

Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania

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Introduction

The book “Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania” had its origins as far back as 1979 when a two page letter by Pennsylvania’s coal regulatory program was written to provide guidelines to mine operators and permit reviewers regarding requirements for overburden analysis. The present book is a 400-page attempt to describe the state-of-the-science for mine drainage prediction and pollution prevention in 1998; it is realized that our knowledge continues to grow. In this spirit, the book is meant to spur innovation, not to freeze thinking. The report represents the combined efforts of many individuals from not only the Pennsylvania Department of Environmental Protection, but also from other government agencies, academia and industry.

Contents of Book

The following are “key principles” excerpted from the 18 chapters.

Chapter 1. Geochemistry of Coal Mine Drainage

Not all mine sites in Pennsylvania make acid. There is a wide range of possible water qualities if one examines the worst-case and best-case water qualities that the Department has documented from mine sites in PA, from very alkaline to highly acidic. The metals concentrations found in mine drainage can vary from <1 mg/L to hundreds of mg/L. Mine drainage tends to be either alkaline or acidic, with pH ~3 or ~6. The presence or lack of carbonates strongly affects shallow groundwater chemistry.

Chapter 2. Groundwater Flow on the Appalachian Plateau of Pennsylvania

There is no such thing as a “dry” mine site in the humid East where in any year precipitation always exceeds evapotranspiration plus runoff. Every mine site contributes groundwater flow to lower strata and to downgradient discharge points. Sites located in groundwater discharge areas have the potential to create much larger problems in terms of the volume of water discharged through and from the site. However, water quality problems cannot be completely avoided by selecting “water-free” sites; they do not exist in the Appalachian coal fields.

Chapter 3. Hydrogeologic Characteristics of Surface-Mine Spoil

Groundwater flow in mine spoil occurs in a “dual-porosity” system. The hydraulic properties of spoil are difficult to predict. Porosity, hydraulic conductivity and transmissivity of mine spoil are much higher than in the undisturbed surrounding rock.

Chapter 4. Effects of Mine Drainage on Aquatic Life, Water Uses, and Man-Made Structures

The environmental, economic and social consequences of incorrect mine drainage predictions are considerable.

Chapter 5. Planning the Overburden Analysis

Obtaining representative samples for overburden chemical analysis is critical. The importance of a well-planned sampling regimen following proper protocols is imperative. No prediction can be better than the quality of the underlying data.

Chapter 6. Laboratory Methods for Acid-Base Accounting: An Update

Laboratory personnel and data interpreters must be aware of aspects of the acid-base accounting (ABA) test that can affect the reliability of the results. The fizz test is subjective. Since it determines the volume and normality of acid used in the neutralization potential (NP) digestion, it affects NP results. Siderite, a common mineral in Pennsylvania coal overburdens, can interfere with NP determinations. The addition of a hydrogen peroxide step seems to reduce this interference. Presently, using total sulfur values leads to more reproducible and accurate maximum potential acidity (MPA) values than does using forms of sulfur data.

Chapter 7. Kinetic (Leaching) Tests for the Prediction of Mine Drainage Quality

Kinetic tests could be a valuable tool in the mine drainage prediction toolbox, because they factor in several variables found under field conditions but not reproducible by static tests. However, the large variation in the test methods used and the lack of standardization has made interpretation of kinetic test results quite challenging. There are specific physical, chemical and biological factors which should be included in any kinetic test.

Chapter 8. Influence of Geology on Postmining Water Quality: Northern Appalachian Basin

In a general sense water quality can be correlated to the geologic units affected by mining, so proper understanding of the geologic section and of controls, such as depositional environments, can serve as a first-cut predictive technique. However, there can also be considerable regional and local variation in water quality generated from mines in the same geologic section. As discussed above, mine drainage quality can be quite variable and the quality is influenced by the mineralogy of the stratigraphic section being disturbed. The distribution of carbonates in the geologic section is critical to predicting mine drainage quality, because without carbonates significant alkalinity will not be produced. Site geology must be thoroughly understood to ensure representative overburden sampling and to develop appropriate mining and special handling plans.

Chapter 9. Groundwater Chemistry from Previously Mined Areas as a Mine Drainage Prediction Tool

Water quality from adjacent mining in the same strata can be a powerful predictive tool. However, site-specific data must be carefully analyzed to ensure that lithologic, geologic, geochemical, and hydrogeologic differences between sites do not negate the validity of the comparisons being made.

Chapter 10. Natural Groundwater Quality from Unmined Areas as a Mine Drainage Quality Prediction Tool.

If the groundwater flow systems are properly understood, background water quality data from a proposed mining site can help confirm overburden analysis data and the presence of carbonates. This background groundwater quality will not help significantly in identification of sulfur-bearing strata however, and it is possible to be misled by shallow flow springs, which typically do not reflect the chemistry of unweathered rock. The presence of alkaline water on a site can be helpful, even if the carbonates that generated it are located off site. Sites with natural groundwater quality low in buffering capacity due to an absence of carbonates can be prone to acid production.

Chapter 11. Interpretation of Acid-Base Accounting

Acid-base accounting has proven to be a valuable and reliable tool in predicting whether a mine site will generate acidic or alkaline water. The key to proper interpretation is to understand that a clear excess of carbonates is necessary to ensure alkaline drainage: predictions based on the assumption that NP need only equal or slightly exceed MPA will fail. Mine water chemistry is controlled by the typically small fraction of the overburden with significant carbonate and sulfide mineral content. As little as five percent of the rock on the site can control postmining water

quality, while the remaining 95 percent of rock is essentially inert in terms of its effects on postmining drainage quality.

Chapter 12. Reclamation and Revegetation

Proper reclamation and revegetation of a site can help reduce the potential for pollution by preventing excess infiltration. However, infiltration cannot be eliminated and even exceptional quality reclamation will not prevent acid mine drainage in an otherwise poor setting.

Chapter 13. Alkaline Addition

Alkaline addition can change the geochemical balance of a site and can produce alkaline drainage where acidic drainage would have otherwise occurred. However, on a typical site the amount of carbonate which must be imported to change the geochemistry, while small compared to the total overburden mass, is large when considered in terms of logistics and economics. The minimum amount needed is often cost prohibitive. Due largely to economic considerations, alkaline addition presently remains most viable on remining sites where lesser water quality standards, and therefore lesser amounts of carbonate addition may be acceptable. Alkaline addition may also be viable on sites with largely weathered overburden.

Chapter 14. Special Handling Techniques in the Prevention of Acid Mine Drainage

The effects of overburden special handling are not completely understood. On Pennsylvania surface mines, keeping the material well above the water table and limiting infiltration into it seems best. Continuous submergence has been shown to limit pyrite oxidation by limiting exposure to oxygen. However, hydrologic conditions are not conducive to continuous submergence on most Pennsylvania mine sites, which are frequently located in upland recharge areas with highly fluctuating water tables.

Chapter 15. Bactericidal Control of Acidic Drainage

The use of bactericides is a management technique presently best suited to limiting water quality problems, not preventing them. As with other management techniques, using bactericides may reduce the severity of a problem but is unlikely to prevent a problem in a setting with a high acid mine drainage potential. While bactericides can reduce bacteria catalysis, the presence or lack of carbonates controls whether a site produces alkaline or acidic drainage.

Chapter 16. Water Management Techniques on Surface Mining Sites

Water management is another technique that can be used to limit the potential for mine drainage problems, but which cannot completely prevent problems on a site otherwise likely to produce acid mine drainage. The emphasis should be on keeping the quality of water coming into the site good through the use of tools like surface water diversions and highwall drains. While capping of a site with ash or clay may be a helpful abatement technique once mine drainage pollution has developed, it is not generally possible, nor desirable, to completely eliminate infiltration into a site.

Chapter 17. Remining

Remining can be an effective way to simultaneously develop energy resources and to reclaim previously abandoned mine lands. Reducing pollution loads by reducing flow can be an effective abatement technique on sites with pre-existing poor quality discharges. Implementing a combination of the management techniques described in this document can also provide positive results. Remining may not successfully rehabilitate sites with particularly negative conditions.

Chapter 18. Application of the Principles of Postmining Water Quality Prediction

What is the best prediction tool? The answer is “all of them.” The best predictions are those that weigh all the predictive factors. Serious errors can result from predictions that fail to consider less than all the available data.

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