# The Acid Drainage Technology Initiative (ADTI) – Coal Mining Sector

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## Abstract

The Acid Drainage Technology Initiative (ADTI) was initiated in 1995 by federal agencies, the National Mining Association and the Interstate Mining Compact Commission to identify, evaluate and develop cost-effective and practical acid drainage technologies. In 1999, ADTI was expanded through the addition of the metal mining sector group, which began organization efforts in 1998. ADTI addresses drainage quality issues involving metal mining and related metallurgical operations and acid drainage from coal mines, for abandoned, active and future mines.

ADTI is a technology development program. It is not a regulatory or policy development program. The guiding principle of ADTI is to build a consensus among industry and federal and state regulatory agencies. ADTI is focusing these efforts on technology development and technology transfer in the areas of mine drainage prediction, sampling/monitoring, modeling and avoidance/remediation.

## Origin and Evolution of ADTI

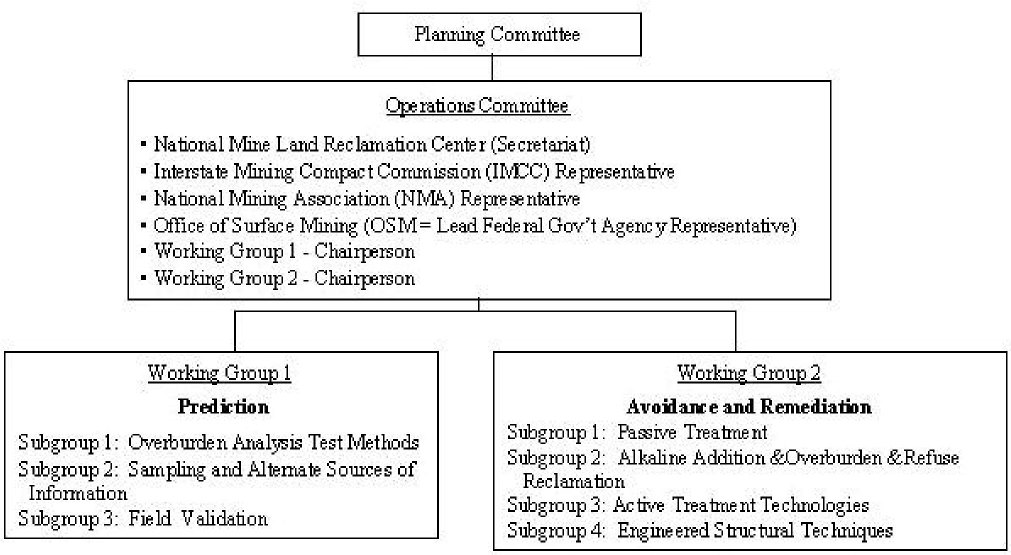
The Acid Drainage Technology Initiative (ADTI) developed its name and mission statement in the fall of 1995, although its origin can be traced back to the Third International Conference on the Abatement of Acidic Drainage in Pittsburgh, PA in April 1994. On the last day of that conference, approximately 25 attendees were invited to an "Expert Meeting on Acid Mine Drainage", which was convened by the U.S. Office of Surface Mining Reclamation Enforcement (OSM) for the purpose of gathering state-of-the-science information on mine drainage prediction techniques. The attendees of that meeting included a cross-section of scientists from federal research and regulatory agencies [U.S. Bureau of Mines (USBM), U.S. Geological Survey (USGS), Environmental Protection Agency (EPA), and OSM], two state regulatory agencies, the coal mining industry and two universities (West Virginia University and Pennsylvania State University). With this array of varying interests and expertise in acid mine drainage problems, it was envisioned that a consensus could be developed on reliable, standard static and kinetic test methods and other aspects of mine drainage prediction in the Appalachian Coal Basin. Recognizing that this task could not be completed in one day, this group with diverse interests and experiences, and a commonality of goals and objectives, agreed to work together to build consensus and solve mine drainage problems.

During 1994 and 1995 discussion and correspondence of this consensus building concept lead to the formation of a planning committee in September 1995. David Finkenbinder of the National Mining Association (NMA), Gregory E. Conrad, Executive Director of the Interstate Mining Compact Commission (IMCC), Paul Ziemkiewicz of the National Mine Land Reclamation Center (NMLRC) and Hammond Eve of the Office of Surface Mining Reclamation and Enforcement (OSM) were the principal organizers of the Planning Committee, although representatives from other federal agencies including the Bureau of Land Management (BLM) and the Environmental Protection Agency (EPA) served on the planning committee. NMA appointed several coal mining and metal mining industry representatives to the planning committee, and IMCC appointed several representatives from three state regulatory agencies. The Planning Committee determined that this organization would be named the Acid Drainage Technology Initiative in order to represent the interests of both acid mine drainage (AMD) issues related to coal mining, principally in the eastern United States, and acid rock drainage (ARD) issues related to metal mining, principally in the western United States.

The name ADTI was also selected to provide a central focus on technology development and technology transfer for the organization, rather than regulatory or policy issues. The National Mine Land Reclamation Center (NMLRC) at West Virginia University was designated as the Secretariat of ADTI. The NMLRC and the Planning Committee produced a white paper, dated December 7, 1995 to serve as the foundation for ADTI, and the work of the planning committee was largely replaced by the newly formed Operations Committee.

The Planning Committee decided that the major technical functions of ADTI could be accomplished by two working groups, one on prediction and the other on avoidance and remediation methods. Initially, a number of other committees were considered, but it was decided to keep the organizational structure simple, and to allow these two working groups to develop a number of subcommittees as needed to efficiently accomplish their work. The original organizational structure of ADTI is shown in Figure 1. Working Group 1 developed three subgroups on various aspects of mine drainage prediction, and Working Group 2 established four subgroups to address the array of existing and developing acid drainage avoidance and remediation technologies as shown in Figure 1.

Figure 1. Original (1995) Organizational Structure of ADTI



Pursuant to the organizational plan in the December 7, 1995 paper, the roles of the Operations Committee were to:

- Coordinate work of Working Groups,
- Provide guidance to Working groups,
- Monitor progress of the Working Groups and
- Monitor and facilitate the consensus-building process.

The objective of ADTI was set forth in the December 7, 1995 paper as follows: "To identify, evaluate and develop cost-effective and practical acid drainage technologies which will facilitate decision-making and subsequent compliance with permit conditions. As a technology development program ADTI aims to identify and develop the best science available in the field of acid drainage. ADTI recognizes the distinction between technology development and its implementation in the regulatory process. ADTI is a technology development program. It is not a regulatory or policy development program. The latter is outside the scope of ADTI and is within the jurisdiction of state and federal regulatory agencies."

Within the strategy section of that paper, the ADTI mission statement is defined as: "The guiding principle works toward a consensus among industry, federal and state regulatory agencies. Consensus on proven technologies in the areas of prediction, avoidance and remediation will assist both industry and the regulatory agencies."

Early meetings of the Working Groups demonstrated the great value of coal mining and metal mining representatives working together on common objectives and acid drainage problems confronting both sectors of the mining industry. Similarities and differences between coal mining and metal mining interests and experiences became apparent very quickly. Many of the physical, chemical and biological factors affecting acid drainage formation are quite similar in the eastern and western U.S., and consequently the coal mining representatives learned much from the metal mining representatives about relevant scientific literature and applications of prediction test methods, for example kinetic test methods that are used more frequently in the western U.S. However, significant differences in geology, climate, mining practices and regulatory procedures between metal mining and coal mining caused the working groups and the Operations Committee to rethink and modify some of the initial goals.

The Metal Mining Sector(MMS)of ADTI was organized in August, 1998, in order to more efficiently represent the interests of the metal mining industry and the federal and state agencies involved with that industry and the remediation of abandoned metal mine sites. In April, 1999 the Operations Committee voted and approved the addition of four MMS members to the Operations Committee, including the Chairperson of the MMS. From that point, the major organizational components of ADTI became the Coal Mining Sector (CMS) and the Metal Mining Sector (MMS), rather than three working groups.

## **Present ADTI Organizational Structure**

The composition of the ADTI Operations Committee is shown in Table 1, and the present organizational structure of ADTI is shown in Figure 2. The representation of

Operations Committee members is shown in column one of Table 1, and the names of the current members and their regular place of employment are shown in columns two and three to depict the professional and geographical diversity of the committee members. Since the technical committees of the Coal and Metal Mining Sectors are essentially separate entities as shown on Figure 2, the Operations Committee has at least two important additional roles, beyond those delineated in the December 1995 paper. These two relatively new roles are: (1) to ensure consistency in the content and quality of technology development and technology transfer activities of the CMS and MMS, and (2) to promote, to the maximum extent possible, equal funding for the CMS and MMS programs, and adequate funding for all CMS and MMS committees and research priorities.

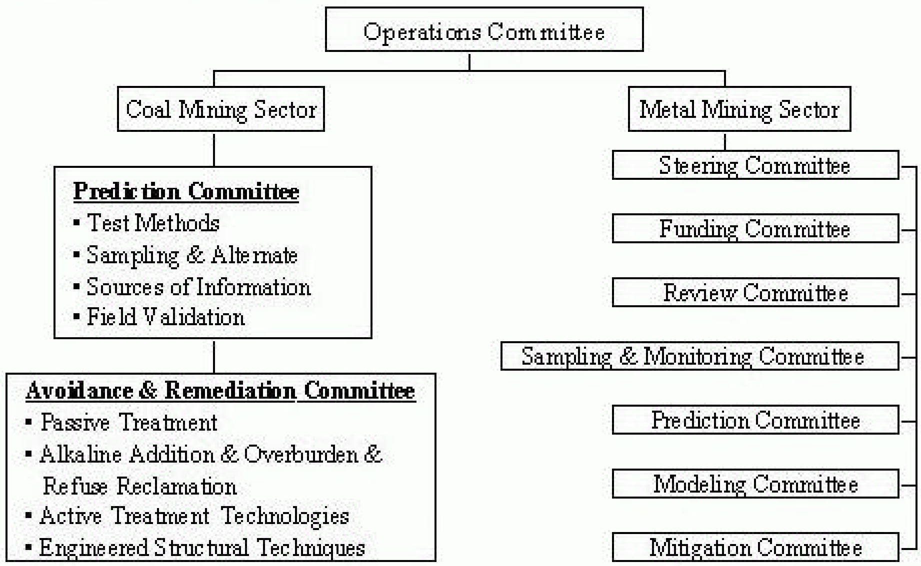
Representatives of the eastern and western university centers are members of the Operations Committee, as shown in Table 1, because these university centers and their affiliated cooperating universities have a very important role in the technology development and technology transfer functions of ADTI. The functions of these university centers are described in more detail in a later section of this paper.

Table 1. ADTI Operations Committee

| **Representation** | **Name** | **Place of Employment** |
|---|---|---|
| Chairman & IMCC | Roger Hornberger | PA Department of Environmental Protection |
| CMS Chairman | Gene Krueger | OSM - Washington D.C. |
| CMS – NMA | Bruce Leavitt | Consol Energy, Pittsburgh |
| CMS – NMA | Ron Hamric | Anker Energy, Inc., Morgantown, WV |
| CMS – A&R | Charles Miller | WV Division of Environmental Protection |
| CMS – Prediction | David Hyman | DOE-FETC, Pittsburgh |
| Eastern University Center | Paul Ziemkiewicz | West Virginia University |
| MMS Chairman | Kim Lapakko | MN Department of Natural Resources |
| MMS – Industry | Charles Bucknam | Newmont Metallurgical Services, Denver, CO |
| MMS – Federal | Nick Rieger | BLM – Washington D.C. |
| MMS – State | Harry Posey | CO Department of Natural Resources |
| Western University Center | Dirk van Zyl | University of Nevada at Reno |
| Secretariat | Greg Conrad | Interstate Mining Compact Comm. (IMCC), Exec. Dir. |
| Ex Officio Advisor | Karen Bennett | National Mining Association (NMA), Washington D.C. |

The organizational structure of the CMS as shown in Figure 2 is essentially the same as the original ADTI structure shown in Figure 1, with two major committees or working groups (Prediction, Avoidance & Remediation) that are composed of several subgroups. The MMS committee structure is significantly different as shown in Figure 2. The MMS is composed of seven committees listed in Figure 2.

Figure 2. ADTI Organizational Structure 1999




## General Goals of ADTI

There are at least five reasons why the Acid Drainage Technology Initiative is needed. They are referred to as general goals here because they are almost equally relevant to coal mining AMD problems in the eastern U.S. and metal mining ARD problems in the western U.S.; as well as acidic drainage problems in general from mining operations throughout the world. They are also relevant to other organizations and governmental agencies, whose mission includes efforts to solve acidic drainage problems associated with active and abandoned mines. These reasons are listed below, and will be discussed briefly in this section as they relate to ADTI goals.

1. Reduce the extent and severity of AMD/ARD impacts on surface waters and ground waters throughout the U.S.

2. Recommend the application of sound science to make sense of the international information explosion concerning AMD & ARD.

3. Resolve the scientific and legal controversy over prediction methods for mine drainage quality by improving and developing consensus on these test methods.

4. Refine avoidance and remediation technology to prevent, treat and abate AMD/ARD pollution in an effective and economical manner.

5. Rely upon the consensus building process to facilitate the solution of mine drainage problems with the participation and mutual benefit of the mining industry, government agencies, university researchers and other stakeholders.

Within the past 30 years, there have been numerous completed and ongoing efforts to inventory the number of streams miles affected by acidic drainage from mines throughout the United States. Much of the acid mine drainage occurring in the Appalachian Coal Region is emanating from abandoned surface and underground mines which were mined and abandoned prior to the enactment of the Federal Surface Mining Control and Reclamation Act of 1977 (SMCRA) and the Federal Clean Water Act (CWA). According to the Appalachian Regional Commission (1969), 78% of the acid mine drainage produced in northern Appalachia is associated with inactive or abandoned mines. More recent U.S. Geologic Survey (USGS) reports (Wetzel and Hoffman, 1983, 1989) provide summaries of surface water quality data and patterns of acid mine drainage problems throughout the Appalachian Coal Basin. A set of companion reports (Hoffman and Wetzel, 1993, 1995) contain similar information for the Interior Coal Province of the Eastern Coal Region of the United States. Current data compiled by IMCC and EPA document that the number one water quality problem in Appalachia is drainage from abandoned coal mines, affecting over 9,500 miles of acid mine drainage polluted streams in Alabama, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee and West Virginia. A 1995 EPA Region III survey found that 5,100 miles of streams in four Appalachian states are impacted by acid mine drainage, predominantly from abandoned coal mines. Pennsylvania alone accounts for approximately 2,600 acid mine drainage impacted stream miles.

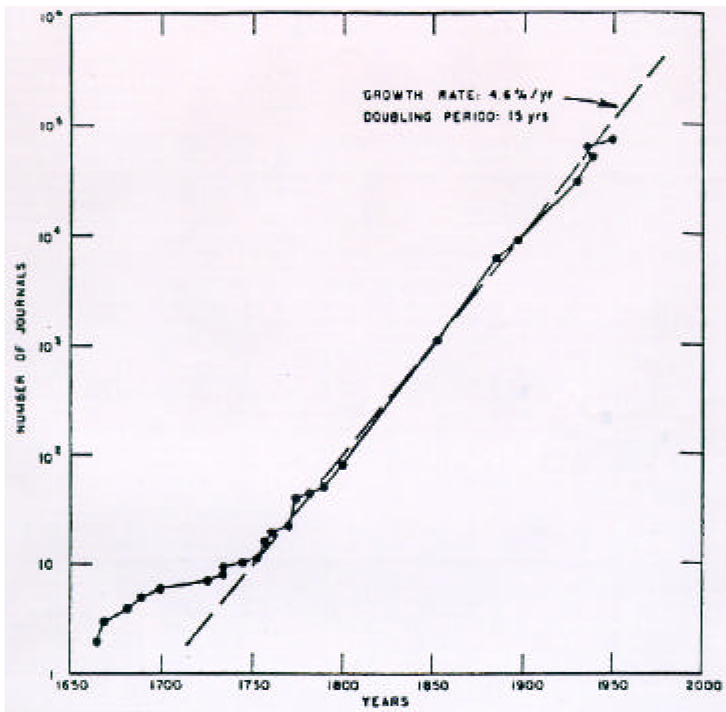
There are currently no accurate water-quality data that give a meaningful measure of the total impact of historical hardrock metal mining activities on surface waters in the western U.S. In 1991, the Western Governors Association (WGA) compiled data on impacted stream miles in a scoping study of inactive and abandoned noncoal mines in the western U.S. That study found a total of approximately 3,350 damaged stream miles in Arizona, California, Colorado, Montana, New Mexico and Utah. However, legitimate concerns have been expressed about the accuracy of some of these data, in the context of interpretations and inferences from the data.

The USGS is working with several western states to prepare a more accurate estimate of the number of stream miles impacted by ARD from historical metal mines. The USGS estimates that more than 40 percent of the watersheds in and west of the Rocky Mountains have been potentially impacted by historical hardrock metal mining activities. Many of these watersheds, however, occur in arid climates where the impact on aquatic resources is minimal. (Church, personal communication, 1999).

The purpose of this discussion is to document that the impacts of acidic drainage from metal and coal mining are extensive and severe throughout the U.S. To reduce these impacts and improve water quality in these mining regions will require the type of cooperation among the mining industry, federal and state agencies, and university researchers that ADTI is promoting. For example, remining regulatory incentive programs and remining operations have resulted in a significant reduction in AMD pollution in Pennsylvania and other states with established remining programs.

The second item in the list of general goals of ADTI refers to the international information explosion on acidic drainage (AMD & ARD) in recent years, which is following a pattern observed in the growth, availability, and quality of scientific information in general. In 1963, M.K. Hubbert wrote a classic paper for his address as the retiring President of the Geological Society of America, entitled "Are We Retrogressing in Science?" Hubbert (1963) plotted the rate of increase in the number of American scientists from 1900 to 1960, the rate of increase in the number of scientific journals in the world from 1665 to 1950, and the dramatic increase in the total amount of yearly grants for scientific research by the National Science Foundation from 1952 to 1961, as evidence for the flourishing state of science at that time. He then contrasted these positive aspects of scientific growth with an extensive discussion of negative evidence on the quality of contemporary scientific works, including “anomalous statements from recent treatises” and what he called the “abandonment of classical physics”. Hubbert (1963) found that after an initial century of irregular growth, the number of scientific journals began a steady exponential increase at 4.6 percent every year, which resulted a tenfold increase every 50 years up to 1950, with the number of scientific journals in the world approaching 100,000 at that time, as shown in Figure 3.

Figure 3. Rate of increase in number of scientific journals (after Price, 1961) based on data obtained from World List of Scientific Periodicals (from Hubbert, 1963).




Although a few citations predate 1950 most of the literature on acidic drainage related to mining has been written in the past 50 years. This body of literature is now very large and is growing rapidly every year. For example, the proceedings of the Third International Conference on Acidic Drainage in 1994 are in four volumes totaling 1648 pages. The following year, the Sudbury 95 conference produced three volumes totaling 1258 pages. The annual proceedings of the American Society of Surface Mine Reclamation (ASSMR) in recent years are contained in a single large volume that resembles the New York City phone book in size; in 1996 it was 875 pages, 787 pages in 1997, 777 pages in 1998, and 736 pages in 1999. In addition to the large amount of scientific papers presented in these mine drainage conference proceedings, each year, there is an even larger amount of mine drainage literature produced annually in numerous journals and periodicals, such as Mine Water and the Environment (Journal of International Mine Water Association).

It is very difficult for mine drainage researchers to keep current with all of this scientific literature. How much of this literature is really read by the average mine operator or mining consultant, who should be aware of significant technological developments that may affect their business? How much of this literature is regularly read by the average permit reviewer or mine inspector in a state regulatory agency who needs to know about major advances in mine drainage prediction, prevention, treatment and abatement technology in order to competently perform their duties? Furthermore, is the average member of a watershed association or other citizens group aware that most of this literature exists, let alone what is worthwhile to further their interests in reducing mine drainage pollution?

The relative significance of these scientific papers may be viewed with the same circumspection as Hubbert (1963). Amidst the many mine drainage papers contained in conference proceedings and other volumes of the literature are some papers which represent really good science and some which, unfortunately, represent not-so-good science. The ADTI organization and its members have been working for numerous years to address these quantity and quality aspects of the mine drainage literature in several ways: by compiling bibliographies and literature reviews on selected topics (e.g. prediction methods); by employing the consortium of members and the consensus building process to produce technological developments that are mutually beneficial to the mining industry, government agencies and others; and by promoting technology transfer of significant findings in the scientific literature. The literature review and evaluation reports by Lapakko (1991, 1993) on metal mine drainage prediction techniques, and the chronology of kinetic test developments and bibliographic data base in Hornberger and Brady (1998) are examples of the first aspect. The paper on improvements to the neutralization potential test method by Skousen et al (1997) is an excellent example of the second aspect, because its co-authors are a multidisciplinary team of university researchers, state and federal regulators, and mining industry geologist/chemist members, who made significant revisions to a widely used test method and performed comparative testing in their respective labs. The technology transfer aspects of ADTI are being promoted through the handbook report series, such as Skousen et al (1998), and through information updated on the ADTI website.

The third and fourth items in the list of general goals of ADTI will be addressed jointly because they have similar roots and they both have resulted in large unnecessary expenditures of money, time and other resources of mining companies, regulatory agencies and others. The scientific and legal controversy over the accuracy of the test methods used to predict coal mine drainage quality has been continuing for more than 20 years (i.e. prior to SMCRA requirements). During this time, millions of dollars have been expended in attorneys fees and expert witness fees in many appeals of permit denials and permit issuances, where the accuracy, precision and interpretations of the prediction test methods were central issues in the lawsuit. In addition, millions of dollars have been spent by coal mining companies in permit applications, permit appeals and other mine drainage litigation cases, for the laboratory analyses associated with some static and/or kinetic test methods that are known to be unreliable or inappropriate for the intended purpose or specific application of that procedure.

The corresponding problems pertaining to the application of avoidance and remediation technology are that many millions of dollars have been expended by mining companies, government agencies, watershed groups and others on: active and passive treatment systems that do not effectively or economically treat the mine drainage; prevention procedures which fail to actually prevent the formation of acidic drainage at active mine sites; and the application of specific procedures to control, mitigate or abate acidic drainage at active or abandoned mine sites where design, construction and operation of these technologies is simply inadequate to solve the acid drainage problems at these sites.

For example, in a preliminary study of the effectiveness of passive treatment systems on surface mine sites with post-mining discharges in Pennsylvania, it was found that one-third to one-half of these passive treatment systems were connected to an active treatment system in series. Of 92 passive treatment systems on primacy permit sites (i.e. permit issued since 1981), 29 (i.e. 32%) were connected to active chemical treatment systems, while 30 of 62 (i.e. 48%) of the passive systems on pre-primacy sites (i.e. permit issued before 1981) were connected to active treatment systems. The passive treatment systems on some of these sites may have been installed by mining companies to simply reduce chemical reagent costs, but conceptually, most mining companies replace an active treatment system with a passive treatment system in order to eliminate the regular reagent consumption, costs and maintenance requirements of the active treatment system. These data indicate that many of these passive treatment systems, particularly on the older pre-primacy sites, were not properly designed or constructed to accommodate the water-quality and/or flow characteristics of the post-mining discharges, or were not capable of meeting the performance standards (i.e. effluent limitations) in the permit or regulations pertaining to these sites. This study is a preliminary compilation of data from Pa DEP permit and mine inspection files. A more detailed study is planned during 2000 to collect sufficient influent and effluent water chemistry data, in order to quantify the effectiveness of passive treatment systems on individual sites and classes of sites within this population of 154 passive treatment systems.

There is insufficient space available here to provide many detailed examples and extensive documentation of the millions of dollars spent unnecessarily or inappropriately on the prediction and mitigation problems described above. Also, much of the case-specific data on legal and expert witness fees and site-specific or nationwide data on mitigation expenses is proprietary or otherwise difficult to obtain. However, from recent cases in Pennsylvania where some litigation fees are made public because judges award recovery of these fees to the winners of the litigation, it can be shown that individual cases where the total of attorney and expert witness fees are in the range of $500,000. to $1,000,000. are not unusual. Not all of these apparently wasted expenses are avoidable, but they can be significantly reduced through better technology development and technology transfer.

Two major components of the ADTI mission are to improve mine drainage prediction methods through the consensus building process, and to refine mitigation technology to prevent, treat and abate AMD/ARD pollution in an effective and economical manner. The ADTI members believe that it is more productive to solve differences of opinion on prediction methods through the application of good science and consensus building rather than litigation. An example of this is the book edited by Brady et al. (1998) which is the outgrowth of a major lawsuit on prediction methods between the Pennsylvania Coal Association and the Pennsylvania Department of Environmental Protection. ADTI members are confident that the works in progress by the prediction committees of the CMS and MMS will produce meaningful results to advance the state of the art and science of mine drainage prediction. The ADTI members are absolutely committed to using this consensus building approach to recognize and refine proven mitigation technologies and to develop and promote new technologies to ameliorate mine drainage problems in metal and coal mining regions.

## The Functioning of ADTI

Most of the current and future work of ADTI will be completed by the committees shown in Figure 2 and the university centers. The committees are composed of members from the mining industry, state and federal regulatory and research agencies, commercial laboratories, consulting firms and university researchers. That diverse collection of members and interests promotes technical information exchange, consensus building on which technologies do and do not work well, and the delineation of mutually beneficial research needs. The university centers serve as focal points for technology development and technology transfer, through their laboratories and other research and educational facilities and staff.

The NMLRC at West Virginia University (WVU) has been the focal point for the activities of the CMS since the start of ADTI in 1995. The Pennsylvania State University (PSU) is a partner with WVU in the NMLRC, and is increasing its involvement in ADTI activities through the efforts of key research professors on several CMS committees. The eastern universities were chosen based on their proximity to critical problems areas and experience. Both West Virginia and Penn State Universities have long histories of successful research and demonstration. Indiana University of Pennsylvania (IUP) is located in the heart of a major acid drainage area which is rich in potential demonstration sites and can network with nearby watershed organizations. The program at IUP is led by its National Environmental Education and Training Center. It will develop the web page and other technology dissemination tools. It will also assist in training both students and community-based watershed organizations in acid drainage technologies and their applications.

The University of Nevada, Reno (UNR) was selected as the Western University Center for ADTI. The newly formed Mining Life-Cycle Center (MLC) of the Mackay School of Mines will administer the Western University Center. Through the MLC a Western University Consortium (WUC) consisting of five universities (University of Nevada, Reno, University of Alaska, Fairbanks, University of Idaho, University of Utah and New Mexico Institute for Mining and Technology) will cooperate in performing MMS related research.

## Results and Expectations of ADTI

In June 1998, the Avoidance and Remediation Working Group of the CMS, under the direction of Chairman Charles Miller, completed its workbook, entitled "A Handbook of Technologies for Avoidance and Remediation of Acid Mine Drainage", by Skousen et al. (1988). That report was published by the National Mine Land Reclamation Center at West Virginia University, and copies can be obtained from the NMLRC. The contents of the report are also available from the ADTI-CMS website at www.neetc.org/adti. The address of the ADTI-MMS website is http://www.mt.blm.gov/bdo/adti, which is currently maintained by staff of the Bureau of Land Management (BLM). The MMS website will ultimately be managed by the MLC at UNR. Additional information about the websites is discussed below.

Most of the sections of the prediction workbook of the CMS were completed in draft form during 1998 and 1999. The contents of that prediction report are undergoing editorial review by Dr. Robert Kleinmann (original chairman) and David Hyman (present chairman) of the Prediction Working Group of the CMS. It is anticipated that the prediction handbook of the CMS will be published by the NMLRC before May 2000.

In addition to the workbook project, the ADTI-MMS Prediction Committee is actively working in a cooperative program with the American Society for Testing and Materials (ASTM), USGS, EPA and the National Institute of Standards and Technology (NIST) in development of standardized testing methods for mine and metallurgical waste characterization, as well as a series of mine waste standard reference materials. This program was extended into the coal sector to prepare a shale standard reference material for their acid-base accounting methods.

The ADTI website ultimately will have two components, structured to the needs of its internal and external users. The internal audience will access communication centers for the Operations Committee, and each technical committee. These will be set up so that members can hold on line meetings and thus minimize travel. Technical issues can be debated as the organization develops consensus. In addition, the website will be the window for members to get updates on activities and to share ideas.

The external users will be able to access information which the Operations Committee has cleared for public release. For example, the workbooks prepared by the technical committees will be indexed and placed, in searchable format, on line. In addition, the external site will be a resource for the public to access spreadsheets enabling them to perform otherwise complicated calculations regarding conversions, flow calculations, acidity, treatment cost options and other mine drainage information.

The preparation of the ADTI workbooks has been partially funded by OSM and NMA. In addition, OSM has provided financial support for the development of the CMS website and other activities of the NMLRC and its affiliated universities (WVU, PSU and IUP). The MMS has received some financial support from EPA and WGA, and some further work is planned with UNR and other members of the WUC.

Significant additional funding will be required to complete some of the bigger and more long-term projects, objectives and expectations of ADTI. The Operations Committee is exploring the development of a partnership of federal agencies to fund some mutually agreed upon priorities in field demonstration technology projects and research and development program projects. For example, the U.S. Army Corps of Engineers (USACE) is planning to develop a database on mitigation technologies in cooperation with ADTI. That database development effort is consistent with ADTI long-term goals of building national database components for mitigation technologies and the field validation of mine drainage prediction techniques. Some field validation database development has already been funded by EPA in Pennsylvania and OSM in West Virginia, with plans to continue these efforts in other states. A partnership among OSM, USACE, EPA and other federal agencies (eg. BLM, DOE, USGS), coordinated with ADTI and its eastern and western university centers, could develop several useful national mine drainage database components for the mutual benefit of these federal agencies, state regulatory agencies, the mining industry and other stakeholders.

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