the Environmental Protection Agency (EPA). Although the total amount appropriated would be difficult to determine, it probably reached several million dollars per year during the 1970s. As an example, the U.S. Forest Service budget for the SEAM project in the West and a surface mine rehabilitation project in the East totaled approximately $1.5 million during years of peak funding. Research projects at universities were supported to a large extent by federal grants, but funds did come from the states. State agencies responsible for the regulation of mining activities contributed some research funds. Although the mining industry provided funds for specific research, its primary contribution was land, materials, and services.

The largest body of reclamation research prior to 1977 was done under the auspices of the EPA and concerned acid mine drainage. The 1937 Pennsylvania Clean Streams Act and the 1972 Federal Water Pollution Control Act led to a large amount of research in this area.

Some state laws predating PL 95-87 provided for a fund to reclaim abandoned mine lands (for example, Ohio, Maryland, and West Virginia). These funds resembled the AML fund in PL 95-87 in that they were composed of a surtax on coal produced in the state with provision for matching by the state government. In 1966, Pennsylvania authorized a half-million-dollar bond fund for "Operation Scarlift," one of the first organized abandoned mine land funds.

With the enactment of SMCRA in 1977, it was anticipated that research for AML reclamation would be supported by the new federal law and the agency created to carry out the law. As it turned out, the overall support for research declined during the years immediately

following SMCRA because of perceptions of uncertainty: industry was now waiting to see what was needed to meet the new regulations, and the newly created Office of Surface Mining and Reclamation Enforcement (OSM) was occupied with developing regulations; officials had little time to consider research and in fact did not see research as a primary part of OSM's regulatory/enforcement mission. OSM did give some limited attention to funding several projects, notably acid mine drainage in West Virginia. OSM also funded applied research/development and experimental practices in AML reclamation through cooperative agreements and grants to states.

In the years following SMCRA, the number of federal agencies involved in mined land reclamation was reduced, federal grant money for research became more limited, and there have been few sources for AML research funding outside the federal government.

## 1.2 SMCRA AND ITS PRIORITIES

Under Title IV of SMCRA, Congress intended to reclaim as much of the abandoned mine land disturbed by surface mining as possible. In order to provide direction on accomplishing this task, priorities for reclamation were established in the act. Under Section 403 of Title IV, the following language addressed the priorities:

> Expenditure of moneys from the [Abandoned Mine Reclamation Fund] . . . for the purposes of this title shall reflect the following priorities in the order stated:
>
> (1) the protection of public health, safety, general welfare, and property from extreme danger of adverse effects of coal mining practices;
> (2) the protection of public health, safety, and general welfare from adverse effects of coal mining practices;
> (3) the restoration of land and water resources and the environment previously degraded by adverse effects of coal mining practices including measures for the conservation and development of soil, water (excluding channelization), woodland, fish and wildlife, recreation resources, and agricultural productivity;
> (4) research and demonstration projects relating to the development of surface mining reclamation and water quality control program methods and techniques;
> (5) the protection, repair, replacement, construction, or enhancement of public facilities such as utilities, roads, recreation, and conservation facilities adversely affected by coal mining practices;
> (6) the development of publicly owned land adversely affected by coal mining practices including land acquired as provided in this title for recreation and historic purposes, conservation, and reclamation purposes and open space benefits.

The inclusion of research in the list of reclamation priorities by Congress indicates that it was a topic of concern. However, its placement within the list of priorities is confusing because it is unclear how Congress intended such research to be accomplished, or how it should be related to the other priorities. Amid this confusion, OSM interpreted the law so as to place priorities 1 and 2 above the others, and it seemed that research projects would have to wait until the higher-priority problems had been addressed. As a consequence, OSM did not allow any purely academic research projects to be included with state proposals as projects to be funded under the state grant provision of the act. Although some states included research projects as part of their proposals, OSM would not fund these proposals because research was a priority 4 item.

## 1.3 THE ESTABLISHMENT OF AML RESEARCH UNDER OSM

The Surface Mining Control and Reclamation Act established an Abandoned Mine Reclamation Trust Fund, administered by the Secretary of the Interior, to finance the reclamation of coal surface mining sites abandoned before August 3, 1977. The fund consists of monies collected from active coal mining operations according to a specified fee collection schedule. The distribution of the AML reclamation fund was apportioned as follows: state and Indian Tribe share, 50 percent; federal share, 20 percent; the Small Operators Assistance Program share, 10 percent or less; and the Rural Abandoned Mine Land Program share, 20 percent or less. Section 401(c)(6) of SMCRA authorized use of monies from the AML fund for research and demonstration projects, among other reclamation-related uses. (See Appendix A for a reproduction of that section of the act).

In the early years of OSM the responsibility for management of the agency's research effort was vested in the Reclamation and Technology Division, with an annual budget of about $500,000. However, that research program was directed exclusively toward resolving active mining reclamation issues. Little or no program emphasis was placed on AML research because management determined that during this period the agency had more pressing organizational and programmatic funding priorities.

By late 1982, however, several states had requested funding for AML research on state-specific problems. Although most of the state research proposals addressed legitimate areas for investigation, OSM determined that such dispersed research efforts would require a very high total funding level and would almost certainly lead to duplication of effort. Therefore, in response to the need expressed by the states, OSM decided to develop an AML research program that would be centrally administered by OSM, but would allow states and Indian tribes an equal voice in the review, selection, and development of research projects.

In the beginning of the program, it was not known how much interest the program would generate in the form of research proposals

or the amount of funds that Congress would appropriate annually. Hence, few proposal guidelines were instituted beyond the requirement that they had to address solutions to AML priorities 1 and 2, or 3 as defined in PL 95-87.

In anticipation of the first appropriation for AML research in fiscal year 1985, OSM and the states/tribes developed procedures for a cooperative AML research program in late 1983 and initiated a research project selection process in 1984. The fiscal year 1985 congressional budget to fund the projects selected in the summer of 1984 was for $2,000,000; these funds were appropriated from the AML fund. To minimize program costs and travel time, it was decided not to accept unsolicited proposals throughout the year, but to make one annual solicitation for proposals and convene a review panel once during the year to select the proposals to be funded for the next fiscal year. Management responsibility for the AML research program was vested in the OSM Division of Federal Reclamation Programs, under the Assistant Director for Technical Services and Research. The primary function of this division was to manage all AML programs administered under federal authority (i.e., AML emergency projects, AML programs in states that elected not to enforce the provisions of SMCRA themselves, and programs for all Indian tribes).

A professional member of the division staff was assigned to be the AML research coordinator on a full-time basis. The coordinator developed for the OSM director's approval all program guidelines for proposal preparation, proposal evaluation, and project selection. In addition, he served as the chairman of the AML Research Evaluation Panel and cast the deciding ballot in the event of a tie vote among the other eight panel members. The coordinator also was to see that all cost and technical negotiations were finalized in a timely manner, that research projects were carefully monitored, that contracts were administered according to federal procurement regulations, and that the final research results were distributed to the appropriate state and federal AML agencies. Although this was the way the system was supposed to operate in theory, there was considerable difficulty in making timely decisions at the various checkpoints (see Chapter 3, Section 3.2).

The selection procedures called for establishing a panel composed of four federal and four state AML program members, with the federal panelists selected by OSM and state members recommended by the Association for Abandoned Mine Land Programs.

When proposals were received, copies were sent to all panel members, who were given about two months to complete their evaluations. At the end of this review period, the full panel met for about three days to make the final recommendation of projects that were to be funded in the upcoming fiscal year. This AML research recommendation was forwarded to the Deputy Director for Operations and Technical Services for final review and approval.

In the spring of 1984 a request-for-proposals letter was sent to all state regulatory authorities and appropriate federal agencies

inviting them to submit research proposals that would address AML priority 1 and 2 (public health and safety) problems. Several organizations submitted proposals addressing AML water pollution issues; these submittals were determined to be nonresponsive since they dealt with priority 3 (environmental) issues. A total of 64 responses were received, and six projects were funded in fiscal year 1985 for a total of $1,412,193. See Table 1.1 below for the breakdown of funding by AML project category, agency, and geographical areas. The fiscal year 1985 congressional appropriation had been for $2,000,000, as noted earlier. However, the panel had decided that not enough high-quality proposals were received concerning priority 1 and 2 problems, and therefore the unused portion of the appropriated funds, $587,807, would be available for use in fiscal year 1986.

A noteworthy feature in the structure of the AML program under SMCRA is the ability for unexpended monies from one fiscal year to be spent in succeeding years. All other reclamation programs funded under SMCRA receive annual appropriations, and unused monies at the end of the year must be returned to the federal treasury. This carryover provision can be valuable to a research program, because it allows greater flexibility in the selection of high-quality projects by eliminating, if necessary, the requirement to spend all the appropriated funds in a given year.

In the spring of 1986 the request for proposals was advertised in the Commerce Business Daily in order to reach a potentially larger number of research organizations. In addition, program management decided to accept research proposals for priority 1, 2, and 3 AML problems, but determined that no proposals would be accepted for revegetation studies, since considerable effort in this area either was currently under way or had already been successfully completed. As a result of this increase in research scope, 104 proposals were received, and 15 were selected for funding. In fiscal year 1986 Congress appropriated $1,900,000 for AML research, with $1,923,491 obligated. The amount in excess of the appropriation was funded from unused fiscal year 1985 funds.

In summary, the Office of Surface Mining managed the AML research program for two years, and during this period it funded 21 projects for a total of $3,335,684. More than 90 percent of these funds were expended on 19 water pollution, subsidence, and mine fire research projects. Twenty-six percent of the funds were awarded to the Bureau of Mines, the only federal agency to submit proposals. Forty-two percent and 29 percent of the funds were awarded to universities and private contractors, respectively. Sixty-seven percent of the funds were awarded to organizations with headquarters located east of the Mississippi River. This geographical comparison of allocation of funds may be misleading, since in several cases research accomplished by a given company is applicable to nationwide AML problems and has little or no correlation to the location of the companies' headquarters. However, it does indicate that most of the funds were expended in the eastern region of the country, where the bulk of the coal problems have been found.

**TABLE 1.1 Summary for AML Research Projects Funded in Fiscal Years 1985-1987 (total number of projects and dollars by AML category and year)**

| | FY 1985 | | FY 1986 | | FY 1987 | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | (No.) | Funding, $ | (No.) | Funding, $ | (No.) | Funding, $ | (No.) | Funding, $ | Percent |
| **Category** | | | | | | | | | |
| Water pollution | | | (6) | 731,242 | (7) | 788,920 | (13) | 1,520,162 | 30.0 |
| Subsidence | (3) | 723,159 | (6) | 717,098 | (3) | 407,028 | (12) | 1,847,285 | 36.5 |
| Mine fires | (3) | 689,034 | (1) | 234,296 | (2) | 234,863 | (6) | 1,158,193 | 22.9 |
| Soils/revegetation | | | (1) | 100,855 | (2) | 91,118 | (3) | 191,973 | 3.8 |
| Mine openings | | | (1) | 140,000 | | | (1) | 140,000 | 2.8 |
| Slope stabilization | | | | | (1) | 201,376 | (1) | 201,376 | 4.0 |
| | (6) | 1,412,193 | (15) | 1,923,491 | (15) | 1,723,305 | (36) | 5,058,989 | |
| **Agency Study Type** | | | | | | | | | |
| Federal government[a] | (1) | 237,100 | (4) | 613,212 | (2) | 351,376 | (7) | 1,201,688 | 23.7 |
| Universities | (5) | 1,175,093 | (3) | 325,527 | (7) | 740,170 | (15) | 2,240,790 | 44.3 |
| Consultants | | | (8) | 984,752 | (6) | 631,759 | (14) | 1,616,511 | 32.0 |
| | | | | | | | (36) | 5,058,989 | |
| **Geographic Area[b]** | | | | | | | | | |
| Eastern | (3) | 734,747 | (12) | 1,485,853 | (10) | 1,261,436 | (25) | 3,482,036 | 68.8 |
| Western | (3) | 677,446 | (3) | 437,638 | (5) | 461,869 | (11) | 1,576,953 | 31.2 |
| | | | | | | | (36) | 5,058,989 | |

[a] Only the Bureau of Mines responded to the request for proposals.
[b] The Mississippi River was considered to be the boundary between east and west.

Given the numerous regulatory and enforcement tasks the agency had to perform, OSM's AML research program was at a relative disadvantage. Several weaknesses characterized the program. First, the system was primarily reactive in nature. The application process reflected OSM's intent to allow the research agenda and research priorities to develop from proposals. The guidelines for submitting proposals were not sufficiently focused, and the resultant proposals covered a wide range of AML topics and problems. Since only limited financial resources were available, the research effort in retrospect should have been focused on several of the more serious reclamation problems. In addition, OSM had considerable difficulty in finalizing contract awards. On several occasions projects were approved in January of the fiscal year, but the related contracts were not awarded for many months. Another problem was that the system had no funding mechanism for amending or extending research projects that had produced promising initial results. All project amendments had to be resubmitted for funding consideration during the next fiscal year. The project selection process contained no formal provision for peer review and, as a result, it is unclear whether the best designed or most important research proposals were selected. An additional weakness in OSM's AML research program was the absence of provisions for technology transfer. That is, once the final research reports were received, no plans were made for providing the research findings to the potential community of users. Finally, the program was designed to develop emergency solutions that, it was hoped, could be applied nationally to a particular reclamation construction problem. But more often than not, this type of solution applied only to local or, at best, regional AML problems. Those who managed the new AML research program did not seek applied research addressing the more complex and intractable AML reclamation problems that could have required years of funding to solve.

## 1.4 THE TRANSFER OF AML RESEARCH TO THE BUREAU OF MINES

In the fiscal year 1987 Continuing Resolution for Federal Agencies (PL 99-591) enacted in October 1986, Congress transferred the AML research program and $1.9 million in funding from OSM to the Bureau of Mines (BOM). This action transferred the authority to conduct AML research as authorized by PL 95-87, Section 401(c)(6) to BOM beginning with fiscal year 1987, but the responsibility for conducting all other functions of the AML program remained with OSM. The appropriation language stipulated that BOM should select reclamation projects based on established research priorities and that an AML research panel be established to evaluate research proposals. The panel was to be composed of four representatives from the bureau, four from state AML program personnel, and one from OSM and would meet at least annually to select the AML research projects that should be funded.

Congressman Nick J. Rahall II, chairman of the Subcommittee on Mining and Natural Resources of the House Committee on Interior and

Insular Affairs, had authored the proposal to transfer the AML research program. In a letter to the director of the Bureau of Mines, he stated:

> . . . it has been my intention to improve the management and effectiveness of the AML research program through this transfer. I believe the Bureau now has before it an opportunity to make an even greater contribution to the development of those technologies that will facilitate better reclamation practices on abandoned coal mine lands.[8]

It was Congressman Rahall's position that the Bureau of Mines already had the research organization in place and the expertise and capability to conduct AML research. Furthermore, the Bureau of Mines is now the predominant agency among public and private organizations conducting research in acid mine drainage, mine fires, and subsidence--three of the most prevalent and troublesome problems that were to be addressed by OSM's latest AML research effort. However, Mr. Rahall stated in the Congressional Record[9]:

> As the author of this provision, I would like to make it clear that the majority of the research and demonstration projects selected to be undertaken under this program should be conducted on a contracted-out basis. Actual project selection will be made by a panel consisting of both State and Federal officials which will review research proposals.

Mr. Rahall was aware that almost 30 percent of the fiscal year 1986 AML research budget had been awarded to BOM, and he wanted to ensure that a significant portion would be conducted through outside contracts.

In congressional testimony, Rahall envisioned how a newly placed AML research program was to be conducted.[10] He emphasized a preference for applied research that could be completed and used in a short time, an intention that most AML research projects be contracted out, and a requirement that the selection panel consider "any proposal that involves a multi-disciplinary approach to addressing in a comprehensive fashion the major technical problems facing reclamation practitioners in this country." He also stressed that an effective technology transfer program was to be incorporated into the research program.

The legislative intent in transferring the AML research program to the Bureau of Mines was to seek innovative technologies to achieve practical, short-term solutions to those reclamation problems remaining in the field, solutions that had broad geographic applicability. This research program, unlike most BOM research traditionally, viewed "research" as a search for solutions.

In December 1986, BOM management officials met with representatives from state AML programs in Salt Lake City to solicit recommendations for state membership on the AML research panel. In mid-January 1987 a memorandum of understanding was finalized between BOM and OSM that outlined the functions and responsibilities of both organizations in making the transition and in implementing the program BOM designed. In March 1987 the BOM review panel met for the first time and selected 15 projects for fiscal year 1987 funding.

## 1.5 THE AML RESEARCH PROGRAM UNDER BOM

Because the congressional action to transfer the AML research program from OSM to BOM did not occur until October 1986, the process for selecting and funding the 1987 AML research projects has fallen about a year behind schedule. In an effort to bring the process to a regular yearly schedule, the new panel decided to select research projects from among the proposals submitted under the OSM-generated 1986 Commerce Business Daily (CBD) announcement and to employ the existing OSM guidelines and criteria for project selection. In addition, the panel recommended that the BOM procurement process be accelerated and that next CBD announcement, for fiscal year 1988, be written by BOM and published as soon as possible, after receiving the benefit of independent professional guidance on AML research priorities from the NRC's Committee on Abandoned Mine Lands Research Priorities.

On March 12, 1987, the review panel convened and selected 15 projects to be funded for a total of $1,723,305. Eighty-six AML research proposals had been received from the federal government (Bureau of Mines), universities, and research consultants. About two-thirds of the funds are devoted to water pollution and subsidence issues. Universities and research organizations from the private sector are receiving almost 80 percent of the funds, and the Bureau of Mines, as the only federal government respondent, is receiving just over 20 percent of the funds to finance AML research projects, through its Pittsburgh Research Center. Approximately 75 percent of all fiscal year 1987 AML research funds are awarded to research organizations with headquarters east of the Mississippi River.

Beginning in fiscal year 1988 the bureau's charge will be to select and fund AML research projects annually, based on established national research priorities. In addition, it is to assure a timely awarding of contracts and an effective monitoring of research progress. The bureau also is charged with establishing an effective program for technology transfer. And it is to encourage active coal mining operations to employ the latest research developments to carry out the mandate of PL 95-87 to mine and reclaim in a contemporaneous manner.

## 1.6 SUMMARY

During fiscal years 1985, 1986, and 1987, Congress has appropriated approximately $5.8 million for the AML research program. During this period 254 AML research proposals were received, and 36 were funded, for a total outlay of $5,058,989, (Table 1.1). Eighty-eight percent of the funds were expended on water pollution, subsidence, and mine fire problems. Forty-four percent went to university research organizations, 32 percent to private research organizations, and about one-fourth to the BOM Pittsburgh Research Center. Almost 70 percent of the funds were awarded to organizations whose headquarters are east of the Mississippi.

The Bureau of Mines has now assumed responsibility for the $2 million/year AML research program, for identifying top research priorities for abandoned mine lands, and for ensuring a project selection process that accurately reflects the highest research priorities.

The next chapter will present an overview of the progress made in research on water quality, subsidence, mine waste, revegetation, and other major problem areas pertinent to abandoned mine lands. The views of geologists, mining engineers, and other specialists in abandoned mine reclamation were sought, and their perceptions of today's top research priorities are also presented.

## NOTES

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8. Letter from Rep. N. J. Rahall II to Robert C. Horton, Oct. 22, 1986.

9. Congressional Record, H11456 (Oct. 17, 1986).

10. Congressional Record, H10873 (Oct. 15, 1986) and H11383 (Oct. 17, 1986).

# Chapter 2

# SETTING AML RESEARCH PRIORITIES IN THE BUREAU OF MINES

## 2.1 AML RESEARCH PROBLEMS RESOLVED AND REMAINING

What has been learned concerning reclaiming abandoned mine lands? Each problem is site-specific, but experience has shown how to reshape the land and control erosion through revegetation. Some physiochemical interactions of minerals in spoils and gob that are acid-producing are understood, and procedures have been developed to reshape the land to reduce or eliminate their impact on vegetation. Those physiochemical mechanisms producing acid drainage that are understood have not yielded to control in certain settings through engineering or scientific procedures.

The discussion in this chapter is framed in the context of the list of research areas used in the committee's field inquiry to elicit the perceptions of experts concerning the highest-priority research needs. This list is shown as Table 2.1. The list does not reflect any ordering or ranking of research priorities. The AML problems being repaired at the present time are justified on the basis of health and safety, which are covered under priorities 1 and 2 of SMCRA. However, in most cases the correction of the health and safety aspect of the problem requires that the actual reclamation work address the biological and environmental rehabilitation of disturbed land. Work done prior to SMCRA was primarily concerned with the mitigation of environmental problems, and many of those problems remain unresolved today. Acid mine drainage, though classified as a lower-priority environmental problem by OSM, is viewed by many people to be the most pressing need in research and development. Therefore this discussion of the status of research on abandoned mine lands will include environmental aspects.

Reshaping the land is the major method for reclaiming abandoned mine sites. Five of the AML reclamation research priority areas (Table 2.1) fall under the category of land reshaping. They are landslides, slope stability, mine waste, topsoiling, and land subsidence.

The abandoned land left after surface mining is affected by many kinds of problems. While the topography and geology of the coal

**TABLE 2.1 AML Reclamation Research Priority Areas***

| |
|---|
| A. AML resource evaluations |
| B. Landslides |
| C. Mine fires |
| D. Mine openings |
| Shaft filling and sealing |
| Adit and portal sealing |
| E. Mine wastes |
| F. Revegetation |
| G. Slope stability |
| Highwalls |
| Refuse piles |
| H. Subsidence |
| Prediction |
| Control |
| Void filling |
| Underground void detection |
| I. Topsoiling |
| J. Toxic soils |
| K. Water quality |
| Acid mine drainage (AMD) |
| Coal mine lakes |
| Suspended and dissolved solids |
| Trace elements |
| L. Others |

* An unranked listing

dictate which mining methods to employ, the problems are similar, regardless of which method has been employed. Erosion, unstable slopes, acid production, sediment production, unstable highwalls, and acid ponds are commonly encountered. Techniques are available to correct these problems, but improvements on these current methods may prove disproportionately costly. An overview of current technologies available for abandoned mine land reclamation is in order.

Probably the most difficult aspect of reshaping the land relates to the expected life of the remedial treatment. In the case of land surfaces, natural geomorphic processes are constantly at work, leveling any oversteep terrain. If a problem on a steep slope is addressed without reducing the degree of slope, the problem might require perpetual maintenance. We need to determine how to apply this geomorphic knowledge to the long-term planning for abandoned mine land reclamation.

In the case of contour mining, reclamation of abandoned highwalls and outslope deposits has been difficult. Expensive and disruptive massive earth-reshaping projects have been the major methods of reclamation. When auger mining follows the removal of coal by contour mining, the long horizontal bore holes may produce acidic drainage. Considering the present condition of partially reclaimed highwalls and the cost of total reclamation, long-term maintenance may be the best solution currently available.[1]

The problem areas discussed below were considered to be of prime importance for AML research, according to the large group of experts consulted by the committee. They are discussed below in order of priority, with water quality perceived as most urgent. Some of the problems pointed out for AML research, according to those consulted, related to health and safety aspects (e.g., subsidence, mine fires, mine openings). However, the major topics of concern were more closely related to priority 3 under SMCRA's section 403. Some general highlights of research progress in these subject areas are now summarized.

Water quality: It is in the area of water quality that the most serious abandoned mine problems exist. Water quality problem areas that have been identified include acid mine drainage, mine impoundments and wetlands, suspended and dissolved solids, and trace elements. Many water problems remain on abandoned mine lands because precipitation on the surface reacts readily with exposed minerals to produce acid conditions. Acidic groundwater may be discharged to streams, lakes, wells, and seeps. The methods of treating surface water to bring it to acceptable levels of quality are well-known, but in some cases the costs are prohibitive. New economical techniques for neutralization are needed. A better understanding of groundwater occurrence in abandoned mines and auger holes should lead to better solutions to the acid mine drainage problem.

Through planned reconstruction of the land and vegetation establishments, erosion is reduced and sediment production is lowered. Vegetation establishment and soil development may reduce the concentration of dissolved solids and trace elements in surface runoff.

Subsidence: The most enigmatic area in abandoned mine land research may be subsidence. Underground mining in the past created cavities that may cause overburden rock strata to collapse. The time of collapse is unknown, because even the costly predictive methods available today are inaccurate. What is known is that the type of rock and the depth of the mine determine when faulure occurs. Current research on subsidence does not appear to be providing economical corrective measures. At present the best way to prevent subsidence in abandoned deep mines is to backfill the underground mine workings with materials. This is very costly and thus not economically feasible except for special cases, e.g., those in which public facilities, houses, and other valuable structures are at risk. In areas such as agricultural land, simply regrading and filling the surface voids as they occur may be the most cost-effective procedure. New insights are needed in this area of abandoned mine land problems. An evaluation of total cost of reclamation, factoring in the time element and continued maintenance or insurance costs, needs to be researched to assure the most cost-effective subsidence reclamation.

Mine waste: Mine waste can generally be classified as coarse materials (gob) and fine materials (slurry). Abandoned gob is generally found in large piles, whereas slurry is placed in ponds because it is transported to the disposal area in water. Each of these kinds of waste poses different problems. Gob is placed in large piles that erode easily to produce sediment, suspended solids, dissolved solids, and trace elements. Earth embankments holding slurry can fail by landslide. Slurry pond embankments or dams have failed and have caused major disasters and loss of lives because of their location near communities. The gob piles and slurry ponds may be a source of acid mine drainage because of the high concentration of pyrite in the waste materials.

Research has been conducted on mine spoils without a significant distinction being drawn between mine spoils produced by excavation and those produced by coal cleaning. Recently many of these waste piles have been eliminated by reprocessing to remove the remaining coal.

In summary, extraction of remaining coal from gob piles, reshaping gob piles to a stable configuration, and covering them with nontoxic materials that will support vegetation generally have been the most widely used methods of reclamation.

Revegetation: Much has been learned about plant growth on active and abandoned mine lands, and our knowledge in this area continues to advance. Properly developed land can produce crops of economic value, recreational areas, and wildlife habitat.

Hundreds of acres of productive forests planted on unleveled, rocky spoil demonstrate that trees and shrubs should receive priority consideration in abandoned mine land reclamation, particularly in the eastern United States. Previous research documents species compatibility, planting arrangement, planting methods, and stock grading systems. Acceptable growth has occurred on sites with a wide range of physical and chemical characteristics. Minimum grading is

required, a rocky surface is acceptable, and the use of topsoil or expensive amendments is seldom required. A low-density cover crop of grasses and legumes must be established to minimize erosion. This can be accomplished on most sites by using current technology.

Agricultural crops may be successful on abandoned mine lands with suitable physical and chemical characteristics, topography that permits the use of farm machinery, and a source of topsoil. Pasture and forage crops have the best opportunity for success. A small percentage of the AML land can be used for row crops. This requires intensive and costly treatment to prepare the site and maintain productivity.

Strong acidic or toxic spoil conditions may occur on the surface of some abandoned mine land before grading, or such conditions may be exposed during grading. Minimum grading should be considered on sites where there is a high potential for toxic spoils. Areas where planted or volunteer vegetation has become established indicate the surface few inches of spoil have leached and weathered to a degree that some plant species will survive. Modest amounts of fertilizer, lime, or other amendments and selected plant species may achieve an acceptable vegetative cover. Regrading these sites could expose unweathered toxic spoil that may be extremely difficult or impossible to revegetate.

Treatment of strongly acidic and toxic spoils may be by burial beneath a nontoxic material, by utilizing neutralizing materials, or by a combination of both. Four to six inches of topsoil over 24 inches of neutralized spoil shows great promise. Research and experiments carried out by the Corps of Engineers on the Tennessee Tombigbee Waterway Project indicated that to get lime to the required depth of one foot required a heavy-duty bogging disc with 28-inch-diameter discs which physically incorporated lime to about eight inches. Leaching then carried the lime to greater depths.[2] Research has shown that vegetation establishment is possible after intensive treatments. However, there is great variability in the length of time these treatments remain effective. Wetting and drying cycles contribute to capillary action that draws toxic ions to the surface. Erosion may remove all or portions of the topsoil, and its beneficial effects will be lost.

Mine fires: Types of fires related to coal mining range from unmined burning coal seams, coal seam fires in mines to spoil and gob pile fires. In the case of coal seam fires, the coal and adjacent shale beds burn because of either high pyrite content or natural ignition of the seam by lightning, range fires, or spontaneous combustion. Our ability to control coal seam fires has not significantly improved, but research conducted by the Bureau of Mines and other agencies has attempted to seek solutions. Limiting the availability of oxygen to the burning coal seam is difficult. Extensive subsurface investigation is required to define the extent of the fire and the nature of the rocks in which the coal occurs. Research is needed in this latter area to reduce the cost of current techniques.

Fires occur in spoils and gob piles through spontaneous combustion or from adjacent man-made or natural fires. The technology for extinguishing the fire is limited to excavation and surface cooling before replacing in an oxygen-reducing subsurface burial. In-situ methods might be more cost-effective if they could be found. Location of the burning boundary is another problem that would benefit from research.

Mine openings: Many of the mine shafts and portals identified as priority 1 or 2 problems have been addressed by a variety of techniques appropriate for the location. The technology may be improved if research is conducted in this area, but it appears that current solutions are cost-effective. Present needs in this area are technology transfer of all cost-effective designs and research concerning hydraulic mine seals.

AML resource evaluations: Prior to SMCRA, some states had conducted inventories of abandoned mine lands within their boundaries. These inventories generally included total acres disturbed, acidity of the spoil, water quality, and in some cases an assessment of the volunteer vegetation and wildlife habitat values. With the advent of remining possibilities for coal mines and waste piles, the abandoned mines might be considered potential mines, and new inventories, including remaining coal resources, may be needed.

Wildlife: The wildlife aspect of abandoned mine lands has been studied in some detail. This was an early component of abandoned mine reclamation research. Different habitats are produced in a given region as the result of mining. Lakes are formed, wetlands are formed, and in some cases, such as in the Midwest, rugged terrain is created. With the expansion of lakes and wetlands, more duck and fish habitats are formed. The rugged terrain created by grading or highwalls provides desirable habitat for wildlife. In the past these lands were often reclaimed as recreational wildlife management areas shortly after the lands were abandoned. Recently, important research has shown that the creation of wetland areas and the associated ecosystem aids in the partial treatment of acid mine drainage, and such solutions are being applied under Title V of the act. Even though wildlife habitat development was incidental to the reclamation objectives of abandoned mines, this form of reclamation could be very cost-effective as well as beneficial. Each species of local or migratory wildlife requires specific types of habitat. The recognition of these requirements and creation of wildlife habitat features targeted to specific species should be strongly emphasized for abandoned mine land reclamation.

## 2.2 IDENTIFYING THE HIGHEST-PRIORITY RESEARCH PROBLEMS

To gain an overall identification of those AML research areas most in need of attention, the NRC Committee on Abandoned Mine Lands Research Priorities sent a letter to knowledgeable professionals throughout the country asking them to identify the highest-priority

AML research needs in their regions. The inquiry was sent to individuals in various research institutions, organizations, government agencies, and industries, covering all coal regions of the country.

The letter (Appendix B) asked the respondents to identify the three most important AML research priorities in their region, and to outline the most challenging, intractable, and promising research problems remaining to be solved that are most likely to have a high return or investment. A list of possible research topics, provided by the AML research office of BOM, was included for their use (Table 2.1).

One hundred thirty-six letters were sent to individuals representing five major groups--state AML program directors, state geologists, Mining and Mineral Resources Institute directors, representatives of the coal industry and mining associations, and representatives of the American Society for Surface Mining and Reclamation. Sixty-eight responses were received, for a 50 percent response rate.

### 2.2.1 Results of the Critical Group Inquiries

The responses were analyzed by grouping them according to the type of organization responding and the region of the country they represented (using Figure 2.1 for the latter). For each respondent, three points were given for a number 1 research priority, two points for a number 2 research priority, and one point for a number 3 research priority. If more than three research priorities were identified, one point was assigned to each additional priority topic. If the respondent did not indicate a priority order to the three topics suggested, each topic was given three points.

Then, using the five organizational groups plus one grouping with no respondent identification, and four regions (including a "region unspecified" respondent group), research priorities were tabulated in rank order, forming a matrix (see Table 2.2).

Table 2.3 indicates the scoring of individual research subject areas by region and by a composite of all regions. Note that water quality, mine wastes, subsidence, and revegetation have by far the largest number of points (288 points out of a total of 394, or 73 percent).

The committee believes that several significant conclusions can be drawn from the views of the respondents (Table 2.2):

- Water quality, subsidence, mine waste, and revegetation are ranked as the top four research priorities in all regions.
- Top research priorities tend to be similar across organizations within a specific region.
- Regional research priorities differ somewhat, but only in terms of relative rank and differing lower-priority problems.

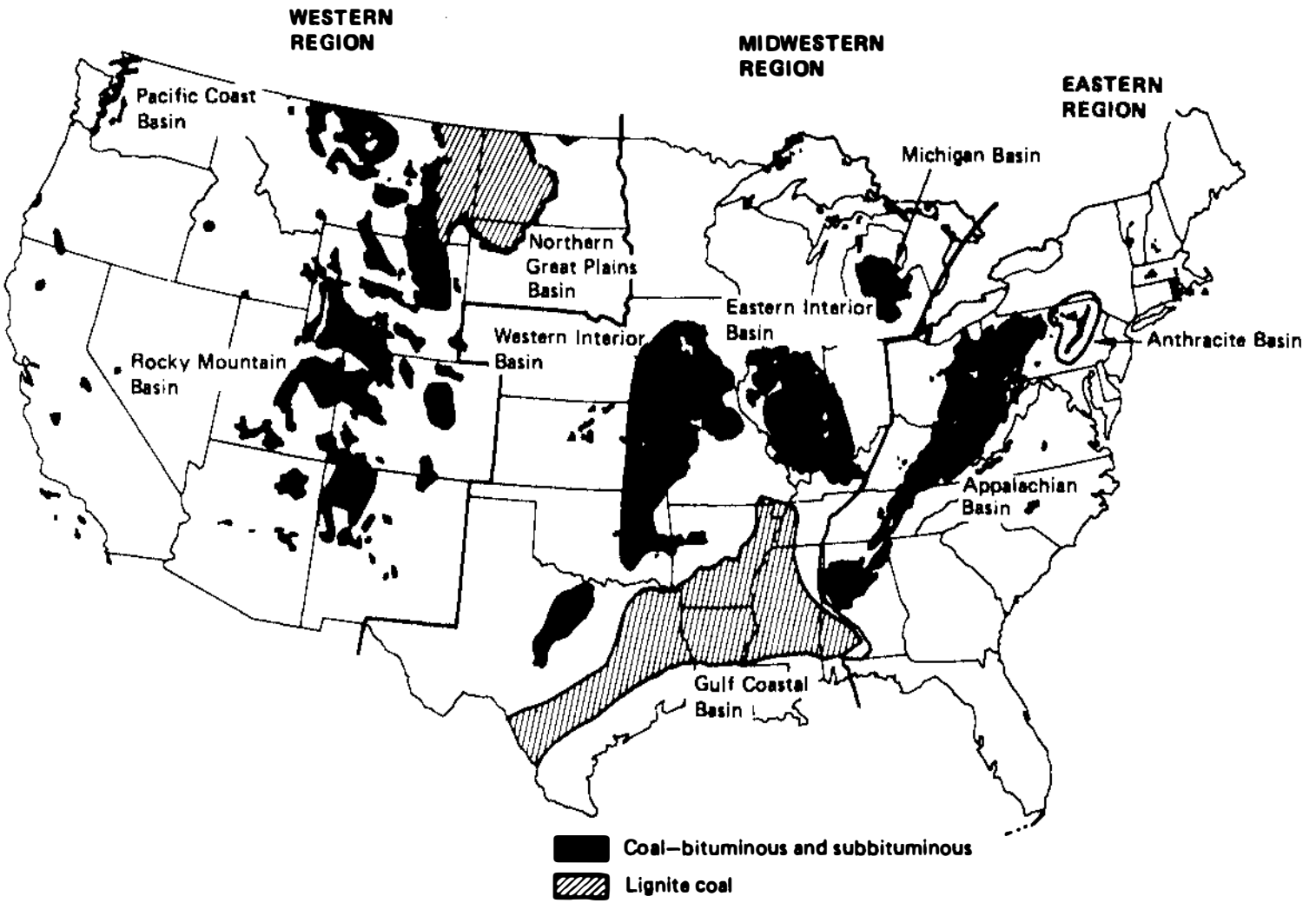


FIGURE 2.1 Coal fields of the conterminous United States.

SOURCE: Department of the Interior (1967) Surface Mining and Our Environment. Washington D.C.: U.S. Government Printing Office.

Department of Energy (1982) Coal Data: A Reference. Energy Information Administration. Washington, D.C.: U.S. Government Printing Office.

## TABLE 2.2 Ranking of AML Research Priorities by Organization and Region

| Organization (No. of respondents) | Region: East | Region: Midwest | Region: West | Region: Unspecified | Composite |
|---|---|---|---|---|---|
| Mining and Mineral Resource Institutes (13) | 1. Water quality<br>2. Subsidence<br>3. Mine waste | 1. Water quality<br>2. Revegetation<br>3. Mine waste<br>Topsoiling | 1. Water quality<br>2. Subsidence<br>3. Revegetation<br>Mine waste | | 1. Water quality<br>2. Subsidence<br>Revegetation<br>3. Mine waste |
| State Geological Surveys (12) | 1. Water quality<br>2. Subsidence<br>3. Revegetation | 1. Water quality<br>2. Subsidence<br>3. Mine waste<br>Topsoiling<br>Toxic soils | 1. AML resource evaluation<br>2. Subsidence<br>3. Mine waste<br>Underground water storage | | 1. Water quality<br>2. Subsidence<br>3. AML resource evaluation<br>4. Mine waste |
| State AML Bureaus (14) | 1. Subsidence<br>2. Water quality<br>3. Landslides<br>Revegetation | 1. Water quality<br>2. Mine openings<br>3. AML resource evaluation<br>Subsidence | 1. Mine fires<br>2. Subsidence<br>3. Toxic soils<br>Mine openings | | 1. Subsidence<br>2. Water quality<br>3. Mine waste<br>Mine openings |
| Coal Companies/ Coal Associations (11) | 1. Water quality<br>2. Mine waste<br>3. Subsidence<br>4. Toxic soils | 1. Mine waste<br>2. Revegetation<br>3. Water quality<br>4. Mine openings | | | 1. Mine waste<br>2. Water quality<br>3. Subsidence<br>Revegetation<br>Toxic soils |
| American Society for Surface Mining and Reclamation (10) | 1. Water quality<br>2. Subsidence<br>3. Mine waste<br>Landslides<br>Topsoiling | 1. Mine waste<br>2. Water quality<br>3. Subsidence | 1. Revegetation<br>Toxic soils<br>Water quality<br>2. Mine waste | | 1. Water quality<br>Mine waste<br>2. Revegetation<br>Subsidence<br>3. Topsoiling |
| U.S. Forest Service (1) | | | | 1. Water quality<br>2. Revegetation<br>3. Slope stability | |
| Respondent Not Identified (7) | | 1. Topsoiling<br>Subsidence<br>2. Water quality<br>Revegetation | 1. Mine waste<br>Revegetation<br>Water quality | 1. Mine waste<br>2. Water quality<br>3. Revegetation<br>Mine openings | 1. Mine waste<br>2. Water quality<br>3. Revegetation<br>4. Subsidence |
| Composite | 1. Water quality<br>2. Subsidence<br>3. Mine waste<br>4. Revegetation<br>5. Landslides/ slope stability | 1. Water quality<br>2. Mine waste<br>3. Subsidence<br>4. Revegetation<br>5. Topsoiling | 1. Water quality<br>2. Subsidence<br>3. Mine waste<br>4. Revegetation<br>5. Mine fires | 1. Water quality<br>2. Mine waste<br>3. Revegetation<br>4. Mine opening | 1. Water quality<br>2. Mine waste<br>3. Subsidence<br>4. Revegetation<br>5. Topsoiling<br>Mine opening |

TABLE 2.3 Composite Scores by Region

| AML Reclamation Research Subject Areas | East Ranking | | Midwest Ranking | | West Ranking | | U.S. Forest Service Region Unspecified | | Composite | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Points | Ranks | Points | Ranks | Points | Ranks | Points | Ranks | Points | Ranks |
| A. AML resource evaluations | 4 | | 3 | | 8 | | | | 15 | |
| B. Landslides | 6 | (5) | | | 3 | | | | 9 | |
| C. Mine fires | 1 | | | | 9 | (5) | | | 10 | |
| D. Mine openings<br>Shaft filling and sealing<br>Adit and portal sealing | 1 | | 8 | | 6 | | 3 | (4) | 18 | (5) |
| E. Mine wastes | 18 | (3) | 30 | (2) | 15 | (3) | 7 | (2) | 70 | (2) |
| F. Revegetation | 10 | (4) | 15 | (4) | 14 | (4) | 5 | (3) | 44 | (4) |
| G. Slope stability<br>Highwalls<br>Refuse piles | 4 | | 1 | | 2 | | 2 | | 9 | |
| H. Subsidence<br>Prediction<br>Control<br>Void filling<br>Underground void detection | 31 | (2) | 17 | (3) | 18 | (2) | 2 | | 68 | (3) |
| I. Topsoiling | 3 | | 11 | (5) | | | | | 14 | |
| J. Toxic soils | 4 | | 7 | | 7 | | | | 18 | (5) |
| K. Water quality<br>a. Acid mine drainage (AMD)<br>Coal mine lakes<br>Suspended and dissolved solids<br>Trace elements | 40 | (1) | 37 | (1) | 21 | (1) | 8 | (1) | 106 | (1) |
| L. Others | 2 | | 4 | | 7 | | | | 13 | |

- Although water quality is perceived as the highest priority in all regions, the top four priorities are ranked fairly evenly in the West; water quality is clearly highest in the East and Midwest.
- Subsidence and mine wastes are ranked either second or third in all regions.
- Despite the substantial amount of research and literature on revegetation, it remains a matter of concern, as it comes out a clear fourth priority in the overall composite results as well as in each region.
- Landslides/slope stability, topsoiling, mine fires, and mine openings are subjects having higher than "background" interest among respondents.

### 2.2.2 Respondents' Comments Elaborating Upon Their Priorities

Several other aspects of research priorities become evident by analyzing various respondents' comments on their priority choices. Table 2.4 presents the research topics specifically mentioned by respondents.

In the prime area of water quality, several participants addressed the problem of finding alternatives to perpetual treatment of acid mine drainage. It was believed that a substitute for chemical treatment is necessary and that wetland (bog) methodologies are a partial answer but need more research. Other participants wanted data on water quality changes. Are the reclamation technologies already in place on completed AML projects working? A need is perceived to obtain reliable baseline monitoring data. Knowledge of how remedial procedures are working is considered essential to make an informed decision recommending whether the AML program should be continued after 1992, when the program ends by law.

Several respondents emphasized the importance of understanding the groundwater flow systems, not only in the natural premining environment and the abandoned mine land, but also in the post-reclamation configuration. Many deficiencies in field studies are thought to originate from poor definition of the hydrology of the mine site, leading to improper tracking of amelioration, improperly designed monitoring networks, poorly located treatments, and poorly designed sampling.

Subsidence was addressed by most individuals from the standpoint of prediction of future occurrences. Use of remote sensing or some other cost-effective mechanism is considered a fertile field for research. They stressed the need to map accurately the location and extent of mine voids, compile an extensive data base of subsidence-related information, and create subsidence prediction models for specific coal fields. One respondent was pessimistic about subsidence and its remediation: "Out of all AML issues (in my state), this will be an unanswered long-lasting problem which will not be solved by the AML program." It is assumed by many people that the

**TABLE 2.4 Respondents' Suggestions for Research Topics Within Four Highest Priorities**

| Water Quality | Subsidence | Mine Wastes | Revegetation |
|---|---|---|---|
| • Alternative to perpetual treatment<br>• Alternative to chemical treatment<br>• Use of wetlands as a treatment methodology<br>• Research to address trace elements and total water quality (dissolved solids) as well as neutralization<br>• How to restore stream quality<br>• Need to monitor remedial measures--are they working?<br>• Need for national classification system for acid mine drainage characteristics can be matched with treatment options<br>• Long-term (multiyear) monitoring of groundwater quality and hydrology should be used to construct solute-transport models<br>• Impacts of acid mine drainage on domestic water supplies<br>• Runoff from waste ponds and waste piles<br>• Opportunity for storage of water in underground mines (West)<br>• Long-term impact on wildlife/fisheries<br>• Need to define subsurface stratigraphy of in-place strata as well as spoil and waste material to provide framework for groundwater modeling<br>• Evaluation of effects of remining on water quality | • Prediction of future subsidence through use of remote sensing techniques and predictive modeling<br>• Methods to control subsidence<br>• Comprehensive data base on subsidence-related information<br>• Extent of mined areas--update and complete mine map repository<br>• Methods to evaluate effects of remining to reclaim recoverable coal and eliminate subsided or potential subsidence area<br>• Methods to reclaim subsided terrain | • Inexpensive, efficient disposal methods<br>• Extraction of by-products leaving residue<br>• Methods to reprocess wastes to recover maximum coal values<br>• Coal content, quality, and stratification of wastes<br>• Geochemistry of wastes<br>• Slope stability particularly in areas of contour surface mining<br>• Run-off from mine wastes<br>• Appropriate amount of cover material (topsoil) to be used to stabilize mine waste (upward migration of salts, maintenance of nutrients, soil erosion)<br>• Applicability of handling methods (e.g., mixing a proportion of soil with refuse to reduce spontaneous combustion potential)<br>• Regional study to carefully define refuse properties and their variability, their relationship to stratigraphy of the seams involved, and geochemical weathering processes in the waste piles over time<br>• Study of old abandoned waste piles to determine mine soils that have developed and plants that have been established<br>• Reestablishing drainage patterns in subsided terrain | • Long-term species development<br>• Development of soil amendments for sodic soils<br>• Reestablishing favorable root zone hydrology<br>• Methods to assure less die-off of seedlings due to competition with grasses<br>• Use of vegetation to ameliorate acid mine drainage (wetlands)<br>• Timing of planting and phased planting<br>• Role of arctic/subarctic soils in revegetation practices<br>• Reducing necessity for continuing soil treatments to maintain cover<br>• Establishment of forest ecosystems on reclaimed areas<br>• Revegetation in areas without topsoil or topsoiling materials<br>• Rock and mineral weathering<br>• Presence of soil micro-organisms<br>• Use of waste products as enhancement<br>• Evaluation of plant species |

extremely high cost of underground subsidence backfill is unavoidable by any means; however, recent developments in new pneumatic backfill processes have cut these costs in half.[3]

On the subject of mine waste, several respondents called for research into techniques that either would extract valuable by-products, leaving nontoxic waste, or would use the mine waste for manufacture of building materials (paving asphalt was mentioned). Reprocessing to remove the optimum quantities of remaining coal in waste was also mentioned as a possible research direction.

Although toxic mine soil was not among the top priorities in any composite category, toxic soil, revegetation, and topsoiling are closely related subjects. The combination of these three categories in each region yields a fourth priority in the East, a second priority in the Midwest, and a tie for first in the West. One respondent pointed out that research is needed on how to establish vegetation in soils of high sodicity and salinity in the West. This problem differs markedly from some eastern and midwestern problems concerning acid soils, but both areas need research contributions. Several people also mentioned that research is needed to increase the predictability of the prereclamation evaluation of mine soils and overburden.

One respondent strongly emphasized the need to integrate research efforts. Although the focus may be on a specific topic (for example, coal refuse), components of a number of other AML problems are related. These include mine waste, toxic soils, revegetation, topsoiling, water quality, and possibly slope stability. Carefully defined research focused on the variability of refuse properties within piles, between various mine sites in a given region, and between regions, is considered to be needed background information. The stratigraphy of the coal measures, their mineralogical makeup, and geochemical weathering processes within waste piles over time are necessary elements for creating a classification scheme that would assist in devising effective reclamation strategies.

Appendix C presents more detailed excerpts from individual respondents, elaborating on aspects of those research subjects perceived to be highest in priority.

It is interesting to note that a poll taken by BOM of Rural Abandoned Mine Program (RAMP) states reveals a very similar list of research priorities:[4]

1. Ways to treat acid and iron discharges.
2. Cost-effective reclamation techniques.
3. Effective methods of extinguishing fires.
4. Use of wetlands to improve water quality from reclamation land.
5. Plants for use in establishing and maintaining adequate vegetation.
6. Effects of abandoned mine lands on groundwater.
7. Use of substitute materials for construction of plant root medium.
8. Subsidence problems that cause structural erosion control practice failures.

## 2.3 CONCLUSIONS AND RECOMMENDATIONS

### 2.3.1 AML Research Priorities in Relation to the Program's Legislative Intent

The legislative intent in transferring the AML research program to the Bureau of Mines, gleaned from congressional testimony and discussions during the transfer process, carried specific implications for the research conducted under this program. The legislative intent was to seek innovative technologies to achieve practical, short-term solutions to those reclamation problems remaining in the field, and solutions with widespread geographic applications.

This intent reflected a responsiveness to OSM and the state personnel who are dealing with the reclamation problems, and so the legislation specified four state members and an OSM representative to serve on the new project selection panel.

The $2-million research fund was intended to develop solutions that would help the overall reclamation effort succeed in a more cost-effective manner in the time remaining until 1992.

Thus the legislative intent in this case applied to a unique research program within the Bureau of Mines, unlike the bulk of research BOM normally conducts. "Research" in this case was to be more aptly viewed as "solutions."

This intent carries limitations on the research viewed as high-priority by the experts consulted by the committee. Several examples illuminate these limitations.

Water quality: The development of wetlands technology to address the persistent and long-term effects of acid mine drainage is an example of innovative technology; it has been applied on a small scale, and presumably it can be applied generally where acid mine drainage is a critical problem. However, the methodology needs a good deal more evaluation and research before it becomes a proven, widespread, operational procedure for amelioration of acid mine drainage. For example, more research is needed on the biochemical mechanisms at work in the plants that raise the pH and precipitate the dissolved solids. So far the technology has been successful only with relatively low flow of acid mine drainage, and longer-term monitoring is needed to evaluate effectiveness over time. Needed research is now under way, but a long-term effort may be necessary.

Subsidence: Most of the respondents who gave high priority to subsidence stressed the need for remote sensing technologies to predict potential areas of subsidence. Although remote sensing methods are available (for example, radar, resistivity, seismic, thermal gravity, and x-rays), they have apparently not been highly successful in predicting potential areas of subsidence. Perhaps new methods or more innovative approaches to existing technologies are needed to address the problem. In any event, this area of research does appear to address the legislative intent of innovative solutions; however, its application within a short time frame and its widespread applicability are in doubt.

Mine waste: The subject of mine waste includes a range of other problems that are closely related. Research into use of the waste to produce by-products or into removing existing coal from the waste may be valuable. Research into revegetation, water quality, topsoiling, and slope stability are also interrelated topics and must be addressed to solve the mine waste problem. No single technological breakthrough is likely to solve the interrelated problems. Baseline monitoring is thought to be particularly essential in these kinds of situations, because an emphasis on short-term solutions may produce long-term problems. For example, reshaping a mine waste pile, covering it with topsoil materials, and revegetating it may cosmetically address the issue for the short term, but monitoring may reveal long-term acid mine drainage or failure of vegetation.

Revegetation: This research priority has probably had more research, demonstration areas, and monitoring than any of the other high-priority research subjects. It is also intimately tied in with other research topics such as topsoiling and toxic soils. Revegetation practices now in common use (replacement of topsoil, liming, fertilizing, mulching, use of legumes) were at one time considered unusual if not experimental. This illustrates the point that practices that are now accepted were at one time viewed as "innovative technology." Revegetation has demonstrated good short-term results, and it has been applied over broad geographic areas. However, many techniques of revegetation have obviously been different for different geographic areas of the country; research may not be applicable nationwide.

Innovative technologies: The legislative intents directed to the Bureau of Mines represents the ideal as applied to AML research and development. Innovative technology is certainly necessary to make breakthroughs in addressing AML problems. To accomplish this as quickly as possible is another desirable goal, particularly considering a possible phase-out of the AML program in 1992. Finally, a broad geographic application of the research is an ideal objective. In the real world, however, a number of considerations and limitations act to constrain these ideals.

Developing innovative technology is a desirable goal, but breakthroughs in such technology are not commonplace. And developing innovative technology within a short time is often not realistic. Innovative technology must be tested to determine its feasibility. It is not generally possible to go from a laboratory to a field application without conducting some rigorous field trials to determine whether the technology works, whether it continues to work through time, and whether it has deleterious side effects. Wetlands usage to ameliorate acid mine drainage is a case in point. This methodology can certainly be considered innovative, but currently it applies only to small volume flows, and the biochemical mechanisms are not fully understood. Years of research and monitoring are probably needed before this technique can be applied to large-scale acid mine drainage projects using reliable construction guidelines.

Geographic applicability: It is also apparent that some research must be directed to geographically limited areas. Research on sodic soils is obviously applicable only to the West; the relationship of permafrost to reclamation and revegetation applies to Alaska; and wetlands treatment of acid mine drainage pertains largely to the East and Midwest.

### 2.3.2 The Need for Research After 1992

It is generally accepted that when the 1992 target date for the termination of Title IV funding is realized, much AML work, and supporting research, will remain to be done. Testifying before the subcommittee on Mining and Natural Resources of the Committee on Interior and Insular Affairs of the U.S. House of Representatives on July 14, 1987, Richard Bielicki, Director of Abandoned Mine Reclamation for the Pennsylvania Department of Environmental Resources, said that there are 4,800 high-priority AML problems in that state, with an estimated reclamation cost of $1.9 billion.[5] Based on historical funding patterns, Pennsylvania will receive close to $500 million in Title IV funds by 1992, leaving a short-fall of $1.4 billion to address high-priority problems. To correct all AML problems--high and low priority--would take an estimated $15 billion. Other state representatives testifying before that committee presented similar estimates. Whatever the outcome of the fund, a great deal of high-priority reclamation work will remain to be done beyond the 1992 deadline. This issue should be faced now. Research projects undertaken now will continue to benefit the reclamation effort, and long-term research will be needed to solve some problems. To delay or forgo this research will be false economy and could result in failure of some reclamation projects.

Concerned about problems related to the bonding requirements of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), the Subcommittee on Environment, Energy and Natural Resources, House Committee on Government Operations, asked the General Accounting Office (GAO) to review the bonding systems for reclamation for strip-mined land in Pennsylvania and West Virginia.[6] The GAO study revealed that in Pennsylvania the bond on 22,450 acres had been forfeited, with over 67 percent of this acreage unreclaimed. In West Virginia there are 6,713 acres, with 28 percent not reclaimed. Most of these sites were mined under the Interim Regulations before final rules went into effect. Sites not reclaimed for an extended time create environmental problems.[6] Undoubtedly there are additional unreclaimed lands in the other coal-mining states. Although not specifically designed to restore lands not reclaimed under SMCRA or restorations that have failed, the AML research and technology transfer program will make substantial contributions to resolution of this type of surface mining problem, as well as to the improvement of reclamation techniques for active surface mines. The investment in AML research and technology transfer will produce beneficial results in spheres far beyond the initial problem.

### 2.3.3 Recommendations

Recommendation 2.1: The committee recommends that the Bureau of Mines use a broad rather than a restrictive interpretation of the legislative intent of the AML research program. All AML lands will not be reclaimed by 1992, and there will be a continuing need for well-founded, longer-term research into corrective measures.

Recommendation 2.2: The bureau would benefit from using the AML research priorities indicated by the committee's survey (Table 2.2) as guidance in setting priorities for future research project solicitations. Most of the funded research projects in the AML program fall within the identified high-priority topics, so only minimal fine-tuning of the existing process will be required.

Recommendation 2.3: It is recommended that the bureau conduct periodic surveys of experts (perhaps in two-year intervals), asking for their views on the highest-priority research needs. The survey conducted by the committee produced a broad consensus on the most important areas for research, offered many insights on specific research topics, and made the community of researchers feel involved in the priority-setting process. The query letter (Appendix B) might be expanded to ask respondents what research they believe would yield the greatest benefits or knowledge in relation to cost.

The following topics are recommended for consideration in subsequent AML research solicitations:

Recommendation 2.4: The committee recommends that BOM assess the cost-effectiveness of various current techniques of abandoned mine subsidence reclamation, e.g., subsidence insurance, remote underground backfill, reclamation of surface depressions with long-term maintenance, land use zoning, and remining. In the short term, certain methods may appear to be low in cost, but what is needed is a firmer idea of total costs for any technique.

Recommendation 2.5: BOM should assess the cost-effectiveness of abandoned mine highwall reclamation associated with contour mining, using an integrated approach as in the recommendation above, but also considering short-term environmental disruption during reclamation versus long-term reclamation benefits.

Recommendation 2.6: Acid mine drainage is perceived to be an urgent problem, but no long-term plan exists for ultimate control of this problem on abandoned mine lands. A long-term plan for control needs to be developed, incorporating all currently known techniques. Such a plan would includes strategies for research and implementation of the results over the next decade. Undoubtedly this problem will continue into the twenty-first century. The bureau should expand its

research on use of wetlands to ameliorate acid mine drainage. OSM currently allows new and innovative techniques to be applied under Title IV of SMCRA. Possibly these experimental practices (e.g., wetlands treatment of acid mine drainage) could be combined with a research project on acid mine drainage.

Recommendation 2.7: Research on the long-term economics of reshaping the land is required to determine the expected life and future maintenance cost. Probably the most difficult aspect of reclamation of abandoned mine land is the prediction of the expected life after remedial treatment. In the case of land surfaces, natural geomorphic processes are constantly at work, leveling any oversteep terrain. If a problem on a steep slope is addressed without reducing the degree of slope, the problem might require perpetual maintenance. We need to determine how to apply this geomorphic knowledge to the long-term planning for abandoned mine land reclamation.

## NOTES

1. National Research Council (1984) Highwall Elimination and Return to Approximate Original Contour as Required in the Surface Mining Control and Reclamation Act of 1977. Committee on Highwalls and Approximate Original Contour, Board on Mineral and Energy Resources, Commission on Physical Sciences, Mathematics, and Resources. Washington, D.C.: National Academy Press. P. 3.

2. McLindon, G. J. (1985) Created Spoil Environmental Geology and Water Sciences, Vol. 7, nos. 1-2, June 1985.

3. Underground pneumatic backfill utilizing high pressure, high volume air without material transport in a pipeline, has reduced costs from $15.20/ton to $6.75/ton on comparable reclamation jobs in Montana. R. Juntunen, chief, Abandoned Mine Reclamation Bureau, Montana Department of State Lands, 1987 communication.

4. Margheim, G. A. (1987) Letter responding to a request by A. Perry, Bureau of Mines, for highest research priorities of the Rural Abandoned Mine Program (RAMP). Aug. 3.

5. Bielicki, R. (1987) Testimony to the Subcommittee on Mining and Natural Resources, House Committee on Interior and Insular Affairs, hearing, July 14, 1987.

6. General Accounting Office (1986) Difficulties in Reclaiming Mined Lands in Pennsylvania and West Virginia. GAO/RCED-86-221. Sept. Washington, D.C.: U.S. General Accounting Office.

# Chapter 3

# SELECTING AML RESEARCH PROJECTS

## 3.1 INTRODUCTION

The method for selecting AML research projects is reviewed in this chapter, and recommendations are offered to improve the process and ensure that proposals reflecting the highest-priority needs are funded.

## 3.2 THE SELECTION PROCESS UNDER OSM

The original standards for submitting AML research proposals and for selecting those to be funded were established by OSM in 1984. These standards were refined and amended during the subsequent years that OSM was responsible for the program. Given the short time period between BOM's assumption of program authority and the fiscal year 1987 funding cycle, BOM program managers adopted OSM's standards for its first year. One purpose of this report is to review those standards and recommend changes to create a more responsive and effective selection process for AML research projects.

### 3.2.1 OSM's Project Selection Panel

Although the program has been managed and coordinated by OSM and BOM headquarters in Washington, D.C., project selection is carried out by a panel made up of four federal and four state/tribe AML program members. The OSM program manager--and now the BOM program manager--votes only to break a tie.

Implementation of the selection procedures began in February, prior to the upcoming fiscal year, when OSM published a notice in the Commerce Business Daily that AML reclamation research proposals were being requested. This invitation was open to individuals, companies, academia, and government agencies at all levels. Interested persons or organizations had to request proposal preparation instructions and a copy of the selection procedures. Usually respondents were required to submit proposals by May or June, which allowed them at least three months to prepare their submissions. In the intervening period, OSM

selected the four federal members for the research evaluation panel, and the Association for Abandoned Mine Land Programs selected the state/tribe members.

When proposals were received, copies were sent to all panel members, who were given about two months to evaluate them. At the end of the review period the Research Evaluation Panel met for approximately three days to discuss all proposals and select those to be funded in the upcoming fiscal year. OSM then conducted cost and technical negotiations on the proposals that had been recommended for funding. When negotiations were completed and appropriations received, as many of the top-ranked proposals as could be funded were submitted to the Deputy Director for Operations and Technical Services (DD/OTS) for approval. Upon approval of the research plan, all proposals with a cost over $100,000 were submitted to the Assistant Secretary for Land and Minerals Management for approval, as required by Interior Department directives. After all approvals had been secured, successful and unsuccessful proposers were notified and contracting negotiations began. During the two-year OSM tenure of the program, this contracting phase of the process often involved delays of up to two years from project selection to awarding of funds. The bureau has a longstanding record of efficient contracting, and so delays in awarding contracts are not likely to be a problem under their management.

### 3.2.2 OSM's Project Selection Criteria

The Office of Surface Mining developed a comprehensive set of instructions for the preparation of proposals (see Appendix D). Due to the limited time for implementing promising research results and the scarcity of funding, proposers were instructed to limit project funding to a maximum of $250,000, with work to be completed within three years. Usually the panel employed the following four generalized guidelines to make the first cut on the proposals:

a. Projects were to be applied research aimed at finding a more cost-efficient and/or a significant technical improvement over currently used technologies for addressing specified AML problems. Research that simply studied a problem without suggesting a solution would not be selected.

b. Research results were to be readily adaptable to operational use. Final reports were to state clearly both how to implement a new technique and the benefits of doing so.

c. The research was to have a diverse geographic application. Generally, the more widespread the applicability, the more valuable the research finding; however, severe localized problems would not be ignored.

d. The research was to offer a high likelihood of success. Addressing high-priority needs was considered pointless if the proposal offered little hope of solving those problems. It was viewed as more efficient to fund lower-priority problems if research indicated that resulting technology could solve the problems.

In addition to these general guidelines, OSM also developed a detailed criteria rating system with a weighted point scoring method (see Appendix E). Panel members were also given instructions for evaluating AML research proposals (see Appendix F). All of the above instructions, guidelines, and criteria, developed by OSM, were referred to appropriate federal and state AML organizations for review and comment before adoption.

## 3.3 THE CURRENT SELECTION PROCESS

Thus far the Bureau of Mines has generally followed the project selection guidelines developed under OSM. For fiscal year 1987, the AML Research Program Review Panel was composed of nine members--four from state abandoned mine programs (North Dakota, Montana, Pennsylvania, and West Virginia); four from the Bureau of Mines (three BOM Research Directors and the Chief of the Division of Mining Technology); and one member from the Office of Surface Mining. Two of the state members and the OSM member had served on the OSM-managed review panel the previous year, evaluating these same proposals; but immediately after that meeting, the research funds were transferred to BOM by congressional action. Due to the timing of the transfer, the FY 1987 selection process was started by OSM with priority selection criteria and publication in the Commerce Business Daily (CBD). Subsequent proposals were evaluated by the OSM-state review panel; however, when the program was moved to BOM, proposals were again evaluated, utilizing the panel described above. As of this writing, the bureau has not had an opportunity to manage a complete research and development selection cycle from beginning to end.

The CBD announcement for FY 1987, prepared by OSM, used a format similar to that of previous years. Minor changes were made to include subarctic revegetation, toxic soils in arid environments, new technologies for closing abandoned mine shafts, predicting subsidence, and at-source control of acid mine drainage from underground mines. The more specific identification of these problems was designed to prompt research proposals on these topics. The input that resulted in developing or changing the call for proposals was informal, based on the review panel chairman's experience. Input from states and internal OSM sources was oral, and no formal request to any individual or group was made by OSM. In short, the advertisement process in the past was guided by informal perceptions of what the research priorities should be.

The question whether to use more specific priority statements in announcements or the more general format as used in the original CBD announcements was discussed by the FY 1986 and FY 1987 review panels. The increased specificity of the FY 1987 call for proposals was the result of internal OSM direction for a more focused announcement, as well as panel agreement that the program should attempt to guide the research organizations to focus on problems of the highest priority rather than allowing complete latitude to work on any, perceived or

real, abandoned mine reclamation problem. The consensus of the FY 1986 and FY 1987 review panels was for a more detailed announcement emphasizing specific reclamation problem areas. However, the panel was told that OSM had been constrained from providing a detailed request for proposals, as this would have severely limited the panel's ability to select projects that were not identified as problem areas in the call. The basic concern was whether the panel could legally reject proposals identified in the advertisement while accepting proposals for which there had not been a specific call. The panel was told that under the scenario described, an unsuccessful proposer could have some standing in a legal action.

The FY 1987 panel did reject proposals that were specifically named as reclamation problems of special concern, and did select other research proposals not specified, and no legal actions resulted. It appears that the FY 1987 advertisement format, with specific research and development goals mentioned, could be expanded upon to improve the number of higher-quality proposals aimed at specific reclamation problems.

For the most recent cycle for FY 1987, 86 proposals were originally received by OSM, and the evaluation process started there. With the transfer to BOM, copies of all proposals were distributed to a reconstituted panel, as described above. All members normally have from one to two months to review and score the proposals before the review panel meeting. As part of the review OSM, BOM, and state officials on the panel avail themselves of staff expertise in their agencies to help in the review of research proposals. Though not required, this internal consultation step garners comments and ideas from a greater number of sources than just the individual panel members. Instructions concerning project rating criteria and scoring sheets with various weighting factors are used by all panel members to obtain rating scores after each proposal prior to the panel meeting.

The FY 1987 panel review under BOM occurred over a two-day time period; however, these same proposals under OSM had occupied a three- to four-day review period. The BOM-managed panel spent less time on the rejected proposals than did the previous panels. This was viewed as an improvement in the process.

As under the OSM procedures reproduced in Appendixes D and E, six basic proposal considerations are currently utilized (Table 3.1), with between one and three different scoring criteria under each proposal consideration.

The weighting factors applied to the six main proposal considerations (Table 3.2) dictate the final score possible for each proposal.

Technical merit, which encompasses soundness and uniqueness of approach, and increase in state of the art knowledge, has the highest factor of 6. Technological need and benefits, composed of cost and time savings, and diversity of application, both have a weighting factor of 5. Proposals that clearly show strength in these areas will receive high weighting factors and are likely to score well.

## TABLE 3.1 AML Research Rating Criteria

| Proposal Considerations | Criteria | Rating |
|---|---|---|
| **I. The Problem** | | |
| A. Need | | |
| 1. Technological need | a. Present technology effective but could be improved | 1 |
| | b. Present technology moderately effective --improvements desirable | 2 |
| | c. Present technology sometimes ineffective --needs improving | 3 |
| | d. Technology to solve problems does not exist | 4 |
| B. Magnitude of problem | | |
| 1. Effect on environment | a. Moderate impact and localized | 1 |
| | b. Moderate impact and widespread | 2 |
| | c. Severe impact and localized | 3 |
| | d. Severe impact and widespread | 4 |
| 2. Effect on people | a. Moderate impact on a few people | 1 |
| | b. Moderate impact on many people | 2 |
| | c. Severe impact on a few people | 3 |
| | d. Severe impact on many people | 4 |
| 3. Economic effects | a. Moderate localized impairment of economic values | 1 |
| | b. Moderate widespread impairment of economic values | 2 |
| | c. Severe localized impairment of economic values | 3 |
| | d. Severe widespread impairment of economic values | 4 |
| **II. Proposed Solution** | | |
| A. Technical merit | | |
| 1. Soundness of approach | a. Some merit but needs major modifications | 1 |
| | b. Plan needs some modifications | 2 |
| | c. Plan needs minor modifications | 3 |
| | d. Well-planned approach uses scientific/engineering principles | 4 |
| 2. Uniqueness of approach | a. Trial and error approach | 1 |
| | b. Modification of previously tried approach | 2 |
| | c. Transfer of proven technology from another field | 3 |
| | d. Totally new concept of invention | 4 |
| 3. Completeness of approach on advancing state of the art (SOTA) | a. Minor contribution to SOTA but significant additional work will be needed | 1 |
| | b. Minor contribution to SOTA; ready for operational use | 2 |
| | c. Major contribution to SOTA but significant additional work will be needed | 3 |
| | d. Major contribution to SOTA; ready for operational use | 4 |
| B. Benefits | | |
| 1. Cost reductions/time savings over currently used methods | a. Moderate cost or time savings | 1 |
| | b. Moderate cost and time savings | 2 |
| | c. Significant cost or time savings | 3 |
| | d. Significant cost and time savings | 4 |
| 2. Diverse applicability of solution | a. Technical transfer possible but uncertain | 1 |
| | b. Some technical transfer possible and likely | 2 |
| | c. Good potential for technical transfer to active mining | 3 |
| | d. Good potential for technical transfer to active mining and other fields | 4 |
| **III. Implementation** | | |
| A. Implementation factors | | |
| 1. Duration | a. Poor schedule, needs major modifications | 1 |
| | b. Fair schedule, needs moderate modifications | 2 |
| | c. Good schedule, needs minor modifications | 3 |
| | d. Excellently planned effort | 4 |
| 2. Total cost over duration (detail deficient areas on cover sheet) | a. Budget needs major modifications | 1 |
| | b. Budget needs significant modification to conform to prevailing rates | 2 |
| | c. Good budget with few items exceeding prevailing rates | 3 |
| | d. Excellent budget as is | 4 |
| **IV. Information on Proposer** | | |
| A. Proposers' qualifications | | |
| 1. Background/experience | a. Some background and experience in activity proposed | 1 |
| | b. Fair background and experience in activity proposed | 2 |
| | c. Good background and experience in activity proposed | 3 |
| | d. Strong background and experience in activity proposed | 4 |
| 2. Past performance | a. No experience but has other qualifications | 1 |
| | b. Average record of producing quality results | 2 |
| | c. Above average record of producing quality results and reports and adhering to schedule | 3 |
| | d. Exemplary record of producing quality results and reports and adhering to schedule | 4 |

TABLE 3.2 Weighting Factors of the AML Research Rating Criteria (condensed from Appendixes E and F)

| Proposal Consideration | Weighting Factor | Formula | Weighted Score |
|---|---|---|---|
| I-A Need | 5 | A x 5 = | |
| I-B Magnitude of Problem | 3 | (Σ B ÷ 3) x 3 = | |
| II-A Technical Merit | 6 | (Σ A ÷ 3) x 6 = | |
| II-B Benefits | 5 | (Σ B ÷ 2) x 5 = | |
| III-A Implementation Factors | 4 | (Σ A ÷ 2) x 4 = | |
| IV-A Proposer Qualifications | 2 | (Σ A ÷ 2) x 2 = | |

Instructions to panel member: Add the weighted scores to derive the total score for the proposal. If you have left any criteria blank (unscored) for lack of information, place an "I" after the total score for that proposal on the rating sheet, to note that this is an incomplete score that must be completed and revised when the Research Evaluation Panel meets to determine a consensus score. A "perfect" total score is 100. This is unlikely to be obtainable, since some criteria may be antithetical to others.

Implementation factors, a consideration encompassing duration and total cost, is given a weighting of 4, emphasizing relatively short-term and small-budget projects. Magnitude of the problem, comprising the effect on the environment and on people, and economic effects, carries a factor of 3. Proposer qualifications, including background and experience in research, receive a weighting factor of 2, the lowest factor among the considerations as a group.

Under this system, the legal priority status of the problem to be addressed is not formally factored in. The overall impact of the problem the research aims to address is clearly secondary to the quality and level of innovation of the research itself.

As currently designed, the rating criteria give great weight to proposals that introduce new technology likely to provide time and cost savings, and having broad applicability to current mining. These factors constitute the major emphasis of the present system, with 16 of the total of 25 weighting factor points (as detailed in Appendixes E and F).

At the start of the review panel meeting, the scores of a proposal from each panel member are tabulated and then averaged to yield a panel score for each proposal. The highest and lowest scores of the nine panel member scores are dropped to obtain the averaged score; however, panel members have the opportunity to defend their scores. In response to a BOM letter of inquiry to panel members seeking comments on the selection process, one member believed that the dropping of high and low scores could inhibit discussion by the panel members who had given these scores.

For review purposes, proposals were grouped under eight research categories: revegetation, slope stability, fires, acid mine drainage, biological, geochemical, subsidence, and "other." Each panel was expected to devise its own groupings based on the proposals received.

Proposals may be rejected at the outset for various reasons, as defined in the instructions, but for those proposals eliminated for noncompliance, a justification must be prepared and included with the recommendations. Valid reasons for rejection are that a major segment such as the budget is missing, the proposed project exceeds time or cost limitations, the research is not related to an abandoned mine problem, the proposer has a poor record of performance, and so forth. Any panel member has the opportunity to defend a proposal or recommend rejection based upon the member's personal experience. Information brought out during the panel discussion may cause any or all panel members to rescore certain proposals prior to final tabulation.

Those projects with the highest total scores are listed and selected in order for funding until the estimated budget for research and development that year is reached. Regarding proposals of unusual merit but with too-high or too-low a budget or time frame, a panel member is selected to negotiate with the proposer. Such negotiations must be performed carefully to stay within contracting law but are very valuable to salvage needed research.

At the conclusion of the panel meeting, all panel members' individual scores plus the total scores for each project are turned in to the BOM procurement office. Any comments and justifications of outright rejections, or projects needing negotiation, are also noted. The panel's selections are final, as indicated in the appropriations language that called for this process. That is, the panel's selections are not subject to change by BOM.

The contracting for research by OSM was subject to many problems. In some cases, projects selected by the OSM-managed panel did not have signed contracts until two years after selection. The time lag in

contracting was a main source of program dissatisfaction on the part of states and private entities. The BOM procurement unit, on the other hand, appears to be moving ahead with the contracting step promptly.

It was generally assumed by panel members and others that results of the research would be published and disseminated. However, this has not happened. Results of AML research completed in 1986 have not been distributed by OSM to the states, nor is there any apparent mechanism in place to do so. As BOM does have a general technology transfer system, and in light of recommendations made in Chapter 4 of this report, problems relating to technology transfer should be resolved under BOM administration.

## 3.4 OBSERVATIONS ON IMPROVING THE SELECTION PROCESS

A survey of previous panel members performed by BOM elicited responses concerning the selection criteria. The consensus was that the overall process was fair and workable, but somewhat cumbersome. Six panel members observed flaws in the present project selection system or provided recommended changes. Comments varied, but the strongest consensus was among three members who suggested that the rating system should be simplified. Suggestions made were as follows:

Scoring: One person suggested scoring only the six major proposal considerations, not each criterion, but suggested keeping the criteria (shown on Table 3.1) for a guide. Another proposed applying a 1-10 score, based on simplified criteria, to the six major proposal considerations.

Two members suggested that there should be a low score cut-off number that would eliminate a proposal from consideration before or at the beginning of the panel review, thereby saving time and discussion on "dead" issues. There was a suggestion that a reviewer who does not know of or understand a certain reclamation technique or regional problem could abstain from voting without his or her abstention being detrimental to the proposal's total score.

Another point raised was that both low scores and high scores by an individual panel member should be defended before the group as a whole, prior to final resolution of the projects. There was a concern that the panel may not get the benefit of an individual's inside or unusually accurate knowledge that should be shared with the whole committee. Currently, the practice of dropping the high score and low score during the averaging tends to inhibit these panel members from participating in the discussion.

Weighting factors: A greater weighting factor to 1-B, "Magnitude of Problem," one of the six major proposal considerations, was sought by a member. Under this major heading (as shown in Table 3.1) three criteria--environmental, human, and economic effects--are thought to warrant more weight. This consideration is currently given a weighting factor of 3, which is second to the last in magnitude, with only IV-A, "Proposer's Qualifications," being lower. (See Table 3.2.)

Criteria: One suggestion was to revise the criteria to correspond to the priorities as listed in section 403 of PL 95-87 (and shown in Chapter 1 of this report).

Along with this comment was a proposal to revise or eliminate the criterion II-A(3) from consideration (shown on Table 3.1). This criterion, one of three under the major proposal consideration "Proposed Solution," is titled "Completeness of approach in advancing the state of the art." Scoring of this criterion is based on the degree of contribution to advancing the state of the art, plus how operational the technique is relative to construction projects now in the field.

Administrative services: Two members of the selection panel proposed administrative support for the review panel. One suggested having a secretary working with the panel to keep up with the bookkeeping of total scores, allowing all committee members to review actively the proposals during discussion. Another suggestion was the use of computer-tabulated score sheets to keep track of individual and group scores during the panel review.

There seems to be a growing concern about continuation of important research projects that are showing promising results. The current system requires a complete resubmission of a proposal in order to obtain funding as a project matures into an innovative technique. This is perceived as involving too much uncertainty and too much time.

## 3.5 CONCLUSIONS AND RECOMMENDATIONS

The committee believes that the review panel structure and the project selection process as it has evolved are well-thought-out. Its recommendations are for refinements to make the system more efficient and reflective of the highest-priority research needs.

Recommendation 3.1: The committee recommends that the bureau prepare a research plan with priorities identified, and that the key elements of the plan be incorporated into the call for proposals and scoring in the selection process. The AML research policy and research priorities are in transition as this report is being written. The previous policy expressed only vague goals and objectives. The research effort was not focused on the solution of either short-term or long-term AML problems. The program was reactive, in that it did not identify specific research priorities but relied on the proposer to define the research direction.

Recommendation 3.2: The present system of informal peer review practiced by panel members within their own agencies should be formalized and expanded to include peers drawn from OSM, BOM, state agencies, academic and research organizations, and industry. BOM can establish a list of qualified people by discipline outside the agency who could review and comment on specific proposals; peer comments should be made available to the review panel for their timely deliberation. The purpose of peer review of research is "to allocate

resources fairly in support of high-quality science in relevant fields."[1] Peer review judges the scientific merit of proposed research projects and usually considers additional factors such as the scientist's past performance and the personnel and resources available to the researcher. As in the selection panel's procedure, peer reviewers generally assign a priority score indicative of their assessment of the proposal.

The peer review process is prospective; that is, proposed research projects are prejudged on their likely scientific and technical merit, importance, and success. Reviewers do consider retrospective aspects, however, such as the quality and quantity of the investigator's previous scientific output.

Consideration might be given to the relevance of research to a goal extrinsic to the research project itself, such as the development of new or improved technology or the solution of social problems. Additional factors could include the relevance to mission-oriented goals of the program, national impact of the research, or interdisciplinary character of some areas of science.

Many methods can be used to select research proposals, but all should require the research activity to be reviewed by peers in the field. One weakness of the OSM's AML program was the lack of a requirement for peer review. Methods for including peer review in the current selection process include several approaches. It would be possible to develop a peer review list based on specific research expertise, and then mail the proposals to at least two of these individuals with a request for review according to an accepted format. A second approach that might be more appropriate to the requirements of the law would be to add a sufficient number of peers to the panel, varying their expertise with the research priorities identifed or topics to be reviewed. In this way the panel could benefit from the technical expertise of the scientists, and the scientists could benefit from the practical aspects of panel members through discussion of the research topic proposed. Normal Bureau of Mines procedures involve review of the project activity with peers from within their organization, and such individuals are part of the current legislated panel, but it is advisable to include peers from outside government as well. Care should be taken to avoid conflict of interest.

Recommendation 3.3: It is recommended that the bureau establish an identifiable or specific research objective at the beginning of the research activity. Technical monitors will be able to follow the progress of the work, with the objective in mind, as it is being performed. There should be a follow-up program to ascertain the success or failure of the technology, and possible need for further research, engineering development, or modification of the system. If a concrete research objective is established at the beginning of the research activity, the effort will be provided with a measurable means of evaluating the effectiveness of the research. If the research

provides the answer to a previously perplexing question, it has certainly been successful. If, on the other hand, the research reveals that the direction taken will not address the problem, this also can be a valuable and defined conclusion.

By its very nature, the development of ideas and their transfer others is accomplished by disconnected steps that form a continuum only if the idea is broad enough to be picked up by other individua at different locations and carried forward by them. A major failin of large organizational research programs and federal government contract research is the lack of continuity and full development of ideas produced by the research effort. The bigger the organization the broader the topic, the more difficult it is to maintain a threa of continuity of developed research ideas.

The program director is an important aspect of the continuity o the research effort. The AML research director should not only mana the paper flow of contract research but should also execute the substantive research plan devised by the policy-making body of the bureau. The director should make site visits to the research activities to ensure that quality work is being performed, that research objectives of each project are being met, and that the work reflects the research priority it was intended to reflect.

Abandoned mine land research is a fairly defined field, and the director should be familiar with most active researchers in the field. Likewise, the director should have a good concept of the sta of the art in those areas important to AML research and be able to bring this knowledge to the research project selection process.

There is a good opportunity to establish continuity in the AML research program now that it is part of the Bureau of Mines. A consistent program can be developed based on the research products o the contracted activities. The program should be reviewed on a regular basis; because of the time constraints on this program, it i recommended for major review within two years to determine if it reflects the objectives and priorities set for it.

In addition, time should be allotted on the first day of each Review Panel session for reports of ongoing and completed research.

Recommendation 3.4: In view of the longer-term nature of some important research, the committee recommends that promising research projects be allowed to be amended, upon the selection panel's approval, rather than be required to undergo a complete submittal fo funding every year. This would probably call for a change in the procurement process. Many new and promising research ideas are in such an early stage of development that needed answers may not be developed in one or two years of work. Most new technologies requir an evolution of progressive steps to reach field implementation. La year's panel discussed the need for a mechanism to assist in this progression, instead of requiring a complete reapplication every year. It can generally be considered cost-effective for the most experienced researcher to continue with projects, thereby adding to

existing experience. A system for easily amending highly innovative and especially exciting projects when needed could be beneficial if not overused.

Recommendation 3.5: The process for evaluating and selecting research proposals should have enough flexibility to consider proposals with unusual qualities. For example, an encouragement of some cooperative research projects should be built in to the proposal submission and evaluation process. If partial funding were to be provided by a mining company and the results of a particular project would be useful to AML reclamation and to active mining as well, the proposal could be given a certain priority or ranking within the overall selection process.

Recommendation 3.6: The committee believes that maximum utilization should be made of the talent in the Bureau of Mines and in the Mineral Institutes in addressing the priority topics. Because the bureau has had a great deal of experience in water quality and subsidence problems, these two areas should receive particular attention for BOM research funding. The bureau is line-item funded to carry out a wide range of scientific and technological research. A review of the publications issued by the bureau in the period 1983 through 1986 reveals that the bureau publishes a good deal of work on the high-priority research topics identified in Chapter 2.[2] Subsidence and water quality are the subjects treated in by far the largest number of papers. Revegetation, mine wastes, and slope stability are also prominent topics.

## NOTES

1. National Research Council (1987) Improving Research Through Peer Review. Committee on Peer Review Procedures, Board on Agriculture, Washington, D.C.: National Academy Press.

2. Pederson, J. R. (ed.) (1986) Research 1986, Washington, D.C.: U.S. Bureau of Mines.

# Chapter 4

# TECHNOLOGY TRANSFER

## 4.1 THE FOUNDATIONS FOR DISSEMINATION OF AML RESEARCH

Congressman Nick J. Rahall II, chairman of the Subcommittee on Mining and Natural Resources of the House Committee on Interior and Insular Affairs and author of the proposal to transfer the abandoned mine land research program from the Office of Surface Mining to the Bureau of Mines, stressed that an effective technology transfer process needed to be incorporated into the research program. The emphasis was appropriate and timely in light of OSM's record in technology transfer and the growing national concern for conveying results of federal research and development to the private sector.

With the transfer of the AML research program to BOM, promulgated by the Continuing Resolution for Federal Agencies for fiscal year 1987, the Office of Surface Mining and the Bureau of Mines amended and reaffirmed the terms of a Memorandum of Understanding (MOU) between them, drawn in November 1979. The original MOU states in part:

> . . . OSM and BOM will jointly use their capabilities and resources to assist in identifying critical research needs to aid in assuring maximum utilization of developments resulting from environmental research. OSM and BOM will determine methods for effective technology transfer . . . [emphasis added]
>
> BOM and OSM shall implement . . . joint use of the methodology to formulate research programs from information received from all sources including that solicited from the mining industry, labor organizations, other governmental organizations, the academic community, organized citizens and regional/national environmental groups . . .

The memorandum reflects a long-standing and evolving commitment by the federal government to technology transfer.

A study by the National Research Council's Committee on Abandoned Mine Lands, entitled A Mid-course Review of the National Reclamation Program for Coal[1] carried out at the request of OSM, supports Congressman Rahall's concern for a viable program of technology transfer for AML research. The study notes:

> The transfer of new ideas and research products, construction techniques, management procedures, legal opinions, and anything else that may improve the cost effectiveness of the program is important. OSM has provided much guidance to the states with respect to abandoned mine land project design. Unfortunately, there are few mechanisms to incorporate the technical advances that are made as the project volume increases each year. The number of experienced designers and constructors is rapidly increasing, yet there appears to be no efficient mechanism for incorporating this burgeoning experience into the design manuals. Perhaps the Eastern and Western Technical Centers should summarize the nature and extent of the remaining abandoned mine land problems that will require abatement and identify the various reclamation approaches that might be used to abate them. These regional manuals, which recognize topographic, geomorphic, climatic, cultural, and other differences, could be published and distributed by OSM and be the end-product of various conferences or symposia.

Suggesting some methods of technology transfer, the committee report continues:

> An effective technology transfer program is not now in place and should be implemented at once. This could be handled through an agency outside of OSM, such as the Bureau of Mines, or could be an assigned objective of one of OSM's technical centers. There are many models to choose from in industry, government and academia.

The report suggests several channels, including documenting case studies in publications, technical workshops, contracting practice workshops, a federal consulting role to state agencies, and encouraging experimental practices. The study concludes with a recommendation that a technology transfer program should be established either through one of the OSM technical centers or through another research-oriented agency.

### 4.1.1 The Federal Commitment to Technology Transfer

It has long been the position of the federal government that the knowledge and technology generated by federally funded research must accrue to the users of the service of the agency carrying out research and development and, where appropriate, to a wider public, for

enhancement of the national economy and well-being. Accordingly, the transfer of knowledge is also intended to utilize research and development from the academic and private sectors and from other countries.

The federal government has been enacting legislation since the mid-1800s to promote technology transfer, and many programs have been established in various agencies to accomplish this task. The more important ones are:

a. The Library Depositories for Federal Documents. There are 1,395 libraries in the United States serving as congressional Federal Depositories. At least one depository library is located in each of the 435 congressional districts. These libraries receive publications issued by the executive, judicial, and legislative branches at no charge in exchange for providing free public access.

b. The Land Grant Universities and Associated Extension Program. One Land Grant University is authorized for each state. The 1862 law that established them gave form to the concept of interaction and interdependence of research, education and training, and information exchange. The impetus for research and technology transfer was fostered by the Hatch Act of 1887, which initiated appropriations for agricultural experiment stations associated with Land Grant Universities. The mission of the extension programs was to carry out technology transfer of scientific, engineering, and social advancements developed in Agricultural Research Stations and the Land Grant Universities.

c. The National Technical Information Service (NTIS). By the mid-1940s, the wealth of information emanating from defense research led Congress to establish the Publications Board for dissemination of technical information useful to private industry. Under PL 81-776 of 1950, a clearinghouse for technical information was set up in the Department of Commerce. This was moved to the National Bureau of Standards within the department, and its function expanded. By 1970 the function of the unit warranted a separate operating entity. It was renamed the National Technical Information Service, designed to make the results of technological research and development more readily available for federal, state, and local government agencies, universities, industry, business, and the general public. This service, which complements the Federal Depository Library Program, maintains a clearinghouse for the collection, storage, and dissemination of scientific, technical, and engineering information.

d. Federal Laboratory Consortium for Technology Transfer. The Federal Laboratory Consortium founded in 1974 is a service organization that today provides a basic link among some 300 federal laboratories representing 10 different agencies. The original organization provided the horizontal linkage, and in 1986 was amended to provide for transfer of information to the private sector.

To summarize, the executive and legislative branches of the U.S. government have understood the importance of information and technology transfer across government agencies and to the public. Significant legislation has been enacted over the last century to that end. There are good programs available to expedite the transfer of knowledge, but special attention must be applied to the system to tailor it to AML needs. The transfer of new ideas from the research laboratory and construction innovations from the AML field sites has not been incorporated into any formal program to date. There is a need for a program of AML technology and information transfer to the states and the mining industry.

### 4.1.2 Technology Transfer in the Bureau of Mines

The Bureau of Mines is the agency now charged with the responsibility for carrying out abandoned mine lands research and the technology transfer program supporting it.

Since its inception, the bureau has engaged in research and established its own research laboratories system, beginning with the Pittsburgh Center, which originally had been set up under the U.S. Geological Survey in 1907, transferring to BOM when it was created as a separate entity in 1910. The Denver Field Station was organized in 1910 and designated as an experiment station in March 1915. Other stations were to follow: Salt Lake City at the University of Utah; Twin Cities (both in 1913); Rolla at the Missouri School of Mines in 1920; the Rocky Mountain Experiment Station in Golden, Colorado in 1920 (this later moved to the University of Nevada at Reno and specialized in rare and precious metals); Southern Experiment Station at the University of Alabama, Tuscaloosa in 1920; Northwest Station at Albany, Oregon, in 1944; and Spokane Center in 1951. These research centers function as separate entities, but where location permits, researchers have maintained close ties with universities and schools with research in mining or mineral extraction.

The process and results of the bureau's information exchange leave little doubt that the bureau has practiced technology transfer from its research endeavors across federal and state agencies, universities, and the private sector.

The research program of the bureau was greatly expanded and strengthened by the Federal Coal Mine Health and Safety Act of 1969 (PL 91-173), which required the bureau to

> conduct such studies, research, experiments and demonstrations as may be appropriate to improve working conditions and practices in coal mines and to prevent accidents and occupational diseases originating in the coal mining industry.

The next major incentive to research and technology transfer was under Title III of the Surface Mining Control and Reclamation Act (SMCRA) of 1977, which appropriated funds extending over 7 years to

assist the states "in carrying on the work of a competent and qualified mining and minerals resources research institute . . . at one public college or university in the state. . . ." The act set certain basic standards for qualification and established an Advisory Committee on Mining and Minerals Resources to determine which programs would be recognized as the Mining and Mineral Resources Research Institutes. Today there are 32 institutes receiving an annual federal grant that has to be matched by state funds. The institutes are able to compete for additional research funds.

In 1982 Congress directed a realignment and consolidation of the research commitment at universities seeking Centers of Excellence in mining and mineral research. This was implemented through the State Mining and Mineral Resources Research Institute Program Act of 1984 (PL 98-409). Extending provisions of PL 95-87, the new act authorized setting up generic research centers to focus development of expertise in depth in distinct mining and minerals topics. Today there are five centers with generic studies: in mine systems design and ground control, pyrometallurgy, comminution, mineral industry waste treatment and recovery, and respirable dust.

The program at each generic center is reviewed for technical competence by a Research Advisory Council made up of industry, government, and university experts in the particular generic area. Associated with each generic center is a reference center, which serves as a depository and distributor of information in that technical area. The objective is to establish centers with comprehensive coverage of specific areas of mining and mineral research and information.

Through the Generic Research Center concept, the Bureau of Mines can direct the focus of research to those topics in need of greatest attention. It seems evident that there is a place for a new generic research center concentrating on abandoned mine land reclamation problems, with affiliated Mineral Institutes located in each coal state where abandoned mine lands are found. This would allow a close working relationship with the AML state agency to address the special conditions found in each state. This kind of program could have similar characteristics to those of the Agricultural Extension program located at the Land Grant Universities. The establishment of a generic center in reclamation is advocated by the Advisory Committee on Mining and Mineral Resources.[2]

If AML reclamation is to be accomplished in an effective and efficient manner, the program of technology transfer put in place cannot be limited to technology derived from AML research. The fact that survey respondents considered revegetation a priority research subject, despite abundant published research on revegetation of severely disturbed soil, suggests a gap in technology transfer and the dissemination of research and field experiment results to AML reclamation practitioners. These broad and interrelated issues should be enfolded in a coordinated and comprehensive information and technology transfer system.

### 4.1.3 BOM's Technology Transfer Program

The major objective of Bureau of Mines research is in support of its assigned missions of advancing mining technology, promoting health and safety in mining, and protecting the environment from the impacts or consequences of mining. This calls for a direct input by the agency into the operations, techniques, and systems of mining. Of high priority has been incorporating research results into the design of new or improved equipment and devices, procedures and methodologies, services, and regulations affecting all sectors of the mining industry and state mineral agencies.[3]

Transfer of technology in the early stages was promoted formally through the bureau's technical publications, by papers presented at scientific and professional meetings, and by articles and news items in technical and trade journals. The same objectives were pursued informally by technical personnel in the field as part of their routine contacts with Mineral Institute personnel, and other research organizations in the public and private sectors, and operating personnel in the mineral industry. These efforts have been sustained throughout the years (BOM personal communication, 1987).[4]

Following a significant expansion of the bureau's health and safety research after the 1969 Coal Mine Health and Safety Act, a need was recognized for an intensified and structured approach to technology transfer (BOM 1987).[5]

In April 1972 a mining research technology transfer program was set up by the Deputy Director for Mineral Resources and Environmental Development. A committee identified research results that were related to mining problems and would lead directly to the improvement of practices, techniques, methods, and/or devices. A permanent Mining Research Technology Transfer Group on the staff of the Assistant Director was formed in 1973 and still functions today.

The bureau was also affected by a significant innovation in technology transfer policy, the Stevenson-Wydler Act of 1980 (PL 96-480). Among its wide-ranging provisions, the act required each federal agency conducting research and development and its major laboratories to identify technology having commercial or practical application, and to encourage transfer of the technology. To do this, federal agencies set up Offices of Research and Technology Assessment. Each of the BOM's Mining Research Centers has a Technology Transfer Officer appointed to assist the Center Director and headquarters by:

- planning, programming, and implementing transfer plans;
- communicating to industry, the academic community, and other agencies new technological developments;
- serving as a focal point for liaison with other organizations on mining technology; and
- planning and executing special briefings, films, documentaries, and information programs to promote use of improved technology to the mining industry, and learning from them of needed research.

The Assistant Directors for other divisions of the bureau managed transfer aspects of their programs, working through the headquarter's transfer staff (Federal Council on Science and Technology 1975).[6]

Early in 1982, as part of a general bureau reorganization, the technology transfer unit became a branch of the Office of Technical Information, which coordinates a bureau-wide transfer effort. This change brought information systems in close coordination with technology transfer and provides more effective support to all bureau research functions.

One information system of value to the technology transfer program is the Mining Research Management Information System (MRMIS), a computerized project information system supporting the planning and management of mining research projects. MRMIS began with an April 18, 1983, memo from the bureau Director to the Assistant Directors for Mining Research and for Minerals and Materials Research, in which the Director expressed his intention to institute an automated project tracking system for both in-house and contracted Research and Development projects. MRMIS became operational on October 15, 1984, and a dBASE III-compatible subset was ready for the Director's Decision Support System (DDSS) by February 1985. DDSS is an IBM-PC-based information retrieval system.

The MRMIS project was developed and is maintained at the Pittsburgh Research Center for the Assistant Director for Mining Research. Unfortunately, access to the system is limited to bureau personnel.

In summary, technology transfer is an integral part of BOM's mission. It has all of the elements of a good program, but it does not currently single out mine land reclamation for current or abandoned mine lands. It should be relatively easy, through special efforts, to initiate abandoned mine land technology transfer activities for the particular audiences in need of this information.

Ways of transferring the technology of the new AML research program are already in place in the bureau. They include:

- Publications--The Bureau produces its own publications, including series of Information Circulars (IC), Reports of Investigation (RI), Bulletins, Technical Progress Notes, and the one-page Technology News.
- Seminars, to inform industry of new technology in specific operational areas, such as ground control and ventilation in mining, treatment of refractory ores in metallurgy, and use of wetlands for acid mine drainage.
- Open industry briefings (OIB), to help keep industry abreast of research in progress.
- Joint industry-bureau meetings, at which information is exchanged on technological problems and on progress in the search for solutions.

- Workshops, to provide opportunities for small groups of industry personnel to gain "hands-on" experience in the application of new technology.
- Demonstrations, to allow industry representatives to witness new processes or new equipment in operation.
- Exhibits, to display bureau technology at local and national industry meetings.
- Technology transfer films and videotapes, to document the application of new technology in a form that can be made readily available to any industry group for showing at its own convenience. The bureau is now distributing these productions in videotape format, which makes them available to a larger audience at minimal cost.

Technology transfer events are announced in advance in press releases distributed to the media and wire services and to technical and trade journals in the minerals field. New films in the technology transfer series also are announced as they become available.

Assisting the bureau's technology transfer effort are the federal mine inspectors employed by the Labor Department's Mine Safety and Health Administration (MSHA). The inspectors, some 1,400 strong, are kept abreast of new technology through frequent meetings of MSHA and bureau staff, distribution of Technology News to MSHA headquarters and district offices, and videotapes on new technology produced by the bureau for the exclusive use of MSHA's National Mine Safety and Health Academy at Beckley, West Virginia. The inspection force is an effective instrument for introducing new technology to mines, especially to small operators, who cannot always afford to send representatives to national functions. This extension program in specialized topics allows direct interaction with the user.

Two other procedures employed by the bureau to further technology transfer deserve mention:

- Cooperative research agreements, which greatly facilitate technology transfer by involving industry as a co-investor with government from the inception of a project. Although an industrial cooperator sometimes contributes funds under such agreements, most contribute by making their mines or other facilities, and frequently their personnel, available to assist in the development or testing of new technology. The close working relationships that evolve, and industry's proximity to the research, foster the effective transfer of technology. During FY 1986, the bureau had 170 cooperative research agreements in effect.
- Patent licensing, whether exclusive or nonexclusive, can be a potent force for the commercialization of new technology, and the bureau actively encourages such licensing. Since 1982, six exclusive licenses and 29 nonexclusive licenses have been granted on patented bureau technology (BOM 1987).[7]

In conclusion, the existing elements of the Bureau of Mines technology transfer program that appear to be immediately applicable to the AML program are publications, seminars, and workshops. The task of the AML research program administrators will be to determine the audience for these activities, as discussed in section 4.2.2 of this report. It is important to realize that the user group will be different from normal Bureau of Mines clientele. Most users will be construction companies, smaller mining companies, and state AML bureaus.

## 4.2 DISSEMINATING AML RESEARCH AND CONSTRUCTION TECHNOLOGY

The instrument transferring the abandoned mine lands research program from the Office of Surface Mining to the Bureau of Mines mandated a technology transfer program, presumably associated with the research being undertaken, although this is not clear. The National Research Council's mid-course review of the national reclamation program for coal included a recommendation that the entire AML technology transfer program be assigned to the Bureau of Mines, a position supported by comments on the AML research program received as part of this study.[1]

The Office of Surface Mining is still the responsible agency for implementing the abandoned mine lands program, and as such will have major inputs into technology and information transfer programs, and will invariably be the point of first contact for questions on the overall AML program. It is not known at this time what administrative arrangements will be made between OSM and BOM on information and technology transfer beyond that agreed to as a result of the 1979 Memorandum of Understanding as amended.

If the AML program is to be implemented in a timely manner, using state of the art techniques, it is imperative that there be a vigorous and well-coordinated program of information and technology transfer. There is merit in the recommendation of the NRC Abandoned Mine Lands Committee (NRC 1986)[1] that the entire OSM AML technology transfer program, not just that emanating from research, be assigned to BOM, with OSM contributing to and supplying information available to them. Currently there is no organized OSM technology transfer program. With one comprehensive program, there should be no gaps in data or information, and the system should be fully accountable.

### 4.2.1 Technology Transfer Defined

There is a need to define "technology" and "technology transfer" as it should apply to the AML program. Many of the accepted definitions and applications would constrain the broad and frequently nontechnical system needed to implement AML reclamation.

Technology transfer is often equated with collecting large numbers of technical reports, storing them in semiautomated retrieval systems,

which include a smaller number of specific innovation reports, and making these available through literature distribution, with the assumption that this will result in significant and measurable technology transfer.[8]

In practice, however, the technology transfer process is or should be iterative and must be designed for inputs at all levels of the system, particularly through detailed user contact and reaction. The phases subsequent to the research may require complex studies to design the systems of implementation, or simple descriptions of application of the established principle. The extent of this intermediate or buffer stage is determined by the complexity of the scientific finding and the extent of understanding of the recipient audience. For those with knowledge and skill in the discipline, the transfer may be the dissemination of research reports, which will permit the recipient to incorporate findings directly into a newly designed or an established system. In other cases the findings may have to be refined and subject to engineering problem-solving to develop equipment or procedures applying the principles. In these instances, it may be advantageous to have direct personal exchange, which brings together designer and user and allows them to work side by side in developing the know-how and method of transfer.

It is possible that the user's hesitancy may be such that a "facilitator" must carry out the procedure under field conditions to demonstrate the effectiveness of the new equipment or process.

When the audience of users is broad and diverse, it is to be expected that each will have its own definition and expectations for technology transfer. It is also the reason why definitive descriptions of the process found in the literature may not reflect the full range of practical interactions. It is said that the transfer of knowledge is a matter of one man absorbing what another man is presenting (Bertsch and McIntyre 1983)[9] subject to the ability of the recipient to understand what is being transferred and the method developed to enable the recipient to grasp the fundamental issues.

In the AML program, hypotheses based on scientific observation suggested the use of wetlands to restore acid mine drainage waters. Technology made possible the building of artificial wetlands; the theory was tested but proven to be only partially successful, removing iron but not manganese. Thus the limitations of the technology seem to suggest the need for particular scientific studies of wetlands. The process thus may be long, complex, and at times, remote from the AML problem. If the study results in a natural process with recuperative capacity to treat acid mine drainage without huge investments of equipment, manpower, time, and money, then the effort will be a great achievement. If the research does not produce a natural process for pollution control through management of natural systems, it will lead to a search for other methods of treatment.

The process is one of action and interaction. This is supported by Jain's observations[10] that:

- Technology transfer of research results is essential if a mission-oriented research organization is to be effective in fulfilling its mission.
- It must be recognized that technology transfer may require direct output and/or compilation of scientific, engineering, or construction techniques. Technology transfer may include guidance on planning and administration, legal aspects, and contract planning. It may also require educational outputs to achieve desired results.
- Effective technology transfer increases user involvement in the innovation process, and this, in turn, positively affects research and development productivity.
- Institutional and organizational constraints, as well as improper planning for technology transfer, impede the process.
- Technology transfer techniques and approaches can be developed to facilitate the process.
- There must be flexibility in the system to make possible the use of new or proven technology for purposes other than those intended in the original scientific or engineering inquiry (known as "dual-use" technology) and capable of responding to widely varying needs at different stages in development.

In his study, Jain[10] cited three general approaches used by industrial research organizations to facilitate research utilization advocated by E. B. Roberts in "Generating Effective Corporate Innovation:"[11] They were:

- Personnel approach--movement of people, joint teams, and intensive person-to-person contact between the generator and user of research.
- Organizational link-pins approach--specialized transfer groups that contain engineering, marketing, and financial (to which could be added administrative, legal, project planning, contract writing, constructor, environmental, media, and educational) skills; use of integrators who act as third-party transfer coordinators; and new venture groups.
- Procedural approach--joint planning, joint funding, and joint appraisal using research and user groups.

In evaluating these approaches, Jain thought it important to consider also the application of engineering advancements, construction techniques, project planning and administration, reclamation, and education singly or as part of a joint study. The strong personal contact and use of intermediaries suggest rapid dissemination and more complete understanding of the technology, allowing proper application and successful implementation.

Further discussion on the development of technology transfer systems in the federal government as a whole and in the Bureau of Mines in particular is found in a comprehensive paper by Gerald McLindon.[12]

### 4.2.2 The AML Technology Transfer Program within BOM

The development of an AML technology transfer program within the Bureau of Mines should include consideration of the current program managed by the Office of Surface Mining on abandoned mine lands and any in-house research under way at the Eastern and Western Technical Centers that may be applicable to the abandoned mine lands construction program. The contract research program conducted by the Office of Surface Mining has produced very few published results because the program has only been in operation for two years. Provisions should be made to include the results of these projects in the bureau's technology transfer system so the results are made available to the user groups; otherwise these results could be lost.

There are two major users of AML technology transfer: (a) the state mining agencies, and (b) the reclamation contractors.

a. State mining agencies. The Bureau of Mines has worked with the state mining agencies over an extended period of time. However, the state AML programs are often separate from the state mining departments, and different personnel and sometimes different agencies of state government are involved. However, under AML Title IV funding, the state AML agencies take on the role of contracting agents, a role that requires in-depth knowledge of the reclamation process and development of new skills. As regulators, they are in the position of reviewing, approving, and overseeing AML reclamations. In implementation they are the responsible agents for initial surveys of a variety of parameters; and they are agents, if not the actual planners, for the project, preparers of specifications, contracting agents, and supervisors of the construction process. This entails much more work and greater responsibilities than those of the regulator as traditionally viewed.

Even when the reclamation plan and process are contracted out to consultants, agency personnel must be skilled in every aspect of the work in order to approve the procedures and intended results. This should entail searches of literature and surveys of other projects to be sure that the plan presented represents the state of the art. To add to the complexities of the operation, many civil and mining engineers acting as consultants may not be fully alert to environmental concerns or the esthetics of earthwork to accomplish a blending of land shaping into the surrounding landscape. Engineering solutions often stress geometric design, which produces harsh angular forms and ditch- and sump-like configurations in what are intended to be streams, ponds, and wetlands. So in addition to complete and thorough knowledge of the reclamation process, the agency staff may serve as moderators of aesthetics and natural forms, requiring extensive field engineering.

Frequently, the design engineers prepare cost-benefit analyses of alternate treatments. The agency staff must be sufficiently informed of the full consequences of each procedure to select a cost-effective

project. As supervisors of construction, the agency representatives must be able to discern departures from correct methods and required practices.

There is every indication that staffs of the state agencies have not only accommodated themselves to these added responsibilities, but have been innovators of cost-effective and improved methods for reclamation. The technology transfer program must recognize the inherent skill of agency personnel and the need to support each facet of the state agency's responsibility, which goes far beyond simple transfer of new technology, reclamation processes, and equipment.

b. The reclamation contractors. The second primary user is the reclamation contractor. In most instances this will be engineering firms, earth-moving contractors, or in some instances, operators/owners of small mines. The engineering and earth-moving contractors are consummate practitioners in the skills of reshaping the land, and as such are vital to the reclamation processes. However, many contractors are not oriented to environmental concerns. Even when such matters are written into the contract, some are not skilled in treating topsoils differently from subsoils, or have not had to identify pyritic and toxic materials and methods for putting them in the proper place. They may be used to working with the harsher geometric forms common on highways rather than contoured landscapes. Often they will overconsolidate the recontoured surface, creating compacted soils unsuitable for seed beds. Some may be unfamiliar with the more stringent specifications of AML reclamation.

Contractors very often become the innovators when the setting is right and when their knowledge and experience lend themselves to the problem at hand. Currently there is no way to capitalize on these ideas, and very often innovation may be stifled by rigid regulations and contracting requirements. This possible area of creativity must be addressed and technology transfer concepts applied.

The strengths of the contractor's experience can ensure a stable reclamation, but their lack of knowledge in ecological areas can cause breakdowns through physiochemical and/or vegetation failures. While each project solution is site-specific, the state agency may be faced with a general problem of education in reclamation. The bureau must have in place a system of technology transfer and informational support to aid the state agency and their contractors through the entire reclamation process.

Many reclamation problems, such as erosion control, topsoiling, soil amendments, seed bed preparation, and vegetation have been researched, and practical applications fall within the expertise of the county agent for the Agricultural Cooperative Extension Service. The extension agent should be very familiar with the soils and vegetation of the county in which the project is located. He possesses background and knowledge and is supported by experts who can make invaluable contributions to the reclamation project. The detailed user contact afforded by the county extension agency can make for an effective program of transfer. This should be recognized by those designing the transfer system.

### 4.2.3 Suggested Channels for AML Technology Transfer

There are several avenues that the Bureau of Mines may follow to maximize AML technology transfer. As previously described, the bureau has a very effective technology transfer program in place, and if consideration can be given to the AML problems, it is possible to use the system to enhance the AML program quickly. The AML state agencies have formed an organization, the Association of Abandoned Mine Land Programs, and are trying to accomplish technology transfer; they need to be assisted and incorporated into the bureau's program. The American Society for Surface Mining and Reclamation is active in research dissemination and it has established a permanent Register of Research and Demonstration Areas on Surface Mined Lands. The use of the Mining and Mineral Resources Research Institutes (MMRRI) in the appropriate states would enhance the technology transfer, and would provide another local contact for the bureau, and would help bring the AML state agency and the MMRRI closer together. The development of a data base, or the coordination of the bureau with existing data bases, would enhance the transfer of knowledge and technology. The expansion of personal contact with concepts such as the "one-stop service," described below, might be explored by the bureau in its planning process for the AML technology transfer program. A sampling of suggestions follows.

Sharing information across states: States are currently cooperating on an OSM/BOM-funded compilation of state reclamation projects that may be considered unique or represent state of the art reclamation techniques. For several years the AML Reclamation Research Program Review Panel commented that state mining agencies had accomplished many unique reclamation projects, but this information was unknown to most professionals in the field. Many previous proposals for research cited a need for information on problems that had already been addressed in completed state reclamation projects. It was apparent to the review panel that much of the state of the art reclamation work was being accomplished on state projects, and few people knew about it.

The state of Montana, working with the Association of Abandoned Mine Land Programs, has collected from all states reclamation project abstracts on data forms that will be bound into hard copy and also inserted into a tested, IBM-compatible software package that sorts by reclamation problem type, equipment used, or state involved. This material will provide information concerning unique reclamation projects already conducted. Since the information will concern actual construction projects, it should be particularly useful in the field.

The materials will be available in the fall of 1987 to all states and federal agencies that request the information. The program should be expanded to include industry and federal reclamation projects not currently included in the compilation, and a method for funding and annual update of materials should be adopted.

Sharing information with industry: Problems involved with active mining are in many cases similar to those addressed by AML research, and vice versa. Opportunities should be made available to share results of research and technology originating in active mining with the results of AML research. Several methods of sharing between AML research and active mining research should be encouraged, including possible cooperative research projects.

Use of data bases: Where there seems to be a need for research or engineering advancement, the proponent and the R&D agency must be able to search the files, including NTIS and Federal Research in Progress (FEDRIP) and state counterparts and generic center reference facilities to determine whether the work has been undertaken or is in progress. For this reason, it is imperative that these depositories and data bases have complete accounting of all work completed or in progress.

One-stop service: To avoid delaying reclamation operations, an effective technology transfer program must feature rapid response. One method is to establish a one-stop information network involving the BOM laboratories, possibly at one or more Mineral Institutes, and at OSM Technical Centers, where the users can access on-line data bases to search for answers. Where field consultation is a requirement, staff or listed consultants from each of the organizations could be on call for one day to two weeks in the field on a fee-for-service basis. This system is used very effectively by the U.S. Army Corps of Engineers.

The state AML agencies need rapid information responses, and they need to eliminate duplicative research. The availability of this one-stop network will provide the user with the most up-to-date information from the data bases or a consultant to address new problems not covered by previous work.

## 4.3 CONCLUSIONS AND RECOMMENDATIONS

Many technology transfer systems are available for AML use within the Bureau of Mines to transfer knowledge from research laboratories and construction sites to new sites to accomplish AML reclamation in a more cost-effective and environmentally sound manner. The following recommendations will help the bureau put in place an effective technology transfer program for AML research.

Recommendation 4.1: Serious consideration should be given to assigning the AML technology transfer program to the Bureau of Mines. The Bureau of Mines has a well-established technology transfer program. It will require special planning, but the AML technology transfer needs can be met by the bureau's current program by adding some new elements and identifying new clientele. Thus, all of the elements of OSM's AML technology transfer activities can be moved to the Bureau of Mines for a comprehensive technology transfer program.

Recommendation 4.2: It is recommended that the bureau establish a task force to define and address the abandoned mine land technology transfer activity. This task force should identify the needs of the AML technology transfer program and link as many of these needs as possible to other established Bureau of Mines technology transfer programs. The bureau should consider including an OSM representative as a standing member of the task force.

Other apsects of the problem to be studied by the task force should include:

- Data base development of bibliographic listings of mining and mineral resources as applied to abandoned mine lands.
- Development of linked series of information circulars, reports, and bibliographies categorized by subject.
- Continuation of joint federal and professional agency-sponsored seminars on abandoned mine land reclamation.
- Compilation and rapid distribution of technology from overseas.

Recommendation 4.3: A universal data base of state AML projects similar to the data base of state AML projects prepared by the Abandoned Mine Reclamation Bureau of Montana should be established within the Bureau of Mines technology transfer program. It may be possible to incorporate this in the MRMIS system and make it, and all other information not used for internal management purposes, available to the public.

Much of the research carried out by state agencies represents state-of-the-art reclamation practice, but it is virtually unknown to other states or researchers. The committee recommends that the bureau utilize the Montana file and incorporate it with its own research-in-progress index. The MRMIS, which currently is used only for internal purposes, and contains confidential data, should be redesigned for public access. The Mineral Institutes, state agencies, state geologists, and Federal Library Depositories will benefit from access to these sources.

Recommendation 4.4: The committee recommends that the bureau establish a "one-stop" information service capable of responding to questions from state AML agencies, Mineral Institutes, contractors, and others. A roster of "one-stop" experts by discipline area would be compiled for each coal region, to include bureau, laboratory, state agency, and university personnel willing to answer inquiries or to meet in the office or field, paid by the user where appropriate. This employs a vital personal component of technology transfer, one that has proven highly productive in other agencies.

Recommendation 4.5: A Generic Technology Research Center in Mining and Reclamation should be established at the earliest date, with affiliate universities located in those states with major AML problem areas. The Surface Mining Control and Reclamation Act authorized the creation and partial federal funding of state Mining and Mineral Resources Research Institutes, under the Generic Center Research Program. The concept of research centers is well-established, not only by the Stevenson-Wydler Act and by other congressional and executive measures, but also by the fact that BOM has already set up five generic centers. Greater benefit could be derived from establishment of a Center for Reclamation. This would serve as a reference center, a depository, and distributor of information on reclamation practices.

The selection of a generic research center for reclamation and affiliate universities should follow the bureau's normal procedure. In this instance, consideration should be given to proximity to areas of major AML concentrations, and to the presence and quality of supporting programs in mining engineering, chemistry, geology, civil and mechanical engineering, soil science, horticulture, forestry, wildlife, agriculture, and landscape architecture. An Agricultural Cooperative Service presence would be an advantage. The generic center should also be a designated Regional Federal Depository Library Center. The center, with its affiliated universities, would also be useful as part of the one-stop network.

Recommendation 4.6: It is recommended that the bureau host small professional seminars or conferences on information dissemination and technology transfer, particularly in the course of designing the AML technology transfer program. These sessions would include representatives of the bureau, OSM, and state agencies, editors of mining publications, and representatives of the Mineral Institutes and Generic Centers, NTIS, and the Federal Laboratory Consortium. Broad participation will allow the input of all federal and state entities having an interest in technology transfer. Currently, some agencies that are in place for the transfer of technology are not being utilized, and it is thought that a meeting of interested people would enhance the design of the AML technology transfer program.

Recommendation 4.7: The committee recommends that the Bureau of Mines incorporate the results of AML reclamation projects into technical guidance documents for use by agencies, mine operators, and contractors. Some manuals have been produced by OSM for other parts of its program, and these have been used extensively by coal mining companies. It is appropriate that this mechanism be utilized for this new clientele. These documents would summarize construction practices that have been used in other areas.

## NOTES

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# Appendix A

## SECTIONS 401 AND 403 OF TITLE IV OF THE SURFACE MINING CONTROL AND RECLAMATION ACT OF 1977 (PL 95-87)



## TITLE IV—ABANDONED MINE RECLAMATION

### ABANDONED MINE RECLAMATION FUND AND PURPOSES

Federal and State abandoned mine reclamation funds. 30 USC 1231.

SEC. 401. (a) There is created on the books of the Treasury of the United States a trust fund to be known as the Abandoned Mine Reclamation Fund (hereinafter referred to as the "fund") which shall be administered by the Secretary of the Interior. State abandoned mine reclamation funds (State funds) generated by rants from this title shall be established by each State pursuant to an approved State program.

Deposits.

(b) The fund shall consist of amounts deposited in the fund, from time to time derived from—

Reclamation fees.

(1) the reclamation fees levied under section 402 of this Act: *Provided*, That an amount not to exceed 10 per centum of such reclamation fees collected for any calendar quarter shall be reserved beginning in the first calendar year in which the fee is imposed and continuing for the remainder of that fiscal year and for the period in which such fee is imposed by law, for the purpose of section 507(c), subject to appropriation pursuant to authorization under section 712: *Provided further*, That not more than $10,000,000 shall be available for such purposes;

User charges.

(2) any user charge imposed on or for land reclaimed pursuant to this title, after expenditures for maintenance have been deducted;

Donations.

(3) donations by persons, corporations, associations, and foundations for the purposes of this title; and

(4) recovered moneys as provided for in this title.

Recovered moneys.

(c) Moneys in the fund may be used for the following purposes:

Fund moneys, use.

(1) reclamation and restoration of land and water resources adversely affected by past coal mining, including but not limited to reclamation and restoration of abandoned surface mine areas, abandone coal processing areas, and abandoned coal refuse disposal areas; sealing and filling abandone deep mine entries and voids; planting of land adversely affected by past coal mining to prevent erosion and sedimentation; prevention, abatement, treatment, and control of water pollution created by coal mine drainage including restoration of stream beds, and construction and operation of water treatment plants; prevention, abatement, and control of burning coal refuse disposal areas and burning coal in situ; and prevention, abatement, and control of coal mine subsidence;

(2) for use under section 406, by the Secretary of Agriculture, of up to one-fifth of the money deposited in the funds annually and transferred by the Secretary of the Interior to the Secretary of Agriculture for such purposes;

(3) acquisition and filling of voids and sealing of tunnels, shafts, and entryways under section 409;

(4) acquisition of land as provide for in this title;

(5) enforcement and collection of the reclamation fee provided for in section 402 of this title;

(6) studies by the Department of the Interior by contract to such extent or in such amounts as are provided in appropriation Acts with public and private organizations to provide information, advice, and technical assistance, including research and demonstration projects, conducted for the purposes of this title;

(7) restoration, reclamation, abatement, control, or prevention of adverse effects of coal mining which constitutes an emergency as provided for in this title;

(8) grants to the States to accomplish the purposes of this title;

(9) administrative expenses of the United States and each State to accomplish the purposes of this title; and

(10) all other necessary expenses to accomplish the purposes of this title.

(d) Moneys from the fund shall be available for the purposes of this title, only when appropriated therefor, and such appropriations shall be made without fiscal year limitations.

OBJECTIVES OF FUND

30 USC 1233.

SEC. 403. Expenditure of moneys from the fund on lands and water eligible pursuant to section 404 for the purposes of this title shall reflect the following priorities in the order stated:

(1) the protection of public health, safety, general welfare, and property from extreme danger of adverse effects of coal mining practices;

(2) the protection of public health, safety, and general welfare from adverse effects of coal mining practices;

(3) the restoration of land and water resources and the environment previously degraded by adverse effects of coal min-in practices including measures for the conservation and development of soil, water (excluding channelization), woodland, fish and wildlife, recreation resources, and agricultural productivity.

(4) research and demonstration projects relating to the development of surface mining reclamation and water quality control program methods and techniques;

(5) the protection, repair, replacement, construction, or enhancement of public facilities such as utilities, roads, recreation, and conservation facilities adversely affected by coal mining practices;

(6) the development of publicly owned land adversely affected by coal mining practices including land acquired as provided in this title for recreation and historic purposes, conservation, and reclamation purposes and open space benefits.

Appendix B

INQUIRIES DISTRIBUTED TO ELICIT VIEWS OF AML RESEARCH PRIORITIES

United States Department of the Interior

BUREAU OF MINES
2401 E STREET, NW.
WASHINGTON, D.C. 20241

March 23, 1987

Dear :

On behalf of the Bureau of Mines, I would like to thank you very much for the time you spent as a member of the AML Reclamation Research Program Review Panel. The high quality and professionalism of the Panel membership was evident throughout the meeting.

As you may recall, the detailed agenda handed out at the meeting included discussion and review topics that were to be addressed, time permitting. As the schedule developed towards the end of the second day, there was not adequate time to address the topics. Therefore, I am now asking you for your comments on the following topics by mail: 1) present rating criteria and review procedures; 2) research needs assessment (using attached list); 3) suggested language for the FY 88 CBD Announcement, stressing priority areas; 4) future funding levels; and 5) technology transfer.

I would appreciate having any recommendations and or comments by Friday, April 10, 1987. We need the Panel's recommendations for FY 88 program planning, which is already well underway.

Sincerely,

Allen Perry

Allen Perry
Division of Mining Technology

Enclosure
Identical Letters sent to: see attached list

## AML RECLAMATION RESEARCH SUBJECT AREAS

AML RESOURCE EVALUATIONS

LANDSLIDES

MINE FIRES

MINE OPENINGS
- SHAFT FILLING & SEALING
- ADIT & PORTAL SEALING

MINE WASTES

REMOTE SENSING

REVEGETATION

SLOPE STABILITY
- HIGHWALLS
- REFUSE PILES

SUBSIDENCE
- PREDICTION
- CONTROL
- VOID FILLING

TOPSOILING

TOXIC SOILS

UNDERGROUND VOID DETECTION

WATER QUALITY
- AMD
- COAL MINE LAKES
- SUSPENDED & DISSOLVED SOLIDS
- TRACE ELEMENTS

OTHERS:

NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND RESOURCES
2101 Constitution Avenue Washington, D.C. 20418

BOARD ON
MINERAL & ENERGY RESOURCES

(202) 334-2744

_____, 1987

(address)

Dear _____:

You may be aware that Congress statutorily transferred the Abandoned Mine Research and demonstration program from the Office of Surface Mining to the Bureau of Mines. At the request of the Bureau of Mines, the National Research Council has recently established a study Committee on Abandoned Mine Lands Research Priorities. As a member of that Committee, I am asking you to take several minutes to provide your expert advice on the priorities and issues that the Committee is addressing.

The Committee's charge is to develop recommendations on research priorities and criteria for evaluation of research proposals dealing with the reclamation of abandoned coal mine lands. In addition, the study should develop recommendations regarding the effectiveness of corresponding technology transfer.

Rather than trying to develop a questionnaire, we wish to ask you two questions which we hope will focus your perceptions about important Abandoned Mine Research:

1. Using the attached list of AML Reclamation Research Subject Areas, choose the three highest priorities for AML reclamation research in your region. If you feel a subject area not on this list should be included, please so indicate in your list of three.

2. Considering that approximately $ 2 million will be available annually for this purpose, please outline among the three subject areas chosen, the most challenging, intractable and promising research problems remaining to be solved which are most likely to have a high return on investment.

I appreciate your time in giving the Committee the benefit of your professional opinion.

Sincerely,

Kenneth N. Weaver, Chairman
Committee on Abandoned Mine
Lands Research Priorities

Encl.

## AML RECLAMATION RESEARCH SUBJECT AREAS

AML RESOURCE EVALUATIONS

LANDSLIDES

MINE FIRES

MINE OPENINGS
- SHAFT FILLING & SEALING
- ADIT & PORTAL SEALING

MINE WASTES

REVEGETATION

SLOPE STABILITY
- HIGHWALLS
- REFUSE PILES

SUBSIDENCE
- PREDICTION
- CONTROL
- VOID FILLING
- UNDERGROUND VOID DETECTION

TOPSOILING

TOXIC SOILS

WATER QUALITY
- AMD
- COAL MINE LAKES
- SUSPENDED & DISSOLVED SOLIDS
- TRACE ELEMENTS

OTHERS:

# Appendix C

## EXCERPTS FROM RESPONSES TO INQUIRIES AS TO WHAT ARE VIEWED AS THE HIGHEST-PRIORITY AML RESEARCH NEEDS

### WATER QUALITY

In Alabama, the most critical areas of concern regarding abandoned mines are those relating to surface water. Within this broad category, stream siltation and acid mine drainage are two areas that deserve special attention, since they not only are interrelated but also are probably controlling factors with respect to dissolved solids and trace elements.

Research is needed to define the extent of the siltation problem and to identify, in specific areas, the exact effects on aquatic and terrestrial plants and animals. Possibly the most challenging but potentially most rewarding area for research would be in the area of mitigation of the effects of siltation and acid mine drainage. What cost-effective measures can be taken to improve, if not completely restore, a surface mine damaged stream? (State Geologist, east)

Long-term monitoring of groundwater quality and water level is needed to select significant chemical parameters and formulate effective groundwater monitoring strategies at abandoned mine sites. The results will also aid in the design of environmentally sound impoundments and groundwater restoration plans. These studies should include analysis of the extensive data already available in our files. (Mineral Institute, midwest)

Preliminary data from . . . various geologic/geochemical settings in North Dakota suggest that reclamation of some sites will result in severe degradation of groundwater quality and diminished plant growth. (Mineral Institute, west)

Acid mine drainage (AMD) would be the most intractable problem. The complexity of the AMD problem indicates that a national classification system for AMD would be useful for the practitioner. Some AMD is treatable with current technology, while other discharges have no practical treatment options. Matching AMD characteristics with treatment options is a reasonable objective. (American Society for Surface Mining and Reclamation)

[Processes and technologies] available for collection and treatment of AMD . . . require continuous operation and maintenance well beyond the scope of the AML program. (Suggested research into artificial wetlands) (State AML official, east)

AMD: Effects on long-term water quality of high rates of lime at the surface and/or incorporated into the surface of mine spoil.

Effect on long-term water quality of the injection of chemical neutralizers into in-place surface mine spoils. (Industry, east)

Abandoned lignite mines: " . . . the high permeabilities of unconsolidated sandy aquifers create the potential for contamination of water resources by major ions and toxic metals contained in spoils from abandoned lignite and uranium mines . . . we therefore rank water quality issues high above other subject areas . . . . Dissolved solids and trace elements in ground waters and acid mine drainage (are important issues), especially with regard to the acid-generating capacity of lignite mine spoils . . . we feel that long-term (multiyear) monitoring of groundwater quality and water levels should be coupled with solute transport modeling in these complex, heterogeneous aquifers." (State Geologist, midwest)

Finding alternatives to perpetual treatment is a must. "We also need alternatives to chemical treatment. Research should address trace elements as well as neutralization as part of the mining and reclamation operation--prevention versus treatment." (Industry, east)

Treatment of AMD by natural or man-made wetlands is another area of research that needs continued support. Treating AMD by a natural, self-perpetuating, ecologically stable system is cost-effective and environmentally sound, in contrast to perpetual treatment. (American Society for Surface Mining and Reclamation, east)

The most promising (water quality) research would combine long-term (multiyear) monitoring of groundwater quality and water levels with solute transport modeling in these complex, heterogeneous aquifers. (Mineral Institute, midwest) (Tex.)

Many treatment (abatement) techniques have been developed . . . However, a great unknown parameter exists between the point of application (generally near surface) and the area of discharge (the seep or outflow). This unknown is within the groundwater regime of the mine and plays an extremely important role in the success or failure of a treatment. (American Society for Surface Mining and Reclamation)

While artificial wetlands have proven to be effective in a limited number of demonstrations such as TVA's, there continue to be some questions that need to be answered before this approach receives industry-wide and regulatory acceptance. (TVA)

Emphasis should be placed on passive (i.e., bogs) treatment. (State AML official, east)

Assessment of impact of vegetation on acid mine drainage. The use of bogs to treat acid mine drainage has been initiated at numerous sites, but quantification of the active principles has not been pursued. (American Society for Surface Mining and Reclamation, west)

## SUBSIDENCE

Research into underground void detection and subsidence prediction using remote sensing methods may prove to be the most viable approach to this problem. (State Geologist, east)

Many of the mine maps are inaccurate or incomplete, and thus it is often a problem finding the actual underground voids. Methods of handling void filling are obviously of much interest. (State Geologist, west)

A. Compile a comprehensive data base of subsidence-related information.
B. Identify, locate geographically, inventory, and computerize for easy retrieval old underground mine maps.
C. Create subsidence prediction models for specific coal producing fields. (State Geologist, east)

Hydrology problems associated with subsidence should be addressed by the Bureau. Land owners continue to concern themselves with hydrology problems and, in many instances, blame mining activities for their water problems. Potential long-term impacts on hydrology, resulting from subsidence, must be identified and quantified. (Industry, east)

## MINE WASTE

A significant portion of our AML efforts in Kentucky is directed toward reclamation of abandoned coal waste areas, both coarse refuse and slurry impoundments . . . . There has . . . been significant interest in reprocessing many of these coal waste areas to recover remaining coal . . . If private enterprise can be encouraged to reprocess and incidentally reclaim coal waste areas, there will be significant savings to the state AML programs and otherwise wasted energy resources will be recovered. (Institutional incentives and new technologies were noted.) (State AML official, east)

This research could also look into techniques that extract valuable by-products and leave nontoxic residues. (State Geologist, west)

(Highest-priority research area:)
Characterization of refuse or gob piles for potential remining.
A. Areal extent and thickness of the mine waste materials.
B. Coal content, quality, and stratification of the waste materials.
C. Geochemical characteristics of the mine waste materials.
D. Determination of slope stability of mine waste materials (particularly in areas of contour surface mining). (State Geologist, east)

A characterization study of wastes as to mineral content, commercial value, and hazard potential is needed . . . to address the applicability of the various handling methods. For example, the state of Utah requires the mixing of refuse with soil in a 1:1 ratio to reduce the spontaneous combustion potential. It is unknown whether this action is sufficient or insufficient, or even justified. Any work into questions concerning proper waste treatment and use could have far-reaching benefits given the vast amount of this material. (Mineral Institute, west)

A large amount of the AML contract monies spent in this region is applied to refuse piles, and unfortunately we know very little about basic refuse properties and variability. For example, we really have no idea of just how much topsoil is required to establish permanent vegetation over toxic waste materials, and a large amount of the money involved in the AML contracts in this area is spent on isolating, hauling, and grading topsoil cover materials. We also know that it is possible to revegetate many waste piles without a topsoil cover (which could save large amounts of AML monies) but this strategy is seldom if ever employed because of the lack of supporting research data. (American Society for Surface Mining and Reclamation, east)

We also need research into whether or not a mine waste is toxic, thereby perhaps reducing the abatement measures that are needed, i.e., there are mine wastes that need little or no precautions in their reclamation. (State Geologist, west)

. . . I'd suggest that some of the available dollars be focused on resource recovery from mining wastes. Most states have adequate laws in place to ensure proper disposal of wastes resulting from new mining operations. If values could be identified or developed from existing wastes, we could have an incentive to remine or reprocess and properly dispose of new waste. (Mineral Institute, west)

Our problems in the Southwest are the stabilization and revegetation of abandoned mine waste and tailings. (American Society for Surface Mining and Reclamation, west)

## REVEGETATION

(Use of) toxic spoils or refuse . . . should promise tangible benefits in a relatively short time frame. The problem is acute in regions where the quantity and quality of topsoil is limited or nonexistent. Inorganic and organic amendments provide a practical substitute for topsoil . . . . Inorganics would include fly ash, bottom ash, lime used in fluid bed combustion, etc. Organics would include residues from processing agricultural and forest products, composted municipal waste, sewage sludge, etc. Lists of approved materials should be prepared and treatment options identified. (American Society for Surface Mining and Reclamation)

By far the most important is research related to the reestablishment of favorable root zone hydrologic properties and groundwater aquifers. Particular attention must be paid to the initial levels of soluble salts and to changes in soluble salt levels with time. Second, many of our AML spoils are highly sodic and will not support appreciable plant growth. Some innovative and cost-effective procedures need to be developed using amendments and available less sodic spoil materials to reestablish a vegetative cover that will adequately control losses by erosion. Third, even on relatively nonsodic spoils, revegetation is frequently less than adequate. Much of this, I believe, is due to poor hydrologic factors in the root zone. Some additional research is needed to develop methods for revegetating and stabilizing these areas. (American Society for Surface Mining and Reclamation, west)

A critical problem to resolve is the need to develop methods to build a better root zone. Most reclamation efforts neutralize acidic refuse (gob and slurry), then cover it with topsoil to build a root zone for revegetation. The effects of the various neutralizing agents need to be investigated and evaluated. Post-neutralization acidification has occurred, and studies should be undertaken to document the conditions under which it occurs. (National Laboratory, midwest)

Use of fly ash, fluidized bed combustion wastes, pulpmill wastes, or other waste materials as a soil amendment or mulching medium should be evaluated and demonstrated. (TVA)

Increased research efforts must be made in the area of reforestation of mine lands. Particularly, coal operators must be allowed to reclaim with trees on spoiled materials rather than having to establish tree growth on compacted topsoil. (Industry, east)

Focusing upon timing and phased planting (of revegetation) has potential. Many projects . . . try to establish all the plant species at one time even though they may compete or be better suited for later

introduction. Phasing is a topic that should be more thoroughly explored, as any aid to revegetation in arid regions will be welcomed by operators. (Mineral Institute, west)

While revegetation may appear healthy in the first few years following planting, the long-term measure of reclamation success is 10 to 15 years of sustained yield. (National Laboratory, midwest)

## SLOPE STABILITY

Predictions to identify risk areas prior to AML treatment and guidelines to prevent instability during and after treatment are required on contour mines in mountainous terrain.

Once a slope has failed, two important research areas are: (1) Predictions to determine if by natural events the slope is stable and no treatment is necessary. If it is unstable, a prediction of the degree of risk it represents is necessary. (2) Development of treatment options for slope failures that are considered unstable. (American Society for Surface Mining and Reclamation)

Our earlier work (on slope stability) showed that some problems could be moderated by creating ponds or other land forms in the reclamation area, but such techniques are not now allowed. We need viable alternatives to some current reclamation procedures. (U.S. Forest Service)

## Appendix D

## INSTRUCTIONS FOR AML RESEARCH PROPOSAL PREPARATION

I. The Research Proposal Submission Cover Sheet

Item 1 - State the abandoned mined land problem addressed by the proposal (mine fires, subsidence, water quality, waste piles, toxic soils, slope stability, mine openings, surface mining, subarctic reclamation, or multiple applications).

Item 2 - Briefly describe the specific problem addressed by the proposal.

Item 3 - Briefly describe the proposed solution.

Item 4 - Select a short title that adequately describes the work and differentiates it from silimlar studies.

Item 5 - Give the name, address, and phone number of the proposing organization.

Item 6 - Give the principal investigator's name, business address, and phone number.

Item 7 - State the expected duration of the work in terms of the number of months between the contract award date and submission of final report (maximum 36 months).

Item 8 - State the total requested federal funding including funds for subcontracts (maximum $250,000). Also indicate cost sharing, if any.

II. Attachments

1. Directly following the cover sheet provide a one page, single spaced abstract and justification of your proposal (Attachment A). The justification should include a description of how the proposed work differs from or supplements similar previous or ongoing studies. It should also state (assuming a successful effort) technology transfer potential, i.e. what the usable product or benefit will be to those doing abandoned mined land reclamation work, particularly in other areas of the U.S.

## RESEARCH PROPOSAL SUBMISSION COVER SHEET

1. AML Problem Type: _____

2. Problem Definition: _____

_____

3. Proposed Research Solution: _____

_____

_____

4. Proposed Project Title: _____

_____

5. Proposing Organization: _____
(Name, Address, Phone No.)

_____

6. Principal Investigator: _____

_____

7. Duration: _____

8. Funding: _____

### Attachments

A. Abstract and justification.
B. Detailed proposal.
C. Proposed researcher's background and experience.
D. Proposed researcher's related accomplishments and publications.
E. Detailed schedule.
F. Detailed budget on standard form pricing sheet.
G. Representations and Certifications.

1. Attachments B, C, and D to the cover sheet sheel total no more than 25 pages. Attachments B and E shall be typed double spaced. Attachments C and D may be single spaced. All pages of proposals should be 8 1/2" x 11" and of a standard format such that they may be photocopied.

2. Proposals should address only abandoned coal mined land issues. They may relate to the reclamation and control of surface or underground mining or coal processing problems and their effects. These include but are not necessarily limited to subsidence, mine fires, water quality, landslides, mining and processing wastes, and hazardous mine openings. Proposals for research on active mining problems will not be accepted for funding. Abandoned surface mine revegetation research proposals for FY 87 must be address AML reclamation in subarctic areas or toxic soils in arid areas.

3. Proposals must include an itemized budget and detailed schedule. The schedule must be no more than 36 months and should be given by approximate duration of tasks. The budget, Attachment F, should be given on the attached Government Pricing Form. All proposal budgets must have a provision for producing and submitting to the Office of Surface Mining, five copies of monthly or quarterly technical and financial reports and 5 copies and a reproducible master of the final project report. Budgets are limited to a maximum of $250,000 over the duration of a project.

4. Submit 3 signed copies of the Representations and Certifications (Attachment G).

III. General Guidelines

A set of review procedures and instructions is being provided as background information. Valuable insights can be gained from a review of these materials which indicate how proposals will be evaluated. The proposal evaluation criteria have been formulated on two general premises: that the most severe and widespread problems should be addressed first; and that proposals should be solution-oriented. Proposals that are only surveys, inventories, and broad studies of the problem will not be accepted. While it is understood that some of these activities my be necessary, the proposer's activity must concentrate on deriving a more efficient or less costly solution for dealing with an AML problem.

Although the magnitude of the problem is a very important factor in the review criteria, broad and lengthy discussions of the problem in the proposal are unnecessary. Be specific and discuss the problem sufficiently for the reviewer to understand exactly what is being proposed. Keep in mind that the review panel will be composed of people who deal with AML issues daily and have broad expertise in this

area. If the addressed problem is so obscure as to require lengthy discussion, it is unlikely to be of sufficient importance to warrant strong consideration. Devote the main body of the proposal to the specifics and details which result in a solution to the problem.

IV. Format

Please submit three (3) copies of your proposal. Submissions should not contain any interleaves or heavy paper pages, nor should they be stapled or bound. If of necessity, you must include pages in your proposal larger than 8 1/2" x 11" or pages that cannot be reproduced by black and white photocopy, you must submit 12 copies of your proposal (which may be bound). If your organization requires an authorization page, include it directly after the abstract sheet. Number the pages beginning with the first page of Attachment B and ending with the last page of Attachment E.

V. Deadlines

All proposals for funding in fiscal year 1987 (October 1, 1986 - September 20, 1987) must be received by OSMREby 4:00 pm (E.D.T.) May 29, 1986.

## Appendix E

## OSM'S RATING SYSTEM FOR SELECTING AML RESEARCH PROJECTS

### AML RESEARCH RATING CRITERIA

| Proposal Considerations | Criteria | | Rating |
|---|---|---|---|
| **I. The Problem** | | | |
| **A. Need** | | | |
| 1. Technological Need | a. | Present technology effective but could be improved | 1 |
| | b. | Present technology moderately effective-improvements desirable. | 2 |
| | c. | Present technology sometimes ineffective - needs improving. | 3 |
| | d. | Technology to solve problem does not exist. | 4 |
| **B. Magnitude of Problem** | | | |
| 1. Effect on Environment | a. | Moderate impact and localized | 1 |
| | b. | Moderate impact and widespread | 2 |
| | c. | Severe impact and localized | 3 |
| | d. | Severe impact and widespread | 4 |
| 2. Effect on People | a. | Moderate impact on a few people | 1 |
| | b. | Moderate impact on many people | 2 |
| | c. | Severe impact on a few people | 3 |
| | d. | Severe impact on many people | 4 |
| 3. Economic Effects | a. | Moderate localized impairment of economic values | 1 |
| | b. | Moderate widespread impairment of economic values | 2 |
| | c. | Severe localized impairment of economic values | 3 |
| | d. | Severe widespread impairment of economic values | 4 |

## AML RESEARCH RATING CRITERIA

| Proposal Considerations | Criteria | Rating |
|---|---|---|
| **II. Proposed Solution** | | |
| **A. Technical Merit** | | |
| 1. Soundness of Approach | a. Some merit but needs major modifications | 1 |
| | b. Plan needs some modifications | 2 |
| | c. Plan needs minor modifications | 3 |
| | d. Well-planned approach uses scientific/engineering principles | 4 |
| 2. Uniqueness of Approach | a. Trail and error approach | 1 |
| | b. Modification of previously tried approach | 2 |
| | c. Transfer of proven technology from another field | 3 |
| | d. Totally new concept or invention | 4 |
| 3. Completeness of Approach in Advancing State-of-the-Art (SOTA) | a. Minor contribution to SOTA but significant additional work will be needed | 1 |
| | b. Minor contribution to SOTA; ready for operational use | 2 |
| | c. Major contribution to SOTA but significant additional work will be needed | 3 |
| | d. Major contribution to SOTA; ready for operational use | 4 |
| **B. Benefits** | | |
| 1. Cost Reductions/Time Savings over Presently Used Methods | a. Moderate cost or time savings | 1 |
| | b. Moderate cost and time savings | 2 |
| | c. Significant cost or time savings | 3 |
| | d. Significant cost and time saving | 4 |
| 2. Diverse Applicability of Solution | a. Technical transfer posible but uncertain | 1 |
| | b. Some technical transfer possible and likely | 2 |
| | c. Good potential for technical transfer to active mining | 3 |
| | d. Good potential for technical transfer to active mining and other fields | 4 |

## AML RESEARCH RATING CRITERIA

| Proposal Considerations | Criteria | Rating |
|---|---|---|
| III. Implementation | | |
| A. Implementation Factors | | |
| 1. Duration | a. Poor schedule, needs major modifications | 1 |
| | b. Fair schedule, needs moderate modifications | 2 |
| | c. Good schedule, needs minor modifications | 3 |
| | d. Excellently planned effort | 4 |
| 2. Total Cost Over Duration (Detail deficient areas on cover sheet) | a. Budget needs major modifications | 1 |
| | b. Budget needs significant modification to conform to prevailing rates | 2 |
| | c. Good budget with few items exceeding prevailing rates | 3 |
| | d. Excellent budget as is | 4 |
| IV. Information on Proposer | | |
| A. Proposer's Qualifications | | |
| 1. Background/Experience | a. Some background and experience in activity proposed | 1 |
| | b. Fair background and experience in activity proposed | 2 |
| | c. Good background and experience in activity proposed | 3 |
| | d. Strong background and experience in activity proposed | 4 |
| 2. Past Performance | a. No experience but has other qualifications | 1 |
| | b. Average record of producing quality results and reports and adhering to schedule | 2 |
| | c. Above average record of producing quality results and reports and adhering to schedule | 3 |
| | d. Exemplary record of producing quality results and reports and adhering to schedule | 4 |

## Appendix F

## INSTRUCTIONS FOR EVALUATING PROPOSALS UNDER OSM

1. Read the proposal.

2. If the proposal can be rejected without a comprehensive evaluation, write on the first page of the proposal and score sheet your reason for rejecting it. For example: not coal related; not AML related; no detailed costs; cost over $250,000; duration over 3 years; no solution proposed; obvious duplication of past or ongoing work; length of proposal exceeds limitation; proposer has past due reports on past projects; etc. Proposals with simple deficiencies or unclear segments should not be rejected; these will be addressed by the rating criteria or through clarification with the proposer. Reject a proposal only if you are absolutely certain you can justify your rejection. If in doubt, evaluate it with the rating criteria.

3. Review the remaining (non-rejected) proposals. For each criterion on the rating criteria sheets, select the one that you think best describes the proposal. Write the appropriate rating score for that criterion in the corresponding box on the scoring sheets. Use only the numbers given; do not use fractions of them. If you feel the proposal is unworthy of any points on a particular criterion, score it zero (0).

   At the bottom of the cover sheet of the proposals, justify any score less than 4 for Criterion III-A-2 by listing areas where you believe proposed costs to be non-standard. Look for underestimations as well as inflated or unnecessary expenses. If there is insufficient information to determine a score for a criterion (a proposer's past performance, for instance), try to determine such information from your fellow reviewers or other sources. If you still cannot make a judgment, leave the appropriate box blank.

4 Once you have rated each criterion, you are ready to obtain the Total Score for the proposal. First, under most criteria categories (I-A, I-B, etc.), there are either two or three criteria. Derive the average score for each category and multiply by the Weighting Factor to obtain the Weighted Score for each category. Round the calculations to hundredth's place.

In summary, the calculations are thus:

| Criteria | Weighting Factor | Formula | Weighted Score |
|---|---|---|---|
| I-A | 5 | A x 5 = | |
| I-B | 3 | ($\Sigma$ B ÷ 3) x 3 = | |
| II-A | 6 | ($\Sigma$ A ÷ 3) x 6 = | |
| II-B | 5 | ($\Sigma$ B ÷ 2) x 5 = | |
| III-A | 4 | ($\Sigma$ A ÷ 2) x 4 = | |
| IV-A | 2 | ($\Sigma$ A ÷ 2) x 2 = | |

5. Add the Weighted Scores to derive the Total Score for the proposal. If you have left any criteria blank (unscored) for lack of information, place an "I" after the Total Score for that proposal on the rating sheet, to note that this is an incomplete score that must be completed and revised when the Research Evaluation Panel meets to determine a consensus score. A "perfect" Total Score is 100. This is unlikely to be obtainable, since some criteria may be antithetical to others.

PROPOSAL SCORING SHEET

| PROPOSAL | I-A | | I-B | | | | II-A | | | | II-B | | | III-A | | | IV-A | | | TOTAL SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CRITERIA | WEIGHTED SCORE | CRITERIA | | | WEIGHTED SCORE | CRITERIA | | | WEIGHTED SCORE | CRITERIA | | WEIGHTED SCORE | CRITERIA | | WEIGHTED SCORE | CRITERIA | | WEIGHTED SCORE | |
| | 1 | A × 5 | 1 | 2 | 3 | Σ B/3 × 3 | 1 | 2 | 3 | Σ A/3 × 6 | 1 | 2 | Σ B/2 × 5 | 1 | 2 | Σ A/2 × 9 | 1 | 2 | Σ A/2 × 2 | Σ Weighted Scores |
| | | | | | | | | | | | | | | | | | | | | |
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## Appendix G

## TECHNOLOGY TRANSFER QUERY LETTERS (TO TWELVE COMPANIES AND TWO INDUSTRIAL JOURNALS)

June 16, 1987

Dear _____:

You may be aware that Congress statutorily transferred the Abandoned Mine Research and Demonstration Program for the Office of Surface Mining to the Bureau of mines. At the request of the Bureau, the National Research Council of the National Academy of Sciences recently established a Study Committee on Abandoned Mine Lands Research Priorities. As a member of that committee I have been assigned the study of Technology Transfer and how effective are the processes of getting information to the industry on research needs, results of research, innovative practices and techniques, new equipment and other topics resulting from research and special studies. I am asking you to take several minutes to provide your expert advice and recommendations on technology transfer and how to get more effective dissemination of information.

Rather than trying to develop a questionnaire, let me ask a few questions which I hope will focus your perceptions on the technology transfer in abandoned mine land studies.

1. How do you learn of the results of research, special studies, innovative practices and other developments in reclamation? Is there a particular method which is more helpful than others?

2. Are civil engineering and university publications being fully utilized in covering advancements in abandoned mine land reclamation practices?

3. How can the Bureau of Mines and/or states get information out to the industry more effectively and more efficiently and provide response to questions on new developments?

4. For abandoned mine lands, which topics or areas are most in need for research and are there subjects where past or present research should be updated, expanded and/or continued?

Any other views or comments will be welcome.

The benefit of your professional opinion and dedication of your time is greatly appreciated.

Sincerely,

Gerald J. McLindon,
Member, Committee on
Abandoned Mine Lands
Research Priorities

ks

NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND RESOURCES
2101 Constitution Avenue Washington, D.C. 20418

BOARD ON
MINERAL & ENERGY RESOURCES

(202) 334-2744

June 8, 1987

To the Editor

Dear Sir:

At the request of the Bureau of mines, the National Research Council of the National Academy of Sciences has established a committee to study the priorities for research needed to help solve problems created by or resulting from abaindoned coal mine lands. My particular assignment on the committee is to study technology transfer, under which the results of research on coal mining undertaken by the Bureau of Mines, OSM, universities, consultants and others is transmitted to the field. From experience in other fields, I know that professional and industry magazines are one and probably the best way of informing a wide range of people who need to know. These write-ups have the added advantage of being written in a style which makes the information understandable to a wide range of readers.

In my paper I will try to describe the present methods for disseminating information and suggest ways of improving the system. Would you help me by describing:

1. The manner in which you became aware of coal mining search projects to be undertaken by:

   (a) Federal agencies - Bureau of Mines and Office of Surface Mining

   (b) State Mining Agencies

   (c) Universities

   (d) The Coal Industry or individual companies.

2. Are you asked to publish solicitations for proposals to carry out research on any aspect of coal mining? If so, how is this information conveyed to you?

3. Are you asked to publish solicitations for bids to undertake reclamation of abandoned mine lands and/or corrective actions on abandoned mine lands?

4. Do you or would you carry these notices of proposals as a news item or public service item?

5. Are you kept informed of completion and results of coal mining research by any of the listed agencies? If so, how?

6. As a matter of course, are you invited to participate in or review demonstration programs, exhibits of new methods or equipment or other innovations in the processes of coal mining or mine land reclamation?

7. We have been told that in many states mining agencies undertake and pay for coal mining research, but that they do not have the staff or funding to publish formal research reports. This may result in poor dissemination of the results. Do states:

   (a) send you information on research to be undertaken?

   (b) send results of research completed?

   (c) If not, and they were to send you a one or two page abstract of the research proposal and results, would you publish this work as a service to the industry?

8. Do federal or state mining agencies or universities use your journal to solicit the views of your staff and/or readers on problems in coal mining for which research is needed?

   Specifically, are your views sought on the problems and possible solutions to abandoned coal mine lands? Would you be amenable to such solicitations, reviews or polls and if so, do you think they would serve the industry and the agencies?

9. Do you have any type of referral service, including a Question and Answer Section in your publication, where readers can request information on specific items of research/technology, ongoing or completed? If not, would you be willing to set up such a clearing house?

10. As a matter of course, do you suggest contact points for technical information on mining and reclamation of mining lands?

11. Would you suggest to me ways in which public agencies, the universities and the industry could help you to get out information on research results, innovative methods, and new techniques?

12. Do you feel that the industry and practitioners are familiar with research programs of public agencies and the universities?

13. What do you consider to be the most pressing problems of abandoned coal mine lands for which research is needed?

Any help or insights on these aspects of the industry and research programs will be most welcome. Our objective is to help the media in its service to the industry and to make research efforts more productive for the industry.

As is usual in studies of this nature, we are working on a very tight schedule. Therefore, I would appreciate a response at your earliest convenience.

Sincerely,

Gerald J. McLindon
Member, Committee on
Abandoned Mine Lands
Research Priorities

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