THE COAL MINING SECTOR OF THE ACID DRAINAGE TECHNOLOGY INITIATIVE

Formation, Goals and Major Accomplishments

Updated August 2014

Introduction .........................................................................................................................2
Background .........................................................................................................................2
Objectives ............................................................................................................................3
Origin and Development of ADTI .....................................................................................4
Organization and Structure of ADTI .................................................................................5
Work and Functioning of ADTI .........................................................................................8
Technical Working Groups and White Papers ...............................................................22
Conclusions .........................................................................................................................24
References ............................................................................................................................24
Introduction

The Acid Drainage Technology Initiative (ADTI) is a coalition of federal and state agencies, industry, academia, and consulting firms working together to promote communications and technology enhancement in the field of prediction and remediation of acid drainage from mining activities, past and present. This joint effort was formed in recognition of the need to address a range of issues dealing with the technical problems of predicting and controlling acid drainage. These include: the legacy of acid mine drainage/acid rock drainage (AMD/ARD) problems throughout the U.S; the development of consensus on improved test methods, particularly for prediction of mine drainage quality prior to mining; avoidance and remediation technology to prevent, treat and abate AMD/ARD pollution in an effective and economical manner and the application of “best science” methods to accomplish these goals.

ADTI is subdivided into a coal mining sector (CMS), and a metal mining sector (MMS). The CMS is organized into two primary working groups, one focused on prediction and the other on avoidance and remediation methods. The MMS is organized around five major technical areas relevant to the particular technical problems it faces: (1) sampling/monitoring, (2) prediction, (3) mitigation, (4) modeling and (5) pit lakes.

This paper discusses the formation, goals and major accomplishments of the CMS, its current and ongoing activities and its future plans. It is compiled from a series of papers presented at the 2004 National Meeting of the American Society of Mining and Reclamation and the 25th West Virginia Surface Mine Drainage Task Force, April 18-24, 2004; published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

The CMS website administered by the National Mine Land Reclamation Center. For more information on the CMS, visit the website: http://www.aciddrainage.com. It contains information about acid mine drainage, the ADTI Mission Statement, ADTI members, projects, publications, and links to other sources of information.

Background

ADTI is an applied science and technology development program that addresses mine drainage issues related to abandoned and active mining activities. These issues include mine drainage prediction, sampling, monitoring, modeling and avoidance and remediation.

A number of federal agencies, including the Office of Surface Mining (OSM),
The Bureau of Land Management (BLM), U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE) and the U.S. Bureau of Mines (USBM), joined together with industry, the states and academia in a partnership-based effort to identify, evaluate and develop “best science” practices to remediate existing sources of mine drainage and to prevent its occurrence from active and future mining. The ADTI program provides a central focus on technology development and technology transfer; it is not a regulatory or policy development program. The guiding principle of ADTI is to build consensus among all partners on acid drainage technology development and technology transfer issues.

ADTI is focused on reducing the extent and severity of acid drainage problems from all sources, including acid mine drainage (AMD) related to coal mining and acid rock drainage (ARD) related to metal mining. The former is primarily an issue in the eastern United States, while the latter is primarily an issue in the western United States. An example of AMD from an abandoned coal mine is shown in Figure 1.

![Figure 1. A typical example of acid mine drainage.](image)

The magnitude of the AMD problem is illustrated by an EPA survey, Figure 2 (EPA 1995), which indicated that approximately 5,100 miles of streams have been impacted by acid mine drainage in five Appalachian region states. Other coal mining regions are also affected by AMD, though not to the same extent, and ARD affects many hard rock mining areas.

**Objectives**
The overall objectives of ADTI are to identify, evaluate and develop cost-effective and practical acid drainage technologies, develop the best science available in the field of acid drainage and work toward a consensus among industry, federal and state regulatory agencies on mine drainage prediction and remediation methods.

Figure 2. Map showing AMD impacted fisheries in part of the Appalachian region (EPA, 1995).

**Origin and Development of ADTI**

The idea for a program that was to become known as ADTI, originated at the 3rd International Conference on Acidic Rock Drainage in Pittsburgh, PA in April 1994, where OSM organized a meeting on mine drainage issues. At this meeting, a cross-section of scientists from federal and state agencies, the coal mining industry and two universities (West Virginia University and...
Penn State University), discussed the current state of knowledge of the science of mine drainage prediction techniques. The goal of the meeting was to develop consensus on reliable, standard test methods for mine drainage prediction applicable to the Appalachian Coal Basin. The group recognized that this task could not be accomplished in one day and agreed to work together to build consensus on solving mine drainage problems.

The next step occurred in September 1995 when a Planning Committee was formed. The Planning Committee consisted of representatives from the National Mining Association (NMA), the Interstate Mining Compact Commission (IMCC), the National Mine Land Reclamation Center (NMLRC), OSM, BLM and EPA. The Planning Committee coined the term: Acid Drainage Technology Initiative to include acid drainage issues related both to coal mining as well as to metal mining. The Planning Committee designated the NMLRC at West Virginia University to be the initial Secretariat for ADTI, which was consistent with NMLRC’s Congressional mandate to: "coordinate research activities and technology development with industry, state and federal agencies and trade organizations." Thus, an integral part of the organization of ADTI is the participation of the academic community.

In December 1995, a “White Paper,” that served as the foundation for the ADTI joint venture, was prepared by the NMLRC and the Planning Committee. The White Paper outlined the roles of a newly formed Operations Committee, which was set up to replace the Planning Committee. The roles of the Operations Committee are to coordinate the work of the ADTI Working Groups, provide guidance to them, monitor their progress and facilitate the consensus-building process. The history and development of the ADTI was extensively detailed in a paper by Roger Hornberger at the 5th International Conference on Acid Rock Drainage (ICARD) in June 2000 (Hornberger et al., 2000), which along with updated material, forms the basis for this discussion.

**Organization and Structure of ADTI**

ADTI became operational in April, 1996. The original organizational structure of ADTI consisted of two working groups supervised by the Operations Committee. Working Group 1 focused on prediction. It had three subgroups: Overburden Analysis Test Methods, Sampling and Alternate Sources of Information and Field Validation. Working Group 2 addressed Avoidance and Remediation; it had four Subgroups: Active Treatment Technologies, Passive Treatment Technologies, Alkaline Addition and Overburden and Refuse Reclamation, and Engineered Structural Techniques.
For the first two years, Working Groups 1 and 2 consisted of members working in and/or representing the coal and metal mining sectors. Initial and subsequent Work Group meetings showed that members from a variety of backgrounds (the mining industry, federal and state agencies and academia), were able to work well together on common problems confronting both industries. However, as there are major differences in geology, climate, mining practices and regulatory practices between metal mining and coal mining, the working groups and the Operations Committee recognized that it was necessary to change ADTI’s structure and some of its initial goals. The Prediction Group realized that a single prediction report would not adequately address the specific concerns and issues of both the metal and coal mining sectors. Therefore, it was decided to produce two prediction reports, one addressing coal mining and one addressing metal mining. In a similar vein, the Avoidance and Remediation Working Group, which was working on one comprehensive handbook, also realized the need for two reports, one on coal mining and one on metal mining, with the coal mining volume to be prepared first.

These developments led to the organization of a metal mining sector (MMS) within ADTI to better address issues and problems faced by the metal mining industry, and the federal and state agencies associated with the industry and the remediation of abandoned metal mine sites. The MMS was organized in August 1998. In April, 1999, four MMS members were added to the Operations Committee, including one as MMS Chairperson. The MMS Steering Committee solicited proposals for a Western university center for ADTI as the counterpart of NMLRC at WVU. In October, 1999, the University of Nevada at Reno was approved as the Western center. With the establishment of the MMS, the current overall organizational structure of ADTI became set, as shown in Figure 3.

![Figure 3. Current ADTI Organizational Structure.](image)

After the MMS was formed, the CMS appointed a Chairperson, which it previously had not had, to balance the organizational structure and
communications functions with those of the Chairperson of the MMS. The CMS was composed of two major working groups, Prediction and Avoidance and Remediation, each with several subgroups, which was the same basic organizational structure (figure 3) as the original ADTI structure. These re-organizational developments helped shape ADTI into a more balanced organization with better capabilities for technology development and technology transfer for both coal and non-coal mining than at the outset. The initial organizational structure of the CMS was the same as the original ADTI structure, that is, two major working groups, Prediction and Avoidance and Remediation, each with several subgroups.

The MMS structure (Figure 4) is considerably more complex than that of the CMS, since it reflects the diversity of issues confronting the metal mining industry.
There are five technical committees: 1) prediction, 2) sampling and monitoring, 3) mitigation, 4) modeling, and 5) pit lakes. Each of the technical committees selects their own chairperson and membership. The technical committees are ultimately responsible for producing their respective sections of an MMS Acid Drainage Workbook. The MMS Steering Committee is responsible for overall guidance of the five technical committees. The MMS Steering Committee appoints the Chairman and the representatives to the Operations Committee. There are also two administrative committees, Funding and Review. These assist the Steering Committee by working on funding issues and coordinating activities and review/consensus functions in developing an MMS Workbook. There may also be additional topics to be added as new technical committees by the MMS Steering Committee if future interest dictates.

The ADTI membership is made up of volunteer experts. Members of both ADTI Sectors usually include specialists from industry, academia, and state and federal agencies. The technical working groups and committees of the CMS and MMS, respectively, are essentially separate entities, as shown in Figure 3. Because of this, the Operations Committee has at least two important new roles beyond those delineated in the ADTI White Paper: (1) to ensure consistency between the activities and work products of the CMS and MMS, and (2) to support, to the maximum extent possible, equal and adequate funding for the CMS and MMS programs and for all CMS and MMS committees and research priorities. Both Sectors maintain close communication with each other through the Operations Committee to optimize technology transfer on topics common to both types of mining.

### Work and Functioning of ADTI

The work of the main operational units of ADTI, the CMS and MMS, is
performed primarily by the respective committees, technical committees or working groups and by the University Centers. The two University Centers have been active in performing research identified by either the Operations Committee or by the CMS and MMS. The Eastern University Center at West Virginia University, through the National Mine Land Reclamation Center, has worked closely with other academic institutions, such as Pennsylvania State University and Indiana University of Pennsylvania on research projects, and has also worked closely with OSM on AMD remediation at abandoned mine sites and on other projects.

The University of Nevada, Reno, the Western University Center for ADTI, collaborates with the other schools involved in the Western University Consortium (WUC), which includes the University of Alaska, Fairbanks, University of Idaho, University of Utah and the New Mexico Institute for Mining and Technology. The MMS also includes a university network, among which requests for proposals are circulated. In addition to the consortium universities, the network presently consists of: Northern Arizona University, University of California (Berkeley), Colorado School of Mines, Desert Research Institute, University of Missouri (Rolla), Montana State University – Bozeman, Montana Tech of the University of Montana, University of New Mexico, and South Dakota School of Mines and Technology.

MMS has also worked closely in the past with the Western Governors Association, (WGA), which has common interests in some of the same acid drainage issues ADTI has worked on. The MMS has maintained contact with the Canadian Mine Environment Neutral Drainage (MEND) group as well as close contacts and coordination with the International Network for Acid Prevention (INAP), an industry acid initiative.
Statement of Mutual Intent

A Statement of Mutual Intent (SMI) was developed to formalize participation in ADTI by federal and state agencies and organizations, academic institutions, and industry to foster cooperation and partnership among all stakeholders. The goals of the SMI are to protect and improve water quality that may be adversely impacted by acid mine drainage from coal and metal mining, to increase cooperation and partnership, and to develop cost-effective controls for acid drainage to protect and restore streams and watersheds. At this time, the SMI has been signed by the Interstate Mining Compact Commission, Mining Life Cycle Center, Mackay School of Mines, University of Nevada, Reno, National Mine Land Reclamation Center, University of West Virginia, National Mining Association, Great Basin Minewatch, and the U.S. Department of the Interior, on behalf of participating Departmental bureaus, including BLM, FWS, OSM and USGS.

Others expected to sign include the Environmental Protection Agency and, U.S. Army Corps of Engineers.

Coal Mining Sector Funding

Funding for CMS has been provided from a relatively few sources. OSM has provided the majority of the funding. OSM has provided $150-250,000 per year over the last 10 years (FY99–FY08). Other past funding has come from EPA, WVU and the mining industry.

Initial Projects

The initial projects identified by the CMS were to produce state-of-the-art summaries of AMD prediction and remediation technology. The first ADTI product was “A Handbook of Technologies for Avoidance and Remediation of Acid Mine Drainage” (Skousen et al., 1998). The second ADTI CMS product was: "Prediction of Water Quality at Surface Coal Mines" (Kleinmann, 2000).

Both publications were published by the National Mine Land Reclamation Center (NMLRC) at West Virginia University.

Printed copies are also available at no cost. To obtain a printed copy, contact: Terry Polce: Terry.Polce@mail.wvu.edu, Phone: (304) 293-2867 x 5450, Fax: (304) 293-7822. Mailing Address: West Virginia University, National Research Center for Coal & Energy, 150 Evansdale Drive, PO Box 6064, Morgantown, WV 26506-6064.

Avoidance/Remediation Handbook. The first publication, A Handbook of Technologies for Avoidance and Remediation of Acid Mine Drainage, was prepared by the Avoidance and Remediation Working Group. This working group consisted of 31 experts who worked under the direction of Chairman
Table 2 gives the makeup of this Working Group.

**Table 2. Makeup of Working Group 2, Avoidance and Remediation**

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>No. of Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Government</td>
<td>8</td>
</tr>
<tr>
<td>State Government</td>
<td>6</td>
</tr>
<tr>
<td>Academia</td>
<td>7</td>
</tr>
<tr>
<td>Industry/Consultants</td>
<td>10</td>
</tr>
</tbody>
</table>

The Avoidance and Remediation Handbook is a comprehensive resource that describes the many applicable technologies, including generalized design and performance criteria. It also describes failures to enable the user to avoid repeating inadequate and inappropriate methods. It includes a series of case studies to provide information on the applicability and limitations of each technique to enable the user to select the best technique for a particular situation.
Table 3 below, gives the four major technical sections and the topics covered in each.

**Table 3. Major Technical Subjects in ADTI Avoidance/Remediation Handbook**

<table>
<thead>
<tr>
<th>Alkaline Addition and Overburden/Refuse Reclamation</th>
<th>Active Treatment Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericides</td>
<td>Aeration/oxidation</td>
</tr>
<tr>
<td>Alkaline addition</td>
<td>Neutralizers</td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>Flocculants/coagulants</td>
</tr>
<tr>
<td>Encapsulation</td>
<td>Reverse osmosis</td>
</tr>
<tr>
<td>Removal of toxic materials (remining and reprocessing)</td>
<td>Ion exchange resins</td>
</tr>
<tr>
<td>Selective handling</td>
<td>Electrodialysis</td>
</tr>
<tr>
<td>Reclamation (regrading and revegetation)</td>
<td>Natural zeolites</td>
</tr>
<tr>
<td>Daylighting underground mines</td>
<td>Metals recovery from AMD sludge</td>
</tr>
<tr>
<td>Synergistic effects</td>
<td>Passive Systems Technologies</td>
</tr>
<tr>
<td>New techniques</td>
<td>Natural wetlands</td>
</tr>
<tr>
<td>Engineered Structural Techniques</td>
<td>Constructed wetlands</td>
</tr>
<tr>
<td>Water management</td>
<td>Anoxic limestone drains</td>
</tr>
<tr>
<td>Inundation (saturation)</td>
<td>Vertical flow systems</td>
</tr>
<tr>
<td>Dewatering</td>
<td>Limestone ponds</td>
</tr>
<tr>
<td>Drains</td>
<td>Open limestone channels</td>
</tr>
<tr>
<td>Impervious soil cover or membrane</td>
<td>Bioremediation</td>
</tr>
<tr>
<td>Underground mine seals</td>
<td>Diversion wells</td>
</tr>
</tbody>
</table>

| Limestone sand treatment                            |                              |

**Prediction Report.** The second ADTI CMS publication, *Prediction of Water Quality at Surface Coal Mines* (Kleinmann, 2000) was prepared by the Prediction Working Group. This working group consisted of 27 experts who worked under the direction of Chairman Robert Kleinmann. The makeup of this Working Group is shown in Table 4, below.

**Table 4. Makeup of Working Group 1, Prediction**

12

The key findings, recommendations and conclusions in the report are summarized below:

- Mine drainage prediction should be considered as the integration of chemical, geologic, hydrologic and biologic processes needed to arrive at an overall estimate of water quality.
- If site characterization is adequate, it is generally possible to predict post-mining water quality.
- Prediction is best achieved by using a variety of tools, including, hydrologic data, geologic data, and data from prior mining sites with equivalent properties. An integral part of the evaluation should be whether predicted water quality is likely to have unacceptable effects on local water quality (i.e., resource sensitivity), and if so, what can be done during mining and reclamation to avoid or negate any such adverse effects.
- Implicit in prediction is the requirement that the samples collected be representative of the site being evaluated; i.e., geologic variability within a site must be captured through adequate sampling. The effect of weathering on the sampled strata must also be considered.
- Acid Base Accounting (ABA) remains the preferred static overburden mine drainage prediction test. The use of ABA for accurate prediction of mine water quality depends on obtaining representative overburden samples.
- There is an uncertain or "gray zone" for ABA overburden analyses, between analytical results clearly associated with alkaline drainage and those that are clearly associated with acidic drainage. Neutralization Potential (NP) values less than 10 tons/1000 tons, or Net Neutralization Potential (NNP) values less that 0 tons/1000 tons are considered potentially acid producing. NP values greater than 21 tons/1000 tons or NNP values greater than 12 tons/1000 tons are considered alkaline. The gray zone was defined as the region between these values.
- Modified ABA procedures are recommended to account for sources of error due to the presence of the mineral siderite and to the subjective nature of

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>No. of Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Government</td>
<td>10</td>
</tr>
<tr>
<td>State Government</td>
<td>7</td>
</tr>
<tr>
<td>Academia</td>
<td>6</td>
</tr>
<tr>
<td>Industry/Consultants</td>
<td>4</td>
</tr>
</tbody>
</table>
the “fizz” test (see Chapter 4). The presence of the mineral siderite is known to cause overestimation of alkalinity levels reported in ABA results.

- ABA analyses should use total (rather than pyritic) sulfur; since this overestimates acid potential, it will provide a margin of safety.
- Overburden analysis may not be necessary, if equivalent information is available from adjacent mining, pre-mining water quality and other site characterization data. The most effective predictor of AMD potential has been found to be previous mining in the same seam and general location as the proposed operation.
- Many recommendations were made for improving and standardizing kinetic (simulated weathering) testing (see Chapter 5). Kinetic testing is especially appropriate when ABA results fall into the gray zone.
- The importance of overburden sampling considerations was emphasized (see Chapter 6). A practical approach to overburden sampling was outlined, using a toolbox of useful information and an experience-oriented understanding of overburden sampling. Overburden sampling considerations include: a sound sampling plan based on geologic knowledge, preliminary drilling, the size, shape and layout of the mine, depth of overburden, depth of the weathered zone, topography and facies changes.
- The ADTI Coal Mining Sector supports the work done in Pennsylvania (see Chapter 6), which indicates that a minimum of three and more typically six to seven drill holes are needed per 100 acres to capture the geologic variability of a site. But, as each site is different, no hard and fast rule can be stated.
- Finally, and most importantly is the need to evaluate each mine site on a case-by-case basis, as each mine site is unique, which precludes the use of a simple cookbook approach.

**Recommendations for Future Work**

Identifying technical areas needing further work is a key component of ADTI Coal Mining Sector activity. The authors of both of the ADTI CMS handbooks identified priority areas that needed to be addressed in future efforts. The priority areas identified in the handbooks have influenced the subsequent work.

In the Introduction to the Avoidance and Remediation handbook, Skousen et al., (1998) identified the need for field testing of then-current technologies and the development and testing of new technologies. The authors noted that variable success in treatment was probably caused by the variability found among mines and their associated environmental conditions. An imperfect understanding of the effect of this variability on the effectiveness and applicability of treatment techniques resulted in imperfect criteria for selecting treatment technique. Long-term follow-up monitoring and analysis of water quality from these field installations will help define the limits of applicability of AMD treatment technology.

In the ADTI CMS Prediction handbook, Geidel et al., (2000), made recommendations on the use of kinetic testing methods and recommended
that a standard kinetic testing method be established to be used for refined analysis of materials falling in the "gray area" of the acid base accounting (ABA) method. Follow up work in this area is discussed below.

Also in the ADTI CMS Prediction handbook, Perry (2000) identified eight "issues, opportunities and needs" to improve on the "ability to correctly anticipate, prevent, or manage mine drainage and its effects." These provide a very useful framework for future efforts by the Coal Mining Sector. His recommendations included:

- Improve quantitative prediction of mine drainage quality.
- Establish a consensus on kinetic test methodology, which supports the recommendation of Geidel et al., (2000).
- Evaluate the effectiveness and limits of applicability of analytical and predictive methods for post-mining and reclamation water quality through field and post-mortem studies of mine sites and water quality.
- Improve and develop technology for underground mine water quality prediction.
- Develop and test new and revised investigative and analytical techniques, such as downhole wireline logging, evolved gas analysis, and other methods.
- Compile and examine existing baseline and monitoring data from ongoing and historical mining available from companies, consultants and government agencies to refine predictive techniques.
- Examine the use of mineralogical data and geochemical modeling techniques to mine drainage prediction, as they are being applied in the hard rock mining industry.
- Evaluate the applicability of analytical tools, such as three-dimensional geologic modeling software to refine overburden volumetric analysis, and geostatistical analysis methods for detailed sampling and analysis.

ADTI CMS activities since the publication of the Prediction and the Avoidance and Remediation handbooks have begun to address a number of these issues, opportunities, and needs and are summarized below.

**Recent and Current Work**
The Coal Mining Sector continues to pursue the original priorities identified when ADTI began as well as issues that have arisen since, such as those identified by Geidel et al., (2000), Kleinmann et al., (2000) and Perry (2000), described above. A vehicle for support of ADTI CMS activities aimed at addressing these priorities is OSM’s funding of a series of cooperative agreements with the National Mine Land Reclamation Center (NMLRC) at West Virginia University. This OSM funding (between $200,000 and $250,000 per year), constitutes an important component of support to address ADTI CMS priorities. Cooperative agreement project proposals that address ADTI CMS priorities are given preference for funding. Following is a summary of some of the tasks funded under the cooperative agreements, as well as other activities addressing ADTI CMS priorities.
Technical Support for Watershed Projects and Follow Up Evaluations

In order to obtain on-the-ground experience with the effectiveness and applicability of AMD remediation technologies at a variety of sites, the coal mining sector of ADTI works closely with watershed groups and others working to clean up streams and watersheds affected by abandoned mines under the Appalachian Clean Streams Program. The Office of Surface Mining and the NMLRC at West Virginia University are working through a series of annual cooperative funding agreements to:

- Provide technical assistance to watershed groups and others in the design, construction and maintenance of remediation technologies, and
- Evaluate the site conditions, technologies applied, cost of remediation and the resulting quality of water from affected sites.

NMLRC has been conducting an ongoing evaluation of the performance of different methods of passive treatment used for remediation of AMD from abandoned mines (aerobic and anaerobic wetlands, anoxic limestone drains, open limestone channels, limestone leach beds). Ziemkiewicz et al., (2003), reported on the results of a comparative evaluation of nine methods. Based on this work, three methods were found to give the best performance, in terms of unit treatment cost, effectiveness of acid load removal and reliability. These were: limestone beds, anoxic limestone drains and open limestone channels. Figure 5 shows an aqueous anoxic limestone drain installed across an acid lake.

Figure 5. An Aqueous Anoxic Limestone Drain installed across an acid lake.

Acid Base Accounting (ABA) for Prediction of Postmining and Reclamation Water Quality

ABA is an important method for predicting postmining and reclamation water quality and evaluating the potential for production of acid mine drainage.
The method, developed in the 1960’s and 1970’s and continuously refined since (Perry, 1998), assesses the potential for the production of acidic drainage at a mine site by balancing the acid-producing and the acid-neutralizing potential of materials at a site to predict the net water quality that can be expected. (Skousen et al., 2002)

The NMLRC has been studying the effectiveness of acid base accounting for predicting postmining and reclamation water quality (Skousen et al., 2002). Overburden analyses, permit maps, and predictions of postmining and reclamation water quality data were collected from regulatory agency permit files from several states in the Appalachian coal region. Data collected from these files was used to calculate mass-weighted acid base accounting for each site. Neutralization potential (NP), maximum potential acidity (MPA) and NP/MPA ratio from each ABA were compared to alkalinity levels in postmining and reclamation water quality data. The results of the ABA analyses were found to be correct in 82% of the cases using the NP/MPA parameter; this indicates that ABA is a good way to predict postmining and reclamation water quality at a mine site (Skousen et al., 2002). More work is planned or is underway to refine this useful analytical tool.

Figure 6. Three-dimensional acid-base account diagram, showing overburden NP values for the Jewett Lignite Mine, Texas.

**In-Situ Underground Mine AMD Treatment Technology**
In-situ neutralization is a relatively new concept in the field of passive AMD treatment. The addition of alkaline materials into underground mine voids and ground-water recharge areas may provide an attractive alternative to
current treatment practices. These systems require limited land area and, because many of these systems are installed in areas that exclude or limit oxygen, may permit the neutralization of acid without the precipitation of metals in the system. Under this task, three in-situ treatment systems were installed in north-central West Virginia. These sites include a deep mine alkaline injection project, an in-situ limestone portal drain, and ground water alkaline recharge trenches. The performance of these systems with respect to acidity neutralized and metal removed from the discharge is being monitored. The final report on this project is pending.

**Kinetic Test Methods**

ADTI is following up on the recommendations by Geidel et al., (2000) and Perry (2000) to find a consensus on the establishment of kinetic testing protocol for evaluating potentially acid-generating materials. There are several humidity cell methods and numerous leaching column methods that have been used to predict the quality of drainage from coal and metal mines. However, there are currently no standard methods that are widely used and accepted as accurate predictors of coal mine drainage quality by state and federal regulatory agencies or the coal mining industry. Hornberger and Brady (1998, page 7-5) state — "A tremendous amount of kinetic test information now exists, but the variety of test apparatus and procedures in use is so great that it is very difficult to interpret the results and make meaningful comparisons of data from different studies in similar or different lithologic settings[.].*** [I]t should be no wonder that mine operator and consultants new to the subject of AMD prediction would shy away from kinetic tests because they don't know which apparatus or procedure to use, nor how to interpret the results." In order to rectify this problem, OSM funded a project to:

- develop standard procedures for a humidity cell test and a leaching column test that will meet the U.S. Environmental Protection Agency (EPA) requirements for performance-based measurement systems (PBMS) methods specifications, and
• improve existing humidity cell and leaching column test methods by maintaining a carbon dioxide enriched gas environment throughout the test to simulate the partial pressure of CO₂ normally found in soils and spoil gas environments. This is needed to optimize carbonate mineral dissolution and the production of significant alkalinity concentrations in ground water, mine drainage discharges, or leachate in laboratory tests used to predict mine drainage quality.

Figure 8. Leaching Column Kinetic Test Apparatus.

The status and results of this project are discussed in detail in Hornberger et al., (2004) presented at this meeting.

Selenium
Selenium is a naturally occurring widely distributed element, which shows an affinity for sulfide minerals. It combines with metals and non-metals and may form both organic and inorganic compounds. Selenium is the most strongly enriched trace metal in coal, and can occur in several forms in solution. Selenium discharges that exceed water quality standards have been identified in several coal mine watersheds in southern West Virginia. It is suspected that these Se concentrations are the result of leaching of selenium compounds in coal and overburden exposed to oxidizing conditions during mining activities in this region.

OSM is funding NMLRC to evaluate overburden cores from mined areas within a Se-impacted watershed of southern West Virginia. NMLRC will develop methods for the identification of selenium within the overburden and coal seams in this area and will examine cores for Se sources and mineralogy. In addition, NMLRC researchers will collect high-Se discharges from the affected areas and conduct bench-scale experiments to determine possible methods for avoidance and/or remediation of Se contaminated discharges. Experiments to evaluate potential techniques to avoid or limit Se mobilization will include leaching Se-source geologic materials along with
absorptive materials, such as shale or fine-grained soils to determine absorptive potential of Se within the backfill of surface mines.

**Future Directions and the Needs for Acid Drainage Research**

As outlined above, the ADTI CMS has achieved a number of accomplishments and has fostered an ongoing spirit of cooperation and collaboration in addressing acid drainage related problems. While some of the initial projections of funding and support for ADTI have not been realized, there has been a steady ongoing effort, in which the ADTI CMS has continued to pursue the original priorities identified when ADTI began as well as issues that have arisen since. OSM’s funding of a series of cooperative agreements with the National Mine Land Reclamation Center (NMLRC) at West Virginia University has been a key component of support to address ADTI priorities. Also, in recent years, through the development of the Statement of Mutual Intent, an effort has been made to expand the commitment to ADTI and to bring other partners into the effort. ADTI members have also been actively working to integrate ADTI’s efforts with those of international organizations and efforts related to acid contaminated mine drainage.

To better plan the future work of the ADTI CMS, a series of meetings were held to evaluate the initial plans and areas of focus of ADTI (Table 5) along with the recommendations that resulted from the two ADTI publications on Avoidance and Remediation and Prediction that have been summarized above. These discussions considered both past accomplishments and ongoing work, and identified current and future needs for applied studies and research related to acid drainage. The results are being crafted into a “Five-Year Roadmap” to guide ADTI related activities and to be used as a tool in recruiting additional participants and obtaining additional funding. It was also determined that the participation in CMS activities needed to be as broad as possible, and that additional avenues for supporting work and additional resources needed to be explored. The group developed a list of priorities (Table 6) as ones worthy of additional consideration.
Table 5. Initial Areas of Focus for ADTI

**Prediction**
- Laboratory Testing (Kinetic and static testing)
- Field Sampling (Density of sampling, methods, variability)
- Hydrologic Analysis (Field sampling and analytical methods)
- Field Validation of Predictions

**Avoidance and Remediation**
- Special Handling (Material handling and placement, alkaline amendments)
- Barriers (Flooding, dry barriers)
- Water Treatment (Active and passive)

Table 6. Priority Issues for CMS

- Treatment standards (Manganese standard)
- Prediction of acid load prior to mining
- Develop relationship between prediction methods and contaminant concentration
- Prediction of infiltration, recharge and discharge of water (hydrologic budget)
- Long term AMD generation
- Flooded underground mines
- Above drainage underground mines
- Surface mines
- Passive treatment systems
- Long term performance and metrics
- Reasons for success or failure
- Improved methods
- Coal combustion by-product minefills
- Risk assessment methods
- Documentation of benefits and impacts (field validation)
- In situ mine treatment: concurrent vs. post-mining methods
- Concurrent treatment of underground mine water prior to pumping
- Alkaline amendments, foundation drains, reactive barriers
- Refuse capping and barriers
- Treatment for “non-conventional” constituents associated with mine drainage
- Technology Transfer
- Update AMD handbooks
- Workshops to update priorities and review progress
- Treatment methods for large volume underground mine discharges
Technical Working Groups and White Papers

As a prelude to building a roadmap for future action, it was decided to develop “White Papers” covering the issues in each of the identified areas, identifying particular work that needs to be completed, and, where possible, developing a specific proposal for work.

A series of 15 White Papers have been prepared covering the issues identified by four Technical Working Groups that have been established. These White Papers outline identifies particular work that needs to be completed and, where possible, include developing a specific proposal for work. The Technical Working Groups and the associated White Papers are listed below (Table 7).

The White Papers can be accessed directly by clicking on the respective web-linked titles. These white papers are being used as planning documents for needed research and as a tool in recruiting additional participants and obtaining additional funding. These White papers are also available at the ADTI website: http://www.aciddrainage.com/problem_summaries.cfm.

Using the White Papers as a basis, the CMS will craft a plan for the work to be conducted during the next five years given the availability of resources. In addition, areas of work not able to be addressed will be ranked so that if additional resources become available, work can be focused on the agreed upon priorities. This will enable the work to progress logically and collaboratively towards solving the most important issues and problems.
<table>
<thead>
<tr>
<th>Technical Group</th>
<th>White Papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Combustion By-Products</td>
<td>CCB-1 CCB: Risk Assessment Methods</td>
</tr>
<tr>
<td></td>
<td>CCB-2 Placement of CCBs at Coal Mines - Documentation of Benefits and Impacts</td>
</tr>
<tr>
<td>Passive Treatment</td>
<td>PT-1 Passive Treatment: Long-term Performance Evaluation and Metrics</td>
</tr>
<tr>
<td></td>
<td>PT-2 Passive Treatment: Reasons for Success and Failure</td>
</tr>
<tr>
<td></td>
<td>PT-3 Passive Treatment: Improved Methods</td>
</tr>
<tr>
<td></td>
<td>PT-4 In Situ Treatment: Alkaline Amendments, Foundation Drains and Reactive Barriers</td>
</tr>
<tr>
<td></td>
<td>PT-5 Coal Refuse Reclamation - Capping / Barriers and Improved Methods</td>
</tr>
<tr>
<td>Water Quality</td>
<td>WQ-1 Manganese Treatment Standard</td>
</tr>
<tr>
<td></td>
<td>WQ-2 Contaminant Loading: Prediction of Contaminant Concentrations from Underground Mines</td>
</tr>
<tr>
<td></td>
<td>WQ-3 Treatment for Non-Conventional Constituents</td>
</tr>
<tr>
<td></td>
<td>WQ-4 Prediction and Treatment of Selenium</td>
</tr>
<tr>
<td>Underground Mining</td>
<td>UGM-1 Contaminant Loading: Predict Hydrologic Budget of Underground Mines</td>
</tr>
<tr>
<td></td>
<td>UGM-2 Predicting Long-term AMD: Discharge from Flooded Underground Mines</td>
</tr>
<tr>
<td></td>
<td>UGM-3 Predicting Long-term AMD from Above Drainage Underground Mines</td>
</tr>
<tr>
<td></td>
<td>UGM-4 Treatment Methods for Large UG Discharges</td>
</tr>
</tbody>
</table>
Conclusions

The CMS of ADTI has been continuing to address areas of work previously identified as being of a high priority, while working to develop a five year roadmap for future work. The initial roadmap will serve as a starting point for cooperative work and as a means for recruiting additional participation and acquiring additional resources to address these issues. It is envisioned that the CMS will regularly update the roadmap to acknowledge accomplishments and to reflect new and emerging issues related to AMD and coal mining. This roadmap will also enable ADTI to more effectively work with other organizations concerned with acid drainage and to communicate to interested parties what has been accomplished and what remains to be done.

References


EPA. 1995. Survey of fisheries impacted by acid mine drainage in five Appalachian states, EPA Region III survey (map).


Parsons, S.C., P. F. Ziemkiewicz, F. Block, R.J. Hornberger and J.R. Craynon,