Longwall Mining, Subsidence, and Protection of Water Resources in Virginia

by

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(ABSTRACT)

In the coalfields of Southwest Virginia, longwall technology accounts for an increasing proportion of underground coal mine production. It is a highly productive, capital intensive method that provides a degree of mine safety greater than conventional methods. However, subsidence caused by longwall mining has been blamed for, among other things, damaging wells, springs, and streams above the mines. Surface land owners whose water supplies are affected by longwall mines may negotiate with mining companies for compensation, or they can seek redress in the courts. At the same time, the U.S. Surface Mine Control and Reclamation Act (SMCRA) provides a framework for regulation of the environmental effects of coal mining, including hydrologic effects. The Department of Mines, Minerals, and Energy, Division of Mined Land Reclamation (DMLR) is responsible for implementation of Virginia’s primacy program under SMCRA.

This research has assessed the potential of longwall mining to damage the groundwater and surface water resources in Southwest Virginia; and examined whether existing laws and regulations, as implemented, provide an adequate and appropriate level of protection to both water property rights and the environment. Methods included review of published and ongoing literature on effects of underground coal mining on hydrologic systems and methods of mitigation; review of mining permits and complaint investigations on file at DMLR; review of court case decisions involving mining effects on groundwater and surface water; review of regulatory documents from other states active in longwall mining and the Federal Office of
Surface Mining (OSM); and interviews with coal company personnel, DMLR and OSM officials, researchers, and regulatory officials in other states.

Review of both DMLR complaint investigations and published reports of numerous hydrologic investigations indicates that longwall mining is likely to alter the hydrologic regime in the vicinity of the mine. The knowledge base for regulation of hydrologic impacts has been inadequate but is being improved in Virginia. Both DMLR and some coal companies recognize the need for more and better data, and are taking steps to develop the requisite data and models. Regulatory personnel in Ohio, Pennsylvania, West Virginia, and Kentucky have expressed recognition of similar data deficiencies in their states. At least one state, Ohio, has dealt with the problem of water rights by enacting legislation that assigns liability for replacing damaged water supplies to the mining companies. West Virginia, through its regulatory program, also requires water replacement. Recommendations are offered that have as their main objective the reduction of uncertainty about the effects of longwall mining and about compensation of surface owners for damage to water supplies.
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Introduction

The relationship between the people of Appalachia and the coal mining industry has a long and fractious history. Although the economies of the Appalachian coal fields have been largely supported by coal mining, so that their fortunes are inextricably linked, nonetheless it has been a relationship characterized at times by bitter conflict, mutual suspicion, and violence; and during the best of times, by uneasy truces based on the recognition of mutual dependence. Although the relationship is less overtly acrimonious than it was 50 years ago, the long history of adversarial relations between the coal mine owners and operators and the miners continues to reverberate around the latest focus of contention, longwall mining.

The longwall mining controversy arises not merely in the context of a history of conflict but also in the midst of a retrenchment of the coal mining industry that has taken a severe economic toll on the Virginia coal fields. Unemployment in Dickenson County, for example, officially averaged 15 percent during 1986, when unemployment in Virginia as a whole was exceptionally low. Furthermore, some researchers familiar with employment in the area
contend that the methodology used to estimate official unemployment rates grossly underestimates the true numbers of unemployed and underemployed workers there.¹

Virginia’s coal mining industry has suffered in the past decade as a result of the decline of the U.S. steel industry and world export competition. In order to stay competitive, the coal industry has looked increasingly to productivity gains made possible by increasing mechanization. Longwall mining technology has been one of the most important sources of increased productivity. Yet insofar as it has contributed to the productivity of Virginia coal mines, longwall mining has cost jobs. According to the Virginia Center for Coal and Energy Research (VCCER), in Buchanan County, “though coal production was high in 1986, industry unemployment was nearly 18 percent due to high-productivity longwall equipment in Buchanan’s largest mines.”²

Industry officials deny that longwall mining costs jobs. Instead, they point out, without longwall technology many of the largest mines could not be operated profitably and would have to be closed. Furthermore, they contend that although there are fewer workers underground in a longwall mine, the technology requires more supporting personnel than conventional mining methods. Finally, according to Gene Mathis, former president of Pittston Coal Group, Inc., longwall mining technology is the only way to mine very deep coal seams with any degree of safety.³

The current controversy over longwall mining, however, concerns its environmental effects, not its effects on jobs in the Virginia coalfields. Residents of Buchanan, Dickenson, and Wise Counties, the three counties in which longwalls are currently operating in Virginia, have complained of subsidence damage to their homes, the venting of natural gas, groundshaking, subsidence damage to their homes, the venting of natural gas, groundshaking,

and loss of wells and springs used for water supply. So urgent have their pleas become that the Virginia legislature, by means of a joint resolution, formed the Joint Subcommittee Studying the Effects of Longwall Mining. At a recent series of hearings held in the coal counties, the subcommittee heard from owners of property damaged by subsidence, from people living in fear of natural gas explosions and earthquake-like jolts and "bumps" caused by active land subsidence, and from people whose tranquil lives have been ruined by anxiety over the anticipated loss of their homes. The subcommittee also heard from mining company executives, who described the programs for mitigation and compensation that the companies have voluntarily implemented, that some citizens have embraced, but that others say are inadequate.

Controversies over subsidence and its impacts are not limited to Virginia. The title of a recent conference on subsidence, co-sponsored by the American Mining Congress and the West Virginia Coal Association, reflects the industry's perspective: An Industry Under Seige: Some Facts About Subsidence. According to Gerald T. McPhee, Director of Governmental Relations for Island Creek Corporation, in 4 of the eleven states in which longwalls are operating, legislation or regulatory revisions aimed at longwall mining have been proposed, and there are organized anti-longwall groups in 3 of the states.

There are also developments on the federal level that may very dramatically change the rules governing subsidence as a surface impact of underground mining. The Office of Surface Mining is currently considering amending its permanent program regulations which address

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4 The Subcommittee released its report, Senate Document No. 26, in January 1989. Based on the Subcommittee's findings, Senator John Buchanan, its chairman, proposed legislation that, in its eventual form, called for increased monitoring of subsidence effects of high extraction mining techniques, as well as better premining notice for surface owners. However, its provisions merely emphasized what is already provided for in the current regulations under the Virginia Coal Surface Mining Control and Reclamation Act of 1979. The bill died in committee.

5 The conference took place in Charleston, West Virginia, April 5-6, 1989. That it attracted nearly 200 industry and nonindustry attendees is testimony to the level of interest and concern in every state in which full extraction mining is practiced.

the extent to which mining companies have a right to mine in areas otherwise declared unsuitable for mining under Section 522(e) of the Surface Mining Control and Reclamation Act of 1977 (SMCRA). The proposed rulemaking also attempts to clarify "valid existing rights"—i.e., rights to mine which companies had prior to enactment of SMCRA. SMCRA prohibits surface coal mining in certain types of areas, including national parks, national wildlife refuges, and some other public lands; Section 522(e) also requires that buffer zones be left around public roads, cemeteries, public buildings, and occupied dwellings. "Surface coal mining" has been defined and interpreted, in regulations implementing other parts of SMCRA, to include the surface effects (including subsidence) of underground coal mining. To apply such a definition to the provisions of Section 522(e) would expand considerably the types of surface features and areas under which high extraction mining, and perhaps all underground mining, would be prohibited.

This thesis focuses on one of the environmental consequences of subsidence caused by high extraction mining, its effects on groundwater and surface water, and on the institutional controls over these effects. There are several reasons for consideration of the hydrologic impacts of longwall mining and other types of high extraction mining. First, of all the impacts alleged by opponents of longwall mining, it may be the least susceptible to mitigation. While a mining company can purchase or repair a house damaged by subsidence, it has not been established that the groundwater beneath the house, upon which the land owner may have depended for domestic and farm water supply, can be "repaired." Second, the loss of water resources has the potential not only to limit future human uses of the land, but to alter the land's ability to support plant and animal life. Finally, because of the nature of hydrogeology, it is the most difficult impact to predict or assess. The consequences of this last consideration for the protection of the hydrologic regime are a major focus of this investigation.

Environmental impacts of underground coal mining are regulated in Virginia by the Department of Mines, Minerals, and Energy, Division of Mined Land Reclamation (DMLR), under the provisions of the Virginia Coal Surface Mining Control and Reclamation Act of 1979
(VCSMCRA). In considering the nature and degree of hydrologic balance protection achieved through the implementation of VCSMCRA, it is useful to bear in mind two conditions that are necessary for a successful regulatory program for environmental protection. First, there must be an adequate knowledge base on which regulatory planning and decisionmaking, both at the policy level and at the individual mining permit level, can be rationally based. Second, there must be an institution capable — i.e., with sufficient numbers of personnel having a sufficient level of technical expertise, armed with sufficient authority — of collecting and analyzing information for rational use in decisionmaking, making decisions, and enforcing them.

Regulation is not the only institutional mechanism for protection of groundwater and surface water from the effects of underground coal mining. Impacts on the water rights of surface owners are controlled to some extent by the common law. The rights of the owners of coal seams have come repeatedly into conflict with the water interests of those who own the surface estate, beneath or adjacent to which coal mining occurs. These conflicts have been resolved through numerous court decisions, which are examined in this thesis to determine if there is a clear rule or at least general direction discernible from them.

**Research question and methodology**

This thesis focuses on the following question: Are the available control mechanisms (technical, regulatory, and legal) adequate for protection of the hydrologic balance from adverse effects of subsidence caused by high-extraction underground coal mining? In order to answer (or at least shed light upon) this question, it has been necessary to develop an understanding of:

- the nature and importance of the hydrologic resource in Southwest Virginia
• the effect of mine subsidence upon water resources

• the technical means, if any, by which adverse effects on water resources may be avoided, prevented, or mitigated

• the regulatory system for control of the environmental effects of coal mining

• the common law governing effects of coal mining on property owners

The methodological techniques employed in this thesis research included:

1. Review and analysis of published and unpublished literature in the areas of mining engineering, geology, geohydrology, hydrology, regulatory analysis, and law.

2. Analysis of the Surface Mining Control and Reclamation Act, the Virginia Coal Surface Mining Control and Reclamation Act, and the Virginia Permanent Regulatory Program for Surface Coal Mining and Reclamation Operations, as well as related materials such as committee hearing reports.

3. Examination and analysis of memoranda and documents of the Division of Mined Land Reclamation (DMLR).

4. Examination of selected DMLR mining permit files and complaint investigations.

5. Personal interviews with officials of DMLR, the federal Office of Surface Mining Reclamation and Enforcement (OSMRE), and mining regulatory agencies in other states; with state environmental officials in Virginia and other states; with attorneys representing environmental groups, citizens groups, and coal companies; and with geologists and hydrologists.

6. Review of OSMRE annual oversight reports for Virginia and other states.
7. Analysis of court case decisions and the common law.

Research was conducted from March, 1988, through March, 1989.

The adequacy of regulatory protection of the hydrologic balance depends on 1) the adequacy of the laws and regulations pertaining to the environmental effects of mine subsidence; and 2) the degree of implementation of those laws and regulations. In order to address the first element, I have examined the Surface Mining Control and Reclamation Act (SMCRA) and the Virginia Coal Surface Mining Control and Reclamation Act (VCSMCRA), as well as the federal regulations and judicial interpretations, and the Virginia regulations under VCSMCRA. This examination of laws and regulations, in light of the review of technical literature on hydrologic effects of coal mining subsidence, focused on the provisions for protection of the hydrologic balance, the scope of their application, and the adequacy of monitoring requirements. My review and assessment of the adequacy of the laws and regulations was buttressed and supplemented by the views of regulatory and environmental personnel. To assess the degree of implementation, I relied upon the analysis and findings of OSMRE’s detailed annual audit and analysis of Virginia’s regulatory program, corroborated and supplemented by interviews with knowledgeable officials and environmental personnel as well as review of selected permit and complaint files at DMLR’s offices in Big Stone Gap.

Again, regulation through a command-and-control system is not the only control on hydrologic effects of mine subsidence. These effects have impacts on surface property owners, and the property rights of such owners are protected through the common law. I have evaluated the extent of protection afforded through the common law by reviewing Virginia court case decisions and interviews with attorneys involved in subsidence damage litigation.

In the following section of this report longwall mining is distinguished from other coal mining technologies, and its contribution to the economic viability of the industry in Virginia is de-
scribed. In Section 3, literature on the nature of the hydrogeology of the coal fields is reviewed. Section 4 describes the mechanisms of hydrologic damage due to subsidence, making use of recent theoretical and empirical investigations. Evidence related to the potential for short-term and long-term impacts is considered. The hydrologic effects of coal mining and the social and environmental impacts of those effects are distinguished, following the work of the National Research Council. The hydrologic effects of longwall mining impact upon surface owners' water rights. These essentially social and economic impacts can be distinguished from the environmental impacts of underground coal mining's hydrologic effects, and in fact the existing framework of institutional controls follows this distinction, not just with respect to hydrologic effects but subsidence effects of underground coal mining in general. In the latter case, subsidence impacts on surface structures are left, in Virginia and some other states, to the common law, while subsidence impacts on "the land" are regulated under VCSMCR. To reiterate, the central focus of this study is whether the protection provided by the combination of these controls is adequate. Section 5 reviews the controls provided by the common law and by the regulatory apparatus established under SMCRA.

The regulations at the federal level contain ambiguities with respect to the status of longwall mining, and there is continuing rulemaking and litigation in this area both at the federal level and in the states. Section 6 considers the constraints to protection of the hydrologic balance currently faced by the regulatory agency and the industry. Evidence from investigation of DMLR permit files and complaint investigation files as well as relevant published research demonstrates that there are four major constraints to protection of the hydrologic balance in the case of longwall mining in Virginia: the level of theoretical understanding of the resource; the availability of data to DMLR; the feasibility of preventing damage through either technical or regulatory means; and the importance of longwall mining to the industry and the economy of the area. Section 7 considers the limitations of common law protection of the groundwater

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resource. Section 8 reviews the progress made toward hydrologic balance protection by DMLR, and Section 9 reviews problems and progress in four states in which longwall mining is practiced. Section 10 presents conclusions concerning the adequacy of protection of the hydrologic system and recommendations for improvement of such protection in longwall mining areas in Virginia.
Longwall Mining

Coal is mined in Virginia by both surface and underground methods. Surface mining is distinguished by the fact that the mining operation takes place on the surface of the ground; only coal seams relatively close to the surface can be mined this way. Surface mining methods include area mining, contour mining, auger mining, and open-pit mining; which method is used depends on the surface topography and its relation to the coal seam.

In Virginia, underground mining accounts for a large majority of coal production, and most of the state’s coal reserves (estimated at 9.75 billion tons) must be mined by underground methods. Continuous mining technology accounts for the greater part of underground coal mine production in Virginia. Continuous mining uses a mobile piece of equipment called a "continuous miner," which breaks coal from the coal face (the exposed part of the coal seam) and moves it to a conveyer, which attends the continuous miner and carries the coal to a central conveyer belt for removal from the mine. Depending on mine conditions, the mine face is worked for six to eight yards, at which point the machine is moved to another area of the

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mine so that the mine roof can be secured and ventilation extended. Because of the necessity of roof support, a considerable amount of coal must be left intact while continuous or conventional mining techniques are used, and the resulting mine design is called room-and-pillar. In a room-and-pillar mine, a series of parallel tunnels, called entries, is developed by using continuous miners. These entries are then connected by tunnels called cross-cuts. The resulting pattern of extraction results in a honeycomb-like mine design (in plan view).

A variation on this technique is called pillar-retreat mining. When the section is fully developed in a room-and-pillar plan, the pillars supporting the roof are "pulled" starting at the far end of the section and working back toward the entry. While there are several methods for pulling pillars, all result in a higher extraction ratio than room-and-pillar (typically, greater than 80% of the coal in the seam is removed).

Longwall mining removes all the coal from a panel 350-1000 feet wide and from 1000 to 9000 feet long. In Virginia mines, the face width varies from 580 to 730 feet. Coal is cut away from the longwall face, which extends across the width of the panel, either by a shearer with rotating cutters or by a plow-like device which is pulled across the face. The cutting device is moved back and forth across the face, removing up to three feet of coal at a pass. The coal is taken from the face by an armored face conveyor to the head- or tailentry, where it is emptied onto a stage loader and thence to the entry belt conveyor which takes the coal toward the mine entrance. A series of self-advancing powered hydraulic supports, four to five feet wide and lined up side-by-side across the longwall face, provides roof support, generally allowing only a foot of unsupported roof. As the cutter advances, these supports are propelled forward, leaving the mine roof behind them to collapse.

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There are no "pure" longwall mines. In the first place, a considerable amount of coal must be removed to prepare for the installation and working of a longwall. This is done by using continuous miners to create the parallel entries and other entries necessary for coal removal and ventilation. Secondly, a single underground mine can extend over a very large area; due to coal seam conditions and other factors, some of the seam may be better suited to room-and-pillar mining, with or without pillar retreat, than to longwall mining.

Longwall mining has some distinct advantages over other mining methods. First, as mentioned above, it allows for more complete extraction of coal from a seam, which makes for more efficient exploitation of coal reserves. Second, it provides miners with a higher degree of safety, because the actual cutting is done beneath the steel canopy of the supports, and because fewer miners are needed below ground. Fewer miners in the ground also may reduce the numbers of men exposed to the coal dust which causes black lung. Finally, longwall mining is the only feasible way to mine very deep seams with any degree of safety, because the compressional forces at great depth can cause both roof collapse and pillar failure.

Longwall mining and pillar retreat mining, because of their systematic removal of roof support, cause rapid and fairly predictable subsidence of the overburden. While the effects of this subsidence vary and may cause environmental damage, its rapidity, predictability, and completeness have some advantages over the subsidence caused by room-and-pillar mining. In many areas, subsidence has only recently developed over coal mines that were mined out decades ago. Remediation or compensation to owners of surface structures damaged in such circumstances may be difficult or impossible, since the company has likely long since gone out of business.12 In the interests of economic efficiency and long-term planning, it is advantageous to have subsidence completed while the mining operation is still in progress or

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12 SMCRA has set in place a mechanism for "restoration and reclamation of land and water resources adversely affected by past coal mining, including ... prevention, abatement, and control of coal mine subsidence." 91 Stat. 457, 30 U.S.C. 1231. The program is funded through a reclamation fee collected on coal currently being extracted.
shortly thereafter. And the degree of predictability allows for measures to be taken to prevent or minimize damage to surface structures.

**History of Longwall Mining**

Longwall mining has been practiced in various forms and with varying degrees of success for over 100 years. Souder and Palowitch distinguish seven eras in the history of longwall mining, based on the technology used: early style (wood props), old style (steel jacks), coal plow/friction jack, low resistance (less than 100 tons) supports, high resistance (greater than 100 tons) supports, total systems longwalls, and shield longwalls. The early and old styles used wooden or steel props to support the roof along the face. The face was undercut by hand, and the weight of the roof would, under “ideal conditions,” break off the face. These methods were unreliable, and were limited to coal seams no deeper than 500-750 feet. From 1875 to 1955, under the early and old style technology, the number of longwalls in service never exceeded 30.

In the early 1950s, a newly developed German technology was introduced which showed promise of applicability to the mining of thin seams of high quality coal. Lewis attributes the earlier development of advanced longwall technologies to the poor quality of European coal for pillar support, and to the limited availability of coal resources there. The technology in-

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14 Ibid., p. 7.

15 Ibid., p. 3.


Longwall Mining 13
volved the use of friction jacks and plows to scrape the coal from the working face, but mixed results and limited applicability prevented widespread use of this method.

One of the primary factors in the failure of the coal plow method was the inadequacy of the roof support systems. Between 1960 and 1965, advances made in Britain and Europe were tried in various locations in the U.S. These advances included hydraulic, self-advancing roof supports, and once they were made capable of supporting the great weight of thick overburdens, these technologies spread rapidly and with some success. By the 1970s, more efficient cutters and more dependable logistic and support systems, together with a wider variety of available equipment that could be tailored to specific conditions, resulted in a dramatic increase in the number of longwalls operating in the U.S. The introduction of shield-type supports increased the reliability and safety of the systems, making it possible to work seams with over 3,000 feet of overburden. Since the 1970s, the number of longwalls in operation has increased exponentially. The only limit on a continuation of this trend appears to be coal market conditions.

**Longwall Mining in Virginia**

In 1987, Virginia had 13 longwalls in operation in ten mines, second only to West Virginia. This number accounted for over eight million tons of coal, over one-fifth of the state’s total underground mine production and nearly one-fifth of the total coal production by all methods. This number represents only the actual longwall production; in the mines in which longwalls operate, the total production is considerably higher: 13.3 million tons, representing over a third of all Virginia underground production and nearly 30 percent of all coal mined in the state in

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The 13 longwalls in Virginia are owned by four companies: Island Creek Coal Co. (5); Pittston Coal Group, Inc. (Clinchfield) (4); Consolidation Coal Co. (2); and Westmoreland Coal Co. (2). As of March 1989, one of the longwall units is idle, so that only 12 are producing coal.

Although modern longwall mining was introduced into the Commonwealth in 1968, its contribution to total production in the state remained small (less than 7 percent) until 1984. It has climbed in each year since then, and can be expected to continue to do so. According to industry officials, longwall mining makes it possible both technologically and economically to mine coal deposits that would not otherwise be mined. Longwall mining is not necessarily more productive than continuous mining; indeed, Pittston's most productive mines (tons per unit of labor) are mined by conventional methods. However, in certain seams, particularly deep ones, its productivity advantage is considerable. Given current market conditions, it is probably safe to say that the use of longwall technologies is that only reason coal production in Virginia has increased since 1984.

While longwall mining has enhanced Virginia coal production, its resulting subsidence has incurred the wrath of surface owners and fueled controversy concerning the benefits and costs of the practice. The controversy is not limited to Virginia, as the current debate over OSMRE rulemaking with respect to valid existing rights and Sec. 522(e) of SMCRA demonstrates.

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18 Randolph et al., p. 15.
19 Randolph et al., ibid., p. 13.
20 Randolph et al., ibid., p. 13.
22 Mathis, E., ibid.
Hydrogeology of the Virginia Coal Fields

Geology

The coal-producing region of Southwestern Virginia is in the Appalachian Plateau physiographic province, and is drained by the Clinch, Powell, and, via Russell Fork and Levisa Fork, Big Sandy rivers. The area is characterized by rugged, mountainous topography consisting of deep, V-shaped valleys with steep slopes and narrow, winding ridges. The landforms in evidence in the region have been shaped by the erosion of a high plateau of sedimentary origin. These sedimentary rocks, which range from Cambrian through Pennsylvanian age, have for the most part been uplifted as a block, and although deformation is present, it is not nearly so dramatic as in the adjacent Valley and Ridge Province. Accordingly, the strata remain nearly level to gently sloping, with only occasional deep fractures. There are several coal-bearing formations, all of Pennsylvanian age, and at least 27 major coal seams. These formations consist of alternating layers of sandstone, shale, thin layers of clay, and coal beds.

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23 National Research Council, Committee on Ground-Water Resources in Relation to Coal Mining. Coal/
Soils in the coalfields are the product of weathering and disintegration of the parent materials. As much of this is sandstone and sandy shale, the soils are predominantly sandy loams. The richest soils are found in the floodplains at the valley bottoms, which are filled with unconsolidated material washed down from the slopes. On the slopes themselves, soils are generally thin and highly prone to erosion when vegetative cover is removed. On the level-topped ridges which have escaped erosion, soil covers are thick. Soil and slope conditions confine the meager agricultural industry to the valley bottoms and ridge tops.

**Surface Water**

The streams draining the coal region are almost universally dendritic, testimony to the erosional morphogenesis of the area. The exceptions occur at major fault lines, along which several of the major streams run in fairly straight lines. Although the region receives plentiful precipitation on average, the streams are remarkable for the variation in their flow. Because of the steep slopes, runoff following precipitation is relatively quick; during the dry months, all but the largest streams are reduced to a trickle.

Surface mining has affected the hydrology of streams draining basins that have been extensively mined. Base flows have increased since the advent of surface mining, and this increase, together with observed changes in flow duration, indicate enhanced infiltration and storage of precipitation with correspondingly more gradual drainage of this water. Surface mining activity also changes surface and groundwater quality: water in mined basins tends to...

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toward a sulfate type, while that from unmined basins is predominantly of a bicarbonate type. 25

Groundwater

Groundwater, like surface water, has its origin in precipitation. Precipitation that does not run off as surface streams and escapes evapotranspiration infiltrates into the ground. Eventually it is discharged into surface streams or is withdrawn by well pumping. The route that it takes and the length of time it stays beneath the surface depend on several factors.

The most important factor in determining overall groundwater flow is topography. Like surface water, groundwater flows down the ridge sides toward the valleys, eventually discharging into streams and comprising their base flows. Groundwater availability, as evidenced by well yields, is greatest in valleys and on lower slopes. 26

Besides topography, rock characteristics exert a great influence on the direction of flow and on the amount of groundwater available. Transmissivity is a measure of the ability of water to move through a rock formation. Transmissivity depends on the permeability of the rock. Permeability can be either primary or secondary. Primary permeability refers to the movement of water through the spaces between the rock grains, and it depends on both the amount of pore space and the size and shape of the rock grains. In small-grained rocks such as shale or clay, permeability is very low. Layers of such rock act as aquitards, retarding the move-


ment of water. More porous rocks, such as certain sandstones, both store greater quantities of water and permit relatively easy passage of water, and thus may be good sources of groundwater. Such rocks are generally referred to as aquifers. However, the sandstones in the Virginia coalfields tend to be well-cemented and thus are poor sources.  

Secondary permeability refers to the movement of water along rock fractures, bedding planes, joints, and faults. Because of the low primary permeability of the rock layers in the formations underlying the valleys and ridges of the Appalachian plateau, secondary permeability is much more important to both groundwater storage and flow than primary permeability. In one study in Preston County, West Virginia, fracture zone permeability was found to be one to three orders of magnitude greater than intergranular permeability of sandstone units. These findings are in agreement with those of Schubert, who points out that the increase in hydraulic conductivity produced by fracturing can drastically alter the hydrologic characteristics of rock and reduce the usefulness or applicability of common "porous media" evaluations. Sloan and Warner, similarly, warn against using groundwater models based on primary hydraulic conductivity in areas such as the Appalachian coal region, where aquifer storage and flow characteristics are fracture controlled.

Considerations of topography, lithology, and stratigraphy are all important in understanding the occurrence and movement of groundwater in the Virginia coalfields. There are two

hydrologic studies that, taken together, provide a good general understanding of groundwater hydrology in the region. The first is an investigation of the role of stress-relief fractures in the hydrology of an Appalachian valley. The erosion of valleys from the sedimentary formations characteristic of the Appalachian Plateau removes compressional stress of overlying material, resulting in predictable patterns of fractures in valleys and on ridge walls. On the ridges, stress relief results in vertical fractures which allow the valley walls to slump outward and downward. This slumping causes compression fractures at the base of the ridges. The slumping also opens up horizontal fractures in bedding planes between different strata. Another consequence of the erosional removal of compressing rock is the upward arching of rock strata on the valley floors, which causes vertical fractures there as well as opening of bedding planes between the strata underlying the valley floors.

Analysis of the results of pump tests and slug tests of strategically placed wells, as well as streamflow data, yielded results consistent with the theory that the fracture system described above controlled groundwater movement in the valley. Under this model, water falling on the ridge tops and slopes enters the vertical fractures and, moving through them and through the horizontal fractures on the ridge sides, descends down the slope until it intercepts the horizontal fractures at the valley floor. The water flows through these until it reaches a point at which the streambed intercepts them, and then it empties into the stream. In this model, there is little movement of water within the ridge mass, except on its outer, fractured edges.

The second study was a cooperative effort of the Powell River Project, the Virginia DMLR, several mining companies, and the U.S. Geological Survey. This study used mobile testing equipment to investigate hydraulic properties of various strata encountered in exploratory drilling by mining companies in the Virginia coalfields. Tests were conducted to determine transmissivity, hydraulic heads, and hydraulic connection of water-bearing zones. Although


the report is still in preparation, the preliminary results are as follows. In this region, the uppermost 100-150 feet is a fractured zone, with a weathered mantle of unconsolidated material (alluvium and colluvium). In the fractured zone is the most accessible groundwater. Fracture flow (i.e., secondary permeability) is predominant, and well yields are low, rarely above 5 gallons per minute (gpm). This zone is the source of most domestic water supplies, either through springs or shallow wells. Recharge of the groundwater in this zone is relatively rapid and, following a rainfall, drainage from it feeds streams for one to four days.

Below this upper layer, the only lithologic units with significant transmissivity are coal seams. The siltstones, shales, and sandstones consistently show extremely low transmissivity, except where fractures are intercepted, over a wide range of elevations. In contrast, the transmissivity of the coal seams shows a consistent correlation with elevation: the deeper the seam, the lower the transmissivity. This is because at greater depth, increasing pressure closes the cleats and microchannels through which water moves. The coal seams comprise the only lithologic units with significant groundwater storage. Most of the perennial springs occur at coal seams, and most of the baseflow of streams in the area is from water slowly being released from the coal seams. Recharge to the coal seams is through deep fractures.

This view of coal seams as being the only lithologic units able to store and transmit significant quantities of water is corroborated by an earlier study of the hydrology of the Upper Russell Fork Basin in Buchanan and Dickenson Counties. Water levels were monitored in five ridgetop wells, each open to a different coal seam. Water levels at the wells were at different altitudes, and unsaturated zones were encountered between the coal beds, "indicating the presence of a series of perched water zones above the coal beds."

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Springs are frequently associated with coal seam outcrops, because the coal seams are relatively permeable and because they tend to be underlain by clay. Hence, water flowing down through vertical fractures is stopped in its movement by the clay layer, and following the slight inclination of the layer, flows along it until it emerges on a hillside. The "perched aquifers" supplying such springs individually may be of little regional significance as water sources, but they are adequate to supply a small number of households where they occur. According to a Virginia Division of Mineral Resources geologist involved in mapping the coalfields, springs are valuable in helping to locate coal seam outcroppings.

**Groundwater Quality**

There are several sources of information on groundwater quality in the coalfields of Virginia. One is the *Planning Bulletins* for Wise, Dickenson, and Buchanan Counties published by the Virginia Water Control Board. Data for these reports are from analyses of spigot samples from wells located, for the most part, in valleys. It is likely that the use of existing wells biases the overall water quality characterization, since these wells will tend to be placed in areas of good water quality. Buchanan County's groundwater is described by Epps as "characteristically acid to slightly alkaline, irony, somewhat hard, and may have a sulfurous odor." Localized problems include higher-than-recommended levels of iron, manganese, chloride, sulfates, and dissolved solids; hardness; acidity; and dissolved gases, including hydrogen sulfide and methane. Water quality problems seem to stem from the geochemistry of the area.

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*Epps, id., p. 29.*

*Hydrogeology of the Virginia Coal Fields*
rather than from substances introduced by man. Dovel, in his review of groundwater conditions in Wise and Dickenson Counties, describes the water from the coalfields in those counties as "irony, moderately hard and acid, and [it] may be discolored and malodorous."38 Water quality problems for these counties are similar to those of Buchanan County, with the exception of the Powell River Valley in Wise County, which comprises a different hydrogeologic regime.

The U.S. Geological Survey has conducted several studies of surface and groundwater quality in the region. In one, a study of groundwater in southern Buchanan County, findings generally support the characterization of groundwater quality found in Epps' study. No areawide degradation of groundwater quality was found, but some local effects of surface mining were apparent. Stream water is generally bicarbonate in unmined areas, but takes on a sulfate character in some heavily mined areas. Well and spring water from coal seams was found to be sulfate-rich.40 In another study, this one in Buchanan and Dickenson Counties, mining was again found to result in increased sulfate concentrations in groundwater and surface water.41

Benefits Provided by Undisturbed Hydrologic Balance

Groundwater provides nearly all the drinking water in the coal fields. In the more remote areas, families depend on well water and spring water for domestic use and for small agricultural operations. While these uses of groundwater may be of little economic significance

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38 Dovel, id., p. 55.
41 Larson, J. D.; Powell, J. D. Ibid.
due to the sparse population and rural character of the area, the importance of an adequate and dependable water supply to the individual landowners cannot be overstated. Groundwater serves as the source of domestic and industrial water in the more densely populated areas of the region, as well. The geology and morphology of the area prevent regional movement of groundwater, and so in each valley the supply is limited. Epps reported in 1978 that some population centers in Buchanan County were in danger of depleting their supplies through overuse. A theoretically correct measure of the value of the groundwater resource for water supply in the coalfields would be the cost of implementing an alternative supply. Even to do so for a limited number of localities would be expensive, because there are no easily available alternatives.

Groundwater is also an important source of water for wildlife, which depend on the springs and seeps which it supplies. Moreover, it supplies the base flow, meager as it sometimes is, for the streams in the area.

Summary

This section has described the hydrogeology of the Virginia coalfield region. The area's normally ample precipitation is carried away relatively quickly by steep streams with low base flows. Groundwater occurs primarily in fractured zones near the surface, and in alluvial valleys. Both storage and transmissivity are dominated by secondary permeability in the fractured zones, which extend from the surface to a depth of 100-150 feet. Coal seams are the only lithologic units with significant groundwater storage.

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42 Epps, id., p. 73.
Groundwater quality is variable over the area; common problems are high levels of iron, hardness, acidity, and odor. Nonetheless, groundwater supplies most of the domestic and industrial needs of the coal counties. Many of these needs could not be supplied economically by any other source of water. Springs, seeps, and surface streams fed by groundwater also provide aquatic habitat and water for game and nongame wildlife.
Subsidence Damage to Hydrologic Balance

The hydrologic balance is defined in the *Virginia Coal Surface Mining Reclamation Regulations* as

the relationship between the quality and quantity of water inflow to, water outflow from, and water storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake, or reservoir. It encompasses the dynamic relationships among precipitation, runoff, evaporation, and changes in ground and surface water storage.\(^4^4\)

It is the balance of overland flow, channel runoff, infiltration, evaporation and transpiration, and outflow of water deposited by precipitation on the system of landforms, soils, rock formations, vegetation, and drainage channels that comprise the geological, chemical, and biological setting of the hydrologic unit. Each part of the system exerts its influence, and changes in any part will affect the hydrologic balance. In this section, a number of studies are reviewed in order to come to an understanding of the mechanism whereby longwall mining (or any underground mining technique, such as pillar retreat, that involves removal of support of the overburden) might affect the hydrologic balance.

The mechanism of action is through subsidence. As described in Section 2, longwall mining unavoidably causes subsidence of the overlying rock by completely removing its subjacent

\(^4^4\) *Virginia Coal Surface Mining Reclamation Regulations*, Sec. 480-03-19.700.5, p. II-10.
support. This is somewhat euphemistically referred to as “planned and controlled subsidence” in the Surface Mining Control and Reclamation Act.

In room-and-pillar mining, columns of stress-bearing coal are left in place to support the mine roof, so that in most cases the cavity is intact when the mine is abandoned. Deformation of the overlying strata is limited to those layers relatively close to the mine. Longwall mining, on the other hand, mines a broad face (typically between 350 and 1000 feet wide, and as high as the coal seam is thick); at intervals, the supports are moved forward and the cave roof behind is allowed to collapse.

The geomechanics of subsidence have been studied extensively and are well-understood. In the case of longwall mining, when the mine roof is allowed to collapse, there is an area of caving and severe fracturing which occurs directly above the mined coal seam, extending upward 30-60 times the coal seam thickness, depending on the mechanical qualities of the overlying rock strata. Above this caved area, the strata sag, causing opening of bedding planes and vertical fractures. This sagging and fracturing extends in most cases to the ground surface, resulting in a well-defined subsidence trough. The horizontal dimensions of the trough are greater than those of the longwall panel, however.

The subsided surface area extends within an area defined by the “angle of draw.” The Institution of Civil Engineers in England defines the angle of draw as “the angle between the line from the edge of the excavated area, normal to the seam, and the line joining the edge of the excavated area to the point of zero effect at the surface.” The Institution of Civil Engineers puts the angle of draw at 25 to 35 degrees; however, because the subsidence trough does not end abruptly, but rather tails off gradually, the extent of major deformation is generally smaller than this. Considering the size of a longwall panel (up to 1000 feet wide and 9000 feet long), and the distance to the surface, it can be seen that the subsidence trough for a single panel

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may cover a large area; furthermore, in a typical mine, there are multiple longwall panels in close proximity.

A conceptual model of groundwater impacts of underground mining was developed by Booth, using mining engineering concepts of strata movement and mine hydrology. His conclusion, supported by field observations in the Appalachian Plateau in Pennsylvania, is that longwall mining causes extensive, high-reaching, well-defined zones of stress, fracturing, and hydraulic impact, the maximum permeability increases being in the tensile zones immediately above the panel and at the sides of the subsidence trough. In shallow aquifers, permeabilities and groundwater velocities increase, and hydraulic gradients decline independently of mine drainage.

During the past decade, there have been several studies documenting the hydrologic impacts of longwall mining, both in the Appalachian region and elsewhere. One of the earliest was Hobba's study of the effects of mine collapse at three mine sites in West Virginia. Hobba found that mining and subsidence fractures increased hydraulic conductivity and the hydraulic connection of aquifers. This resulted in changes to the hydrologic balance that included increased infiltration of precipitation and surface water, decreased evapotranspiration, and higher base flows in some small streams. Static head in observation wells fluctuated as much as 100 feet in the course of a year. Pumping of mine drainage caused diversion of water underground from one basin to another. Rock units near the surface showed higher transmissivity in mined basins than in unmined basins, and increased infiltration and circulation of groundwater through these rock units resulted in higher mineral loads in streams.

Stoner used well testing methods to determine the hydrologic characteristics of an area in the Appalachian Plateau in Pennsylvania before and after underground coal mining. He found

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47 Ibid.

water-bearing zones to be common at the interfaces between sandstones and shales, and in fractured sandstones and coals as well. Mining was associated with decreases in static water levels in wells in inverse proportion to the vertical distance between the mine and the well bottom. Both pillar retreat and longwall mining "may cause increased vertical permeability by fracturing which could hydraulically connect shallow aquifers to a deep mine." Stoner speculates that, following complete collapse of the overburden, cracks and fissures in the more plastic strata may reseal, allowing the recovery of water levels in shallow aquifers. This is a position taken by mine engineers at some mining companies, according to one DMLR geologist. However, others, including Gary LeCain of the U.S. Geological Survey, doubt that the fractures will become sealed. LeCain points out that it only takes a small break in an aquitardal layer to drain the water from above it; furthermore, if the theory were correct, there would be no groundwater recharge even before mining, because all the existing fractures would have become sealed over the millenia.

Depending on the lithology and structure of the strata overlying a longwall mine, wells at different depths may be affected unequally. In one U.S. Bureau of Mines study, subsidence and groundwater levels were monitored over an active longwall panel in western Pennsylvania before, during, and after mining. Zones of fracturing were increased by subsidence, which stopped within four months after passage of the longwall face. Transmissivity was dramatically impacted by this fracturing, and changes in groundwater flow patterns were observed. Coal seam thickness was between four and five feet, and depth of overburden was 550 feet; panel length was 2900 feet, and the face was 585 feet across. Although the deep aquifer monitoring wells showed "precipitous" declines in water levels, wells penetrating the shallow aquifer zone were protected to some extent by an aquitardal layer which evidently resisted


Subsidence Damage to Hydrologic Balance 29
fracturing. This conclusion was borne out by observation of flows from a spring near the center line of the longwall panel, which correlated with precipitation but not passage of the longwall face. Hydrology was still unstable at the end of one year, as indicated by cascading in some monitoring wells; the deep well water level declines had recovered only slightly after one year. However, aquifer dewatering was limited mainly to the area directly above the longwall operation, and water quality, as indicated by conductivity, was only slightly affected.52

Another U.S. Bureau of Mines study showed a similar result with respect to differential dewatering of aquifers. Subsidence and groundwater effects were monitored over a coal mine in Barbour County, West Virginia. The overburden thickness was approximately 600 feet, and the coal seam thickness was 5.5 feet. This study used a clustered piezometer technique, with seven piezometers in two clusters penetrating strata at depths of less than 150 feet, 150-300 feet, and 300-600 feet. Water levels were measured before, during, and after pillar-retreat mining. There were significant declines in deep strata, but effects were minor in the shallower wells. In this case, however, water quality changes were observed, with higher concentrations of dissolved solids, increased conductivity, and lower pH following mining.53

Dewatering effects depend on the location of the well in relation to the longwall panel, as demonstrated by another U.S. Bureau of Mines investigation. Groundwater levels, stream flow, and subsidence were monitored above a longwall panel in southwestern Pennsylvania at a greater depth than the above study. In this case, the overburden thickness ranged from 750 to 1000 feet. Maximum surface subsidence in the center of the trough was over three feet. Five 150-foot deep monitoring wells, designed to simulate typical domestic water wells, were


constructed across the longwall panel. Wells 500 feet or more outside the panel rib line were unaffected, while those within the boundary of the longwall showed precipitous declines as a result of undermining. One well near the centerline went dry and had not recovered at the end of a year of postmining monitoring. Two wells, 100 and 300 feet outside the rib line of the longwall panel, declined 15-20 feet but recovered to near premining levels within ten months. Small streams and a spring located within 1200 feet of the panel were unaffected.

Effects of longwall mining on groundwater were compared with those of room and pillar mining in Barbour County, West Virginia. Groundwater sources (wells and springs) did not show any evidence of impacts from room and pillar mining, but dewatering was apparent over the longwall mines. Dewatering of strata over longwall mines extended to nearly 300 feet above the top of the mined coal seam; less severe but still apparent impacts were seen up to 360 feet above the coal seam. Dewatering of the overburden extended within an angle of influence of approximately 20 degrees from the mined panel. Well and spring dewatering was dependent upon lithology and the location of a groundwater supply’s recharge zone, such that if most of the recharge zone was within the angle of influence, dewatering was almost certain. The presence of lineaments also influenced dewatering. Eighty percent of the accessible dewatered wells showed no significant recovery one to three years after dewatering. Streamflow was also affected, with a decline in flow proportional to the percent of the recharge area that was dewatered, in areas with 100-170 feet of overburden. Complete loss of flow was seen in some of these streams.

Besides reductions in streamflows resulting from decreased groundwater contributions, streams may be directly affected by the development of subsidence cracks and fissures in the

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streambed. Such effects are not uncommon in West Virginia, where subsidence has resulted in the complete or partial capture of the stream's flow. Subsidence has also been found to alter drainage patterns, resulting in ponding in some areas. Perhaps more destructive than the subsidence cracking and ponding have been the measures taken by coal operators to correct these problems. In the case of subsidence cracking intercepting stream flow, coal operators sometimes grade streambeds, then line them with plastic or rubber to prevent water inflow to the mines. Channelization and rerouting of streams are undertaken, in some cases at the request of the surface landowner, to alleviate ponding.

Hydrologic effects of multiple longwall panels were studied by Walker et al. and by Schultz. In the former, five wells were positioned over the centerline, edge, or chain pillar of three consecutively mined longwall panels in Green County, Pennsylvania. Overburden thickness was 750-1000 feet, and the wells were constructed to a depth similar to that of domestic water wells, 150 feet. The wells over the panel centerline showed the greatest water level fluctuations and loss of static head. Fluctuations and head loss also occurred over previously mined panels during active mining of an adjacent panel. Water levels recovered after mining, but not completely.

Schultz's study involved not only well level monitoring but also aquifer tests. Ten observation wells 17 to 150 feet deep over two longwall panels, mined at a depth of 670 to 804 feet, were monitored, along with springs and seeps. Eight of the wells were near the panel centerlines.

56 Jernejcic, F. West Virginia Department of Natural Resources. Personal communication, January 6, 1989.


Subsidence over the panels caused increased permeability, resulting in static water level declines in the observation wells ranging from 1.56 to 41.99 feet. Water levels were influenced by dry weather as well as mining. Fluctuating water levels were observed in wells over the longwall panels. Three observation springs located over the panels showed a decline in discharge, while new springs or seeps were observed to have formed downslope from them.

There is a remarkable unanimity in the research that has been conducted on the hydrologic effects of longwall-induced subsidence, despite the fact that the exact nature of the effects is dependent on site-specific factors of lithology, topography, and stratigraphy. The fracturing and sagging of strata overlying the panels and within an angle of draw causes dramatic increases in permeability. Groundwater levels decrease in the vicinity of the panels, affecting wells and springs. Groundwater flows are rerouted, and water quality may or may not be affected, depending on the geochemistry of the overburden. Surface streams may be directly affected by fracturing of streambeds, or indirectly affected by rerouting of groundwater.

The existence and magnitude of these effects have, it would appear, surprised some industry and regulatory officials. In Virginia, most longwall operations are conducted in seams at least 600 feet deep, well below drainage. Industry officials cite the lack of water entering the mines as proof that their hydrologic effects are negligible. However, as the studies above show, depth in itself is no barrier to hydrologic effects near the surface. During this decade, sufficient evidence in the form of published literature, sharing of professional experiences at conferences, and mounting numbers of complaints, has led DMLR to recognize the potential for damage to the hydrologic balance posed by longwall mining. The agency's response is detailed in a later section.

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For example, in a response to a Revision Order Notice issued by DMLR to the Clinchfield Coal Company, a company engineer stated that “historically, no adverse effects to the hydrologic balance have been encountered at mines where the depth is greater than 200 feet.”
**Dimensions of the Problem**

The effects of subsidence due to underground coal mining on groundwater levels and flow in the Virginia coalfields are localized, and readily circumscribed. According to the findings in the literature, effects such as lowering of groundwater levels and dewatering of aquifers supplying wells, springs, and seeps are not likely to extend much beyond a limit defined by an angle of draw that is generally between 15 and 35 degrees. Indeed, in the coal producing region, groundwater systems themselves are generally limited by topography, such that there is no hydrologic connection between a groundwater system in one valley and a similar system in the next. This fact is recognized by Epps, in her report on groundwater prospects for Buchanan County:

> Groundwater shortages in high use areas will become more severe unless new areas with underdeveloped groundwater supplies are tapped. Considering the difficult terrain and the economics involved, it is probable that people in built-up sections will continue to suffer seasonal shortages which will gradually become year-round shortages while the next valley a mile away has groundwater to spare.  

To say that the hydrologic effects are localized is not to diminish their importance. The impacts of these effects may be severe on affected individuals and local ecosystems. And, while the area of potential effects around a particular mine in most cases does not extend much beyond the area undermined, it should be kept in mind that some of these mines are very large, with thousands of acres subject to subsidence over the life of the mine. The percentage of the land area in Buchanan, Dickenson, and Wise Counties that is potentially affected by longwall subsidence is not negligible. Nevertheless, it should be possible in most cases to determine the limits beyond which subsidence-related effects of mining on groundwater levels and flow regimes will not occur.

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Effects on surface waters could create impacts outside the immediate area of the mining operation. Research suggests that streams draining mined areas show changes in chemical composition, with increased sulfate levels and in some cases increased dissolved solids. These effects are perhaps more closely related to surface mining, however, and Virginia is fortunate in that the pyrites that are responsible for the worst coal mine drainage problems in some other Appalachian states are not found in large quantities here. Thus, water quality effects of mining in general are not severe.

A potential effect of subsidence on surface streams is the alteration of base flows. Hobba, in his investigation of hydrologic effects of subsidence due to underground mining, found that subsidence increased infiltration, reduced evapotranspiration, and increased base flows in small streams draining the subsided area. Such an effect is possible, and the ecological and social impacts stemming from it might actually be beneficial. Streams in the coalfields are known for their quick discharge of precipitation runoff and low base flows, and it is difficult to see how retarding this process somewhat could be harmful, so long as water quality remained unaffected.

Summary

Subsidence caused by longwall mining has very substantial effects on the hydrologic balance. Fracturing above the longwall panel causes increased permeability resulting in declines in static water levels. Wells and springs above the panel within an area defined by the “angle of draw” are likely to be dewatered. Subsidence effects on groundwater occur within a matter of days of the passage of the mine face. In some cases, substantial recovery of water levels

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in wells is seen within one year, but in others no recovery or only slight recovery was observed.

The effects of subsidence from high-extraction mining on groundwater generally are limited to a well-defined area above the mined panel and within the angle of draw. However, a mine large enough to use longwalls may extend under several thousand acres over the life of the mining operation, so the effects of subsidence, though localized, are not insignificant. Subsidence from longwall mining has also been found to result in dramatically reduced streamflows in some areas. Such effects could have impacts outside the immediate area over the mine. Other impacts may be beneficial, although this is somewhat speculative. The increased transmissivity and storage of groundwater caused by subsidence may result in greater availability of groundwater for development, as well as increased baseflows in surface streams.
Institutional Mechanisms for Protection of Hydrologic Balance

We have seen that high-extraction coal mining can cause, and has caused, changes in the hydrologic regime in the Virginia coalfields, and these changes have had social impacts and (though this is not well documented) ecological effects. Next we review the institutional controls — laws, policies, and organizations that implement them — that protect the hydrologic balance from adverse impacts of coal mine subsidence. Before doing so, however, it may be well to consider the nature of protection of the hydrologic balance, since this concept is central to the regulatory framework for control of the environmental effects of coal mining.

Levels of Protection

Public policy must consider what level of protection is possible, desirable, and appropriate, and in doing so must weigh the potential social and environmental impacts of high-extraction coal mining against the potential economic impacts of regulation of the industry. In theory, the
range of levels of protection extends from full protection to none at all. Level of protection can be viewed as a continuum, and associated with each level of protection would be a level of acceptable damage. On a general level it is only possible to distinguish a few broad categories:

Full protection. No damage would be allowed to groundwater and surface water resources. No diminution in quantity or quality would be allowed; this would be consistent, for groundwater, with Virginia’s antidegradation policy. There would be no adverse social or environmental impacts, and productive and beneficial uses of both water and land, insofar as its use depended on water availability, would be unimpaired. This level of protection may be inconsistent with development of coal resources through high extraction methods.

Partial protection. Partial protection would countenance limited deterioration of water quantity or quality in connection with coal extraction. Limits could be set in terms of severity of degradation, areal extent, and duration, or a combination of these parameters. Damage allowed would be short-term, localized, and consistent with long-term, cumulative protection of the resource. Thus, for example, temporary disruption of wells and streams, with recovery after a year or two, would be permitted under a partial protection standard. Partial protection is consistent with a cost-benefit approach, since it allows for flexibility and compromise. Temporary disruption of streams and wells within a circumscribed area might be considered a reasonable price to pay for extracting coal (who pays the price is a separate question, addressed in Virginia by the common law). However, if enough short-term local disruptions were allowed in an area, there would be the potential for long-term, cumulative impacts; and so this possibility must also be considered in permitting decisions.

No protection. If no protection were provided, severe damage to the hydrologic balance would be allowed. Damage could be widespread, particularly in areas with numerous
mining operations. Streams and rivers could be rendered unable to support aquatic life (as indeed they have been in some parts of Appalachia); groundwater could be rendered unusable without extensive treatment. The productive use of land could be foreclosed, at least for the foreseeable future, by the degradation of water resources, with resulting severe impacts on the area’s economy and future prospects.

The level of protection that the Congress seems to have intended to provide when it passed the Surface Mining Control and Reclamation Act of 1977 is partial. SMCRA has two overall purposes, one of which is to encourage exploitation of the coal resource, and the other to minimize the environmental damage in doing so. What the following review of the provisions of SMCRA (as implemented in Virginia) will show is that Congress was aiming at a level of protection of hydrologic resources that would minimize mining’s impacts and contain them, spatially and temporally. Throughout the Virginia and federal statutes and regulations can be found the phrase, “minimize the disturbance to the hydrologic balance.” This is the performance standard for allowable hydrologic damage within the mine permit area, and areas adjacent to it. Outside the permit area, “material” damage is to be prevented.

It should be noted that a mining operation could minimize the disturbance to the extent technologically and economically feasible, and still do considerable damage. Such a standard only carries the implication that the operation will do no more damage than is necessary, that the damage will “constitute the least possible,” to quote from Webster’s definition of minimal. No particular standard of protection is implied by “minimal damage.”

Short-term, localized damage consistent with long-term, cumulative protection is what the Congress seemed to intend in requiring that (a) damage to the hydrologic balance be minimized within the permit area (localized damage); (b) lasting impacts be considered in the cumulative hydrologic impact assessment (CHIA) process; and (c) impacts outside the permit area (nonlocalized damage) be prevented. And this localized, short-term damage constitutes environmental degradation that is acceptable under SMCRA. It is clear that exploitation of
coal reserves cannot be accomplished without some localized, short-term damage to the hydrologic balance, and hence some level of environmental degradation. Congress recognizes this principle throughout SMCRA. Although SMCRA and its implementing regulations are highly complex and detailed, through its use of such terms as "minimize," "significant aquifer," "material damage," and the like, Congress and OSM recognized that these were determinations that could not be made across the board and were better delegated to the personnel implementing the regulations. Thus, Congress left considerable latitude to DMLR and similar agencies in other states for determining what the level of protection of the hydrologic balance should be.

There are currently two institutional frameworks in Virginia that provide a mechanism for controlling the impacts of coal mine subsidence effects on water resources. The Surface Mining Control and Reclamation Act, as implemented by VDMLR, provides a mechanism for protection of the hydrologic balance. The common law, or judge-made law as it is sometimes called, does not provide any protection for water resources except insofar as the property rights of individuals are involved. In the following sections, these two mechanisms are described.

The Regulatory Framework Under SMCRA

History

While it is not the purpose of this thesis to trace in detail the historical development of the existing regulatory framework for control of the environmental effects of coal mining, some general comments are necessary to "set the stage" for the detailed description of the regu-
lations to follow. The Surface Mining Control and Reclamation Act of 1977 was passed after a number of years in which similar bills were introduced, only to fail. The impetus for the bill came from documentation of the depredations of essentially unregulated strip mining, mainly in the Appalachian states. Coming as it did in a time when the environmental movement was at its zenith and the 1973 energy crisis was still fresh in the minds of the public and its representatives, it is not surprising that SMCRA is a compromise law, embodying both Congress' desire to control the environmental impacts of coal mining and its desire to encourage coal production as a means to energy independence. A number of SMCRA's provisions can also be viewed as compromises between the environmentalists on the one hand, and the coal industry, most coal-producing states, and their supporters in Congress on the other. For example, the coal industry resisted additional regulation of underground mining, while others argued that both surface and underground mining should be regulated under the new law. The resulting compromise includes regulation of surface mining and the surface effects of underground mining.

Since its passage, SMCRA and its implementing regulations, issued by the federal Office of Surface Mining Reclamation and Enforcement in the Department of the Interior, have been under sustained assault, both in the courts, and, since the Reagan administration took office, from above. Although the federal agency initially took a fairly hard line with respect to implementation and enforcement by the states, its approach has become considerably more conciliatory and cooperative since then. The combined effect of litigation and the federal

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agency's softened stance is a trend toward a greater role for the states in determining how the law will be implemented and enforced (one of the original reasons for the bill was the perceived inadequacy of some state programs for regulating coal mining, so to some extent the original purpose of the law has been subverted) and a willingness to "work with" coal companies to bring them into compliance.

The Commonwealth of Virginia, through its representatives and elected officials, was one of the staunchest opponents of the passage of SMCRA. In order to prevent the federal regulators from assuming control over coal mine regulation in the state, the Virginia General Assembly passed a bill, the Virginia Coal Surface Mining Control and Reclamation Act (VCSMCRA), to allow the state to implement a primacy program under SMCRA. The regulations produced by the Division of Mined Land Reclamation (DMLR) in the Department of Mines, Minerals, and Energy (DMME), like VCSMCRA itself, essentially mirror the federal regulations. Perhaps indicating the reluctance of the state government to adopt the federal regulatory scheme, VCSMCRA actually contains the statement that nothing in it shall be construed "as expressing the Commonwealth's approval of or satisfaction with the standards or provisions contained in the regulatory program of the federal act."\footnote{Virginia Code, Chapter 19, Sec. 45.1-227.}

**Virginia's Coal Surface Mining Reclamation Regulations**

Following the federal regulatory scheme, Virginia's regulations rely on a system of permitting, bonding, monitoring, and detailed performance standards for all phases of the coal mining operation to achieve their purpose, which is to minimize the environmental damage associated with coal mining. The following sections describe the relevant permitting, monitoring, and performance requirements for protection of the hydrologic balance.
Permitting

Applicants for permits for underground mines are required to submit a general description of the premining environmental conditions, to include: cultural and historic resources; climate; vegetative cover; fish and wildlife resources; and land use, capability, and productivity. Detailed information regarding the mining operation itself is required in an operation plan, to include maps, schedules of planned operations, what mining techniques and equipment are to be used, and an explanation of the construction, maintenance, use, and removal of mining facilities.

A reclamation plan describing the intended methods and timing of reclamation efforts, and their estimated cost, must also be submitted. Detailed hydrologic information is called for by the regulations. Baseline groundwater information required includes "the location and ownership for the permit and adjacent areas of existing wells, springs, and other ground-water resources, seasonal quality and quantity of ground water, and usage." Minimum requirements for groundwater quality include measures of total dissolved solids, pH, total iron, and total manganese, while for groundwater quantity, the minimum requirement are "approximate rates of discharge or usage and elevation of water in the coal seam, and each water-bearing stratum above and potentially impacted stratum below the coal seam." Additional data may be required if the determination of probable hydrologic consequences (PHC; see below) indicates that adverse impacts to the hydrologic balance may occur, on or off the permit area. There is a very significant difference at this point between the hydrologic information requirements applicable to surface mines and those applicable to underground mines. For surface mines for which adverse impacts to water resources used for domestic, agricultural, industrial, or other legitimate purposes are expected, applicants are required to identify alternative sources of water. DMLR also has the authority to require the mining company to

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**Sec. 480-03-19.784.14**

**Ibid.**
replace affected water supplies in the case of surface mining. This is not the case for underground mines, and so the identification of alternative sources is not required. The reason for this difference, and it is an important one, is described in a later section.

The permit applicant is required to submit a determination of probable consequences of the mining operation on the "quality and quantity of surface and ground water under seasonal flow conditions for the proposed permit and adjacent areas."79 The PHC is to describe predicted adverse impacts, if any, on the hydrologic balance, including specifically sediment yield from the disturbed area; acidity, total dissolved and suspended solids, and other water quality parameters; flooding or streamflow alteration; and groundwater and surface water availability. The PHC also must determine whether contamination of groundwater or surface water could occur as a result of contact with toxic or acid-forming materials. Each permit revision for an ongoing mining operation (and for a large mine, there could be many) must be reviewed by DMLR with regard to whether a new or revised PHC is necessary.

Before issuing a permit, DMLR is required to undertake an assessment of the probable consequences of the applicant's mine, together with all other active, planned, or abandoned mines in the area, on the area's water resources. This "cumulative hydrologic impact assessment" (CHIA) must also be reviewed for each permit revision. The purpose of the CHIA is to determine "whether the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area."71 (emphasis added).

A hydrologic reclamation plan must be submitted to show how the applicant's mining and reclamation operations will be conducted to "minimize the disturbance to the hydrologic balance" within the permit and adjacent areas, to prevent material damage outside the permit area, and meet applicable water quality laws and regulations, in particular those of the Clean

79 Sec. 480-03-19.784.14(e)

71 Sec. 480-03-19.784.14(f). "Material damage" is used in the context of SMCRA to mean functional impairment.
Table 1: Elements of the Mine Permit Application Process

Submitted by Applicant
- Premining Environmental Resources Information
- Mine Operation Plan
- Reclamation Plan
  - Geologic Information
  - Groundwater Hydrology
  - Surface Water Hydrology
  - Probable Hydrologic Consequences
  - Hydrologic Reclamation Plan
  - Groundwater Monitoring Plan
  - Surface Water Monitoring Plan
  - Subsidence Survey
  - Subsidence Control Plan

Performed by DMLR
- Cumulative Hydrologic Impact Assessment

Water Act at 40 CFR Part 434. Specific objectives of the plan are to "avoid acid or toxic drainage; prevent to the extent possible using the best technology currently available additional contributions of suspended solids to streamflow; provide and maintain water treatment facilities when needed; control drainage; and restore approximate premining recharge capacity." The plan is to specifically address the potential adverse impacts identified in the PHC.

The PHC is also the basis for groundwater and surface water monitoring plans required by the regulations. The monitoring plans should be focused on those parameters related to the suitability of groundwater and surface water for current and approved postmining land uses. The design of the monitoring plans and the intensity of monitoring efforts depend on the expected hydrologic consequences. Groundwater monitoring plans should include installation of monitoring wells in significant water-bearing strata; water quality monitoring within the permit area; and individual monitoring of "each significant aquifer" in the adjacent area with

72 Sec. 480-03-19.784.14(g)
wells, springs, mine discharges, or a combination of them. Quarterly submission of monitoring data is required. Monitoring should be sufficient to identify the causes of diminution or contamination of usable groundwater, guard against offsite influences, and provide representation of the effects of the proposed coal mining operation. The specific instructions for groundwater monitoring allow for tailoring of the monitoring network according to the specific conditions and expected effects of the mining operation, and for waiving or adding some monitoring requirements at the discretion of the regulatory agency.

Surface water monitoring requirements include measurements of total dissolved solids or specific conductance, total suspended solids, pH, total iron, total manganese, and flow at strategic locations upstream and downstream of potential impact areas. Point source discharges must be monitored in accordance with Clean Water Act requirements.

For underground mines, a subsidence control plan is required, to include a survey showing whether structures or renewable resource lands exist within the permit or adjacent areas. Renewable resource lands are defined as "areas which contribute significantly to the long-range productivity of water supply or of food or fiber products, such lands to include aquifers and aquifer recharge areas." The plan is required to demonstrate whether subsidence would cause material damage or diminution of reasonably foreseeable use of the structures or resource lands. If the survey shows, and DMLR agrees, that either such structures or resource lands do not exist in the permit or adjacent areas, or that subsidence would not cause material damage, no further information is required. If the contrary is the case, the subsidence control plan must contain a description of the size, sequence, and timing of development of underground mine works; the mining method used; a description of the geological conditions likely to affect subsidence development and its effects; and a description

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73 Sec. 480-03-19.700.5
of the anticipated effects and measures planned for mitigation of these effects. Potential impact areas are usually calculated using a 28 degree angle of draw.\textsuperscript{74}

\textbf{Performance Standards for Hydrologic Balance Protection and Subsidence}

The general performance standard for underground mines with respect to protection of the hydrologic balance is that all mining operations "shall be conducted to minimize disturbance of the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area, and to support approved postmining land uses."\textsuperscript{75} Specific performance standards for groundwater protection relate for the most part to the surface impacts of underground mining within the permit area: handling of earth materials, excavations, and runoff. Besides the requirement that these operations be conducted so as to minimize acidic or toxic infiltration to groundwater systems and restore the approximate premining recharge capacity, the specific performance standards in this section are related entirely to monitoring. Only one section raises the possibility that something other than monitoring may be required: Section 480-03-19.817.41(c)(2)(ii) states, "if degradation, contamination or diminution of water quality or quantity are evident through monitoring, then additional monitoring \textit{and/or remedial action} may be required by the Division." (emphasis added).

The performance standards for both groundwater and surface water protection seem to apply mainly to above-ground operations of an underground mine, apart from the monitoring requirements. In both cases, monitoring is required throughout the course of mining and reclamation up until bond release, unless DMLR is satisfied the operation has met the general performance standards stated earlier: minimized disturbance to the hydrologic balance in the

\textsuperscript{74} Brown, D. R., Commissioner, DMLR. Memorandum re: Requirements for Subsidence Control Plans, October 10, 1988.

\textsuperscript{75} Sec. 480-03-19.817.41(a)
Table 2: Performance Standards for Hydrologic Balance Protection

<table>
<thead>
<tr>
<th>Inside the Permit and Adjacent Areas</th>
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</thead>
<tbody>
<tr>
<td>• Minimize disturbance to the hydrologic balance</td>
</tr>
<tr>
<td>• Support approved postmining land uses</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Outside the Permit and Adjacent Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Prevent material damage</td>
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</table>

permit and adjacent areas, prevented material damage to the hydrologic balance outside the permit area; and left water resources in a condition suitable for postmining land uses.

The performance standards for subsidence control demonstrate the somewhat paradoxical treatment of longwall and other high extraction mining methods that is evident in SMCRA.76 Mining operators must either take whatever measures are technologically and economically feasible to prevent subsidence, or adopt a mining technique (e.g., longwall mining or pillar retreat mining) which provides for planned subsidence "in a predictable and controlled manner."77 If subsidence results from a mining operation, the mining operator is required to repair damages to surface lands "by restoring the land to a condition capable of maintaining the value and reasonably foreseeable uses which it was capable of supporting before subsidence";78 and, to the extent required by State law, either correct material damage resulting from subsidence to any structures or facilities by repairing the damage or compen-

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77 Sec. 480-03-19.817.121(a)

78 Sec. 480-03-19.817.121(c)
sating the owner. The emphasized phrase in the last sentence is the product of a significant change in the federal regulations, the consequences of which will be discussed below.

Underground mining cannot be conducted under or adjacent to public buildings; churches, schools, and hospitals; and water impoundments, unless the subsidence control plan demonstrates that subsidence will not cause material damage to them. DMLR reserves the right to limit the amount of coal extracted in order to prevent subsidence damage to the facilities listed above, and to "any aquifer or body of water that serves as a significant water source for any public water supply system." The Division may also suspend mining operations if such damage is imminent, or if public safety is imperiled. Finally, mining operators are required to give six months' notice to owners and occupants of surface structures beneath which mining is planned.  

**Significant Regulatory Changes**

Since Virginia's regulatory program under SMCRA was approved by the federal Office of Surface Mining Reclamation and Enforcement (OSMRE), there have been significant modifications for both hydrologic balance protection and protection of the rights of surface owners from the effects of subsidence. As a rule, these modifications have resulted from litigation over statutory authority for some regulatory requirements.

One change of major significance for protection of surface owners concerns the requirement for replacement of water supplies destroyed by mining operations. As mentioned above, Virginia's regulations, and those of OSMRE at the federal level, require the replacement of

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79 Sec. 480-03-19.817.121(d)

80 In Virginia, the notice requirements are generally for surface owners and occupants over the mine works and (for high extraction mines) within a 28 degree angle of draw. Haynes, L. DMLR Technical Services Division, Big Stone Gap, Virginia. Personal communication, February 8, 1989.
water supplies disrupted by surface mining, but not those disrupted by underground mining. In OSMRE’s original regulations under SMCRA, this protection was considered applicable to both surface and underground mining. However, in In Re: Permanent Surface Mining Regulation Litigation, Judge John Flannery ruled that the language in SMCRA, Sec. 717, applied only to surface coal mining, despite the fact that in Sec. 701 of SMCRA, “surface coal mining operations” is defined to include “surface impacts incident to an underground coal mine” as well as the areas “where such activities disturb the natural land surface.” Following this ruling, the federal regulations were modified accordingly, and Virginia incorporated this distinction in its permanent regulatory program. A later challenge to this distinction pointed to the reclamation plan requirements in SMCRA as a basis for requiring water replacement by underground coal operators. Sec. 508(a)(13) calls for the reclamation plan to include a description of measures to be taken to assure protection of the quantity of surface and ground water systems, both on- and offsite, or to provide alternative sources of water where such protection of quantity cannot be assured. However, Judge Flannery ruled that this section’s scope is limited to planning and permitting requirements, not performance standards. As a result, water replacement is still not required for underground mining operations under the federal regulations, although, as will be discussed further in the section describing other states’ regulatory programs, some states have enacted laws requiring it.

A significant change to Virginia’s regulations with respect to protection of the hydrologic balance from the effects of underground mining was made in 1986. Prior to October 1986, the performance standards for subsidence control included perennial streams among the surface

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<tr>
<th>Year</th>
<th>Action</th>
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<tbody>
<tr>
<td>1980</td>
<td>Ruling that water replacement was not required for underground mining operations.</td>
</tr>
<tr>
<td>1987</td>
<td>Deference to state law on liability for subsidence damage to structures.</td>
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**Virginia**

<table>
<thead>
<tr>
<th>Year</th>
<th>Action</th>
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<tbody>
<tr>
<td>1986</td>
<td>Perennial streams, which had been protected under the performance standards for subsidence control, now subject to performance standards for hydrologic balance protection, which are less restrictive.</td>
</tr>
<tr>
<td>1987</td>
<td>DMLR no longer responsible for enforcing liability for subsidence damage to structures.</td>
</tr>
</tbody>
</table>

features under or adjacent to which mining was prohibited. This blanket protection was removed in a revision which placed perennial streams under the standards for protection of the hydrologic balance, meaning that mine operators would henceforth be required to “minimize the disturbance” to perennial streams. This is clearly a lesser degree of protection to perennial streams than an outright prohibition of undermining them; and, as we have seen, subsidence damage to perennial streams is one of the impacts that has been observed over longwall mines by regulatory personnel in several states, including Virginia.

In 1987, regulatory control over subsidence damage was relaxed still further. Prior to July 1987, Virginia’s performance standards for subsidence control, like those at the federal level, provided for surface owner protection from the effects of subsidence. Mine operators, in the event of subsidence damage to structures and other surface features, were required to either promptly replace or repair each damaged structure to the condition it would have been in had

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*Sec. 617.126(a)*

*Brown, D. R., Commissioner, DMLR. Memorandum re: Requirements for Subsidence Control Plans, October 10, 1986.*
subsidence not occurred; purchase the damaged structure for its pre-subsidence fair market value; or compensate the owner for damages due to subsidence. However, litigation over a proposed revision to the federal regulations was resolved in 1987, allowing the revision to be promulgated. This revision alters the damage correction provisions of both the subsidence control plan and subsidence control performance standards sections to include the phrase, “to the extent required under State law.” Virginia changed its regulations accordingly, and surface owners whose structures are damaged must negotiate with the coal companies individually or go to court. The remainder of this section discusses the extent to which the property rights of surface owners are protected by common law.

**Common Law: Protection of Property Rights**

The body of Virginia law concerning property rights in water makes a sharp (and, from the point of view of a hydrologist, entirely unwarranted) distinction between waters flowing in a well-defined channel and “percolating” waters, i.e., what is normally thought of as groundwater. The doctrine of riparian rights applies to waters flowing in a channel, even if the channel is an underground one. Under this doctrine, riparian property owners (i.e., those owning property on the banks of the channel) have the right to use the water flowing through the channel, so long as this use does not interfere with the similar rights of other riparian property owners downstream.

There are two common law doctrines applicable to the right to groundwater. One is the so-called English rule of absolute ownership. The owner of a piece of land is entitled to the use

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* Sec. V817.124

of any and all groundwater he can recover. This rule has been referred to (somewhat facetiously) as the law of the biggest suck - i.e., whoever has the biggest pump gets the water. There are no restrictions or considerations regarding the use of the water, except that it cannot be used maliciously. The American rule, or reasonable use doctrine, also allows the property owner to withdraw as much groundwater as he wishes, except that his use of the water must be reasonable, and the water must be used on the premises; it cannot be exported. The Virginia courts have held that mining operations are a reasonable use of property insofar as percolating waters intercepted by mining operations are concerned. Although the Virginia courts have not made a definite choice between these two theories, the reasonable use doctrine seems to be favored. The crucial difference between these doctrines and the riparian doctrine is that, in the former, the effect of a property owner's use of groundwater on his neighbor's use of groundwater is not considered. This is probably due to the archaic origins of the common law, when groundwater's extent and movements were considered essentially unknowable.

Although the body of law governing the effects of underground mining on the surface owner's groundwater rights is still evolving, several important issues were settled early in this century. The distinction between waters flowing in well-defined channels and percolating waters was elaborated in Clinchfield Coal Corp. v. Compton. Here the rule was stated that for the riparian doctrine to apply, the water not only must flow through a defined channel, but that the channel must be discoverable from surface indications without excavation for that purpose. The presumption is that underground water is percolating water unless it is shown to be otherwise.

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80 Clinchfield Coal Corp. v. Compton, 148 Va. 437, 139 S.E. 308 (1927)
82 139 S.E. 308, 148 Va. 437 (1927)
81 C&W Coal Corp. v. Salyer, 104 S.E.2d 50, 200 Va. 16 (1958)
Several cases involving water supplies damaged by coal mining demonstrate that liability depends on whether the water was percolating or flowed in a defined channel, the ownership of the surface lands and their relation to the coal operation, the terms of the deed severing the mineral and surface estates, and the right of subjacent support. Some explanation of this latter principle is perhaps necessary. It is a well-established principle of Virginia law that the owner of the surface lands in a split estate (i.e., where ownership of an underlying coal deposit has been split off from the ownership of the overlying lands) has an absolute right to support of his land, unless this right has been waived. This means that the coal mine owner must leave sufficient coal pillars, props, or other means to support the roof, and in practice it precludes the use of high extraction mining methods, unless the coal mine owner is prepared to accept liability for damages to the surface lands.\(^2\)

If subjacent support is not sufficient, the coal owner may also be liable for damages to groundwater supplying wells and springs, depending on the terms of the deed severing the mineral estate. The seminal case of this type, at least in Virginia, is Stonegap Colliery Co. v. Hamilton, in which it was held:

> Where the surface of land and an underlying mine belong to different owners, if the mine owner, in mining the minerals, fails to leave sufficient pillars, props or other means of support to prevent the strata overlying the minerals from breaking and falling, and as a result the said strata are broken, and thereby a spring on the surface is drained and destroyed, the mine owner is liable for resulting damages.\(^3\)

In the same opinion, the court stated that

> If, in mining in the usual and ordinary way, subterranean streams or percolations of water which feed a spring on the surface are intercepted, thereby causing the spring to sink or become dry, there is no liability therefore upon the owner and operator of the mine.

Thus, liability for damage to water supplies hinges upon the question of subjacent support.

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\(^2\) A case now approaching the Virginia Supreme Court involves a question of a coal company's ability to conduct longwall mining operations without the permission of the surface owner to remove subjacent support. This case stems from the Clinchfield Coal Corp.'s planned removal of coal with eight longwall panels from beneath 80 acres of undeveloped land owned by Gerald and Betty Large of Dickenson County. The coal company is taking the position that there is no liability if there is no damage, and that there will be no damage because the land is undeveloped. Personal communications, Gerald Gray, Attorney, Clintwood, Virginia, January 4, 1989; and Fletcher Cooke, Attorney, Pittston Coal Group, Lebanon, Virginia, January 6, 1989.

\(^3\) 119 Va. 271, 89 S.E. 305 (1916)
This principle was applied in the case of *Drummond v. White Oak Fuel Co.* In this case, the rule was that the owner of coal is liable to the surface owner for destruction of a spring only if the damage is the result of removal of subjacent support; if adequate support was left and no subsidence resulted, the coal owner is not liable. The principle has been affirmed repeatedly in the Virginia Courts.

The case of *Oakwood Smokeless Coal Corp. v. Meadows* is interesting in that the spring, the damage to which was the cause of action, was not dewatered but rather was rendered unuseable because of polluted water draining from the mine, which flowed from the coal mine owner's land onto the plaintiff's adjacent land as percolating water. Because both the coal owner's land and the plaintiff's land had been part of the same parcel when the right to mine the coal was ceded, the present owner (plaintiff) had acquired the land with this burden, which entailed, among other things, the coal owner's right operate his coal mine; and, as the court points out, "the right to mine coal without the right to drain the mine is no right at all." Since that time, the Clean Water Act and its amendments have sharply limited the right to dispose of mine drainage into surface streams.

This review of Virginia common law shows that protection of property rights with respect to groundwater from the effects of underground mining is limited in scope. The question whether protection of property rights, even if it were comprehensive — and it is not — could constitute protection of the hydrologic balance raises a difficult issue: what is the hydrologic balance apart from the rights of individuals to use whatever parts of it they can? It is in part to correct environmental abuses that fall outside the sphere of property rights and their exchange in the market that environmental laws are created, and this is true of SMCRA.

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* 104 W. Va. 368, 140 S.E. 57 (1927)
* 184 Va. 168, 34 S.E.2d 392
While the common law focuses on damages to property rights, and VCSMCRA establishes a regulatory apparatus focusing on a particular industry, there is a third area of public policy relevant to this problem, although it has not been invoked: Virginia's Groundwater Protection Policy. As implemented through the Virginia Water Control Law, the policy reflects the following language from Article XI, Section 1 of the Virginia Constitution:

Further, it shall be the Commonwealth’s policy to protect its atmosphere, lands, and waters from pollution, impairment, or destruction, for the benefit, enjoyment, and general welfare of the people of the Commonwealth.

The report of the Groundwater Protection Steering Committee, *A Groundwater Protection Strategy for Virginia*, notes that DMLR's authority to require water supply replacement does not extend to underground mining. The report recommends that the Department of Mines, Minerals, and Energy review the adequacy of DMLR's authority to protect the groundwater supply when affected by underground mining. DMLR's current representative on the Steering Committee, when queried regarding the status of this recommendation, responded that changes in the VCSMCRA regulations since the preparation of the report had made such a review unnecessary. The change referred to is one allowing DMLR to include the surface area over underground mines outside the permit area in their monitoring and PHC determination requirements. The significance of this change is discussed in Section 8 of this report.

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*Virginia Code 62.1 et seq.*


Summary

The effects of coal mining and their social and environmental impacts are subject to both regulatory controls and the common law in Virginia. In theory, regulation can provide any level of protection for the hydrologic balance. SMCRA provides for partial protection. The complex regulatory scheme implemented under SMCRA, and in Virginia under VCSMCRA, includes detailed requirements for permitting, bonding, performance standards, monitoring, reclamation, and enforcement. The standards for protection of water resources under this regulatory framework are to minimize mining’s hydrologic impacts in the immediate vicinity of the mine; leave the land in a condition that will support approved postmining land uses; and prevent material damage outside the immediate vicinity of the mine. There have been several changes in the regulatory programs at both the federal level and the state level that have resulted in less stringent control over the impacts of underground mining subsidence.

The impacts of underground coal mining on water rights of surface landowners are largely controlled by the common law in Virginia. The Virginia courts have recognized the principle that coal companies are liable for damage to water supplies caused by mine subsidence, but not for damage where there is no subsidence. Virginia’s Groundwater Protection Policy, which contains a nondegradation standard, has not been invoked in the case of mining subsidence effects on groundwater.
Constraints to Regulatory Protection of the Hydrologic Balance

The field of possible actions for any governmental agency, including regulatory agencies, is constrained by external factors, over which the agency has no control or only limited control, and by internal factors, in the form of past decisions and regulatory interpretations. The Virginia DMLR is no exception. The courses of action that are possible for the agency to protect the hydrologic balance are constrained by the state of the art in theoretical understanding of subsidence effects on hydrology, by the availability of data, by statutory authority, and by economic considerations. This section will consider the nature of the constraint posed by each.

Level of Understanding

The precision with which predictions can be made concerning the effects of subsidence on the hydrologic balance depends in part on the degree of knowledge of the mechanisms of
groundwater flow and of groundwater-surface water interactions in the area of concern. Although considerable progress has been made, modeling of groundwater systems is still relatively limited.

Mathematic modeling of groundwater transport began with the classic work of Henri Darcy, which described the flow of water through porous media in terms of pressure and head.\textsuperscript{100} The equation for the flow of water through saturated porous media has been known in its steady-state form since the late nineteenth century. Early mathematical models for groundwater were characterized by the use of simplifying assumptions that allowed the processes to be modeled, but which, because they were not usually met in practice, limited the usefulness and validity of the results obtained. Such assumptions included those of isotropy (groundwater can flow in any direction with equal ease); homogeneity (the aquifer is homogeneous in terms of water storage and transmission); infinite extent in the horizontal plane; and instantaneous response to pumping. Early models, moreover, were only able to consider the steady state. The history of the development of groundwater hydraulics has been "largely a history of the systematic removal of these assumptions one by one."\textsuperscript{101} Despite the steady improvement of groundwater modeling, numerical and finite difference models still have difficulty handling saturated zones characterized by inhomogeneity.\textsuperscript{102} Moreover, the more complicated the model, the more extensive are the data requirements.

These same cautions apply to integrated groundwater-surface water models, since they generally consist of a groundwater model linked to a surface water model. Mathematical simulation of groundwater/surface water interaction has been the subject of a considerable


\textsuperscript{102} It should be noted, however, that the effects of inhomogeneity are scale-dependent. Over a large enough area, variations in aquifer characteristics tend to smooth out.
number of works over the past two decades.\textsuperscript{103} Several of these models seem at least potentially useful for understanding the hydrology of entire catchments. For example, Miles and Rushton describe a model that uses a finite-difference method to simulate groundwater flows in an aquifer and flow balance techniques to simulate surface flows to represent the hydrology of a basin.\textsuperscript{104} The model incorporates the effects of three geologically different land types. Cunningham and Sinclair, in the introduction to a paper describing their coupled surface/groundwater model, sum up the situation:\textsuperscript{105}

> While research results to date provide an optimistic outlook for attaining these goals [an integrated approach to deterministic modeling of the land phase of the hydrologic cycle], they also demonstrate that much additional work is needed in order to completely develop the potential for this particular modeling technique, particularly regarding application to real hydrologic systems.

A review of the state of the art of mathematical modeling techniques for hydrologic systems leads to the conclusion that they have limited applicability in the complex hydrogeologic systems characteristic of the Appalachian Plateau. The effects of extensive fracturing, complex stratification, and topography on transmissivity, storativity, and recharge will be difficult for any mathematical model to handle, and the data requirements for precise modeling of a specific site would probably be prohibitive.

The preceding comments on the theoretical and practical limitations on achieving a precise understanding of the hydrologic system are fortified by the additional complexity and uncertainty of subsidence and its effects on the rock layers that comprise aquifer media. Although the development of the subsidence trough over a high-extraction mine is predictable and, in theory, well-understood, there are many complicating factors that make it difficult to predict the size and shape of the final subsidence basin with precision. These factors are the physical

\textsuperscript{103} See, for example, Vasiliev, O. F. "System modelling of the interaction between surface and ground waters in problems of hydrology." \textit{Hydrological Sciences Journal} 32(3):297-311, 1987.


properties of the overlying strata; the size of the gob (the broken rock filling the cavity immediately above the caved seam); mining depth, in combination with the height and width of the mine opening; topography; the presence of adjacent panels or overlying abandoned mine works; and time.¹⁰⁸

A recently developed model shows some promise of applicability to modeling the hydrogeological impacts of subsidence. Developed as a tool for mine planning, the model uses a combination of "conceptual, physical, empirical, and numerical approaches to define, characterize, analyze, and evaluate flow controlling properties of fractured rock systems."¹⁰⁷ The model assumes that secondary permeability (i.e., fractures) completely dominates the flow of water through the rock matrix. Another assumption is that fracture openings in the rock matrix are a time-dependent function of horizontal and vertical stresses. The model was tested against field observations at a longwall operation located in a complex hydrologic environment. Predicted insignificant mine inflows were confirmed by observations underground. The model was designed for application to mine subsidence effects on hydrology, and may be useful in meeting regulatory requirements for prediction of the probable hydrologic consequences of a mine operation. It is unclear from the description of the model what its data requirements are; these may limit its usefulness or make its application very expensive.

Although the model described above seems to have the potential to provide improved predictive capability to both the industry and DMLR, it remains true that, to date, the limited applicability and practicality of mathematical models of groundwater and surface water in the coal counties of Virginia have made it impossible to predict with much precision the hydrologic effects of subsidence. It could be argued, however, that such precision is not always essential for regulatory purposes. DMLR, using descriptive models of the hydrologic


balance, together with the results of studies of the hydrologic effects of subsidence and experience gained through observation of effects of longwall mines in Virginia, by now has an adequate knowledge base for understanding the potential impacts of subsidence. It is this knowledge and experience that have led to DMLR's increasing hydrologic monitoring requirements.

The knowledge base has sometimes been inadequate in situations in which DMLR must make a determination as to (a) whether a specific observed effect, for example the loss of a spring or well, was caused by subsidence from an underground mine; or (b) whether observed effects indicate significant damage to the hydrologic balance. An adequate PHC determination should identify any stratum "which serves as an aquifer which significantly ensures the hydrologic balance within the cumulative impact area." However, the inadequacy of the hydrologic information submitted by some permit applicants has made it difficult for DMLR to determine whether an affected aquifer was one which significantly ensured the hydrologic balance. This difficulty is in part due to the vagueness of the language of the regulations — what does it mean to "significantly ensure the hydrologic balance"? However, DMLR has also contributed to the problem by not requiring sufficient data during the permitting process to allow it to understand the hydrogeology of the specific area. In Sec. 480-03-19.784.14(h)2, there is a provision that hydrologic monitoring requirements may be waived if the applicant demonstrates in the PHC that "a particular water-bearing stratum in the proposed permit and adjacent areas is not one which serves as an aquifer which significantly ensures the hydrologic balance within the cumulative impact area." OSMRE, in its annual oversight evaluations of DMLR's implementation of SMCRA, has identified unjustified waivers of groundwater monitoring for underground mines as a problem in several of its reports. What

106 One such model is that of Wyrlck, G. G., supra note 32. Anthony Scales, DMLR, Big Stone Gap, Virginia. Personal communication, August 22, 1989.

107 Sec. 480-03-19.784.14(h)

would be necessary, ideally, for a determination that a particular aquifer is a significant component of the hydrologic system is premining data on aquifer characteristics (storage and transmissivity, as well as areal extent), discharges to surface water, and water quality data. However, as discussed in the following section and elsewhere, such data were rarely, if ever, required of applicants. Such a requirement would probably be considered onerous by the mining industry.

**Data Availability**

In general, DMLR, although it has statutory authority to do so in its regulations on permitting requirements, has until recently not required premining installation of monitoring wells (except in alluvial valleys), piezometers, aquifer testing, or even, in some cases, monitoring of existing water wells. And, considering the expense involved in gathering data, one would not expect mining companies to supply such data if it were not required. In the DMLR permit files examined as part of this research, both subsidence control plans and PHCs simply assert that the hydrologic effects of the proposed mines are not expected to be significant. No modeling or monitoring evidence was offered to support their position.

The lack of hydrogeological data available to regulatory agencies has been noted in the literature. Chugh et al. note that hydrogeology is the most neglected area in premining investigations. "Report for the Regulatory and Abandoned Mine Land Reclamation Programs Under the Surface Mining Control and Reclamation Act of 1977 in the State of Virginia for the Period May 1, 1985 to June 30, 1986. Big Stone Gap, Virginia: Office of Surface Mining Reclamation and Enforcement, February 1987, p.9.

Pendleton argues that the state of the art of predicting hydrologic consequences of subsidence lags behind that of predicting geomechanical consequences. His comments are worth quoting at length:

*Nineteen of the 37 [Colorado coal mining] permit applications reviewed for compliance ... have delineated ground water aquifers or surface water bodies within their permit and adjacent areas. All 37 ... contain projections of the specific hydrologic consequences anticipated as a result of subsidence. Faced with a mandate to minimize impacts to the hydrologic balance, any permit applicant would prefer to demonstrate that the anticipated hydrologic consequences of subsidence are minimal. Virtually every permit application's probable hydrologic consequence description observes that ground subsidence will result in cracking of the ground surface above the proposed underground mine workings, but that weathering processes will rapidly seal and eliminate that cracking. While this observation may seem intuitive, little documented evidence exists within the literature to support it. The physical expression of the cracking will probably be relatively rapidly eliminated, but evidence suggests that the hydrologic consequences may be of very long duration.*

Another reason for the optimistic predictions found in the PHCs examined, and their acceptance by DMLR, is that prior to February 15, 1987, the PHC only needed to address anticipated effects within the permit area. The permit area is typically a relatively small area encompassing the mine's surface works, and is not the area that will be affected by subsidence.

Mining companies are not required to report instances of damaged water supplies of surface land owners in Virginia, as they are, for example, in Ohio. Impacts on water supplies as a rule only come to DMLR's attention when the surface owner and the mining company cannot come to a settlement, and the surface owner files a complaint. To judge the dimensions of the problem, information on the number and location of wells impacted is crucial; yet this information is unavailable both to DMLR and to researchers.


114 Ibid., p.5.


Constraints to Regulatory Protection of the Hydrologic Balance 64
The difficulty encountered by DMLR technical services staff in obtaining data from mining companies is illustrated by the following comments by a DMLR geologist on a mining company's responses to a DMLR revision order notice (RON) issued following investigation of groundwater complaints by surface owners over a longwall mine:

3. No data supportive of this contention is supplied. 4. Please clarify the need for the designation of a buffer zone around Dry Fork when the impact area will include this area. No data supportive of the contention Dry Fork will not be adversely impacted is supplied. 5. It is noted that no data is included supportive of the contention that no adverse impacts will result. 6. As no data is available/included to validate claims of negative impact, it would appear prudent to conduct monitoring for future subsidence control updates.

The inability to predict hydrologic effects that results from inadequate understanding of hydrologic processes and limited data is greatly amplified by the longstanding drought that has plagued southwestern Virginia. Precipitation in Wise, Virginia, for example, has shown a cumulative shortfall from 1981 to 1986 of almost 50 inches below the 1955-1986 average; 1987 and 1988 were also drought years. Naturally, the effect of such a shortfall in precipitation has been widespread and severe; however, the precise contribution of the drought to observed effects in specific locations is uncertain for the same reasons that the effects of mining are uncertain. Did a formerly dependable well go dry because of the drought or because of nearby longwall mining? What part of the observed unusually low flows in a particular stream can be attributed to mining in the watershed and what part to the drought? These questions plague DMLR's complaint investigations, making it impossible to attribute observed effects definitely.


118 Hydrologic Information Storage and Retrieval System (HISARS), Virginia Water Resources Research Center, Blacksburg, Virginia.
Prevention of Damage Through Mine Engineering

A review of the mine engineering literature on ground control and prevention of subsidence damage reveals two possibilities for preventing subsidence damage from longwall mining. Measures may be taken at the surface to strengthen structures, isolate them from surface deformation, or incorporate flexible elements into their design. Mining measures include strategically planning mine layout and conducting operations to protect surface structures and land features.

While a discussion of the broad range of structural protection measures that could be taken would be outside the scope of this paper, there are some that are relevant to the protection of hydrologic features from subsidence damage. Where damage to structures or facilities could result in spills of toxic or hazardous materials into the environment, it is imperative that engineering measures be taken to prevent such occurrences. The Pennsylvania Division of Fisheries Environmental Services documented a fish kill caused by a major oil spill that resulted from a pipeline broken by subsidence above a longwall mine in Cambria County in October, 1982.

In some cases, surface measures have done more harm than good. An official of the West Virginia Department of Natural Resources stated that grading and channelization of streams are not infrequently undertaken by mining companies, sometimes at the request of surface owners, to alleviate drainage problems caused by subsidence or to prevent infiltration of water into mines. These practices have in some cases resulted in severe, though localized, environmental damage in that state. The channelization may take the form of installation of

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rubber liners in streams after bulldozing several miles of streambed, to the detriment of aquatic habitat.\textsuperscript{120}

Finally, grouting of subsidence fissures in streambeds has been attempted in some cases. The effects of such efforts on George’s Creek in western Maryland are currently under study by the U.S. Bureau of Mines, but results have not been reported.\textsuperscript{121} The various measures reported here to protect or repair surface water features obviously are not applicable to groundwater, and there are no reported (or for that matter, conceivable) techniques applied at or near the surface for protection or remediation of subsidence damage to groundwater recharge or flow.

Mining measures to prevent surface subsidence damage generally attempt to prevent subsidence in a particular location, or to alter the development or progress of the subsidence “wave” that travels with the advancing longwall face. Backfilling of a longwall “gob” (the mined-out area behind the advancing face) to alleviate subsidence is precluded by both cost and technical feasibility.\textsuperscript{122} As a general rule it can be stated that the development of a subsidence trough over a longwall panel cannot be prevented. There are, however, mining methods for reducing the damage produced by subsidence ground motion.

The most obvious method for preventing subsidence damage is either leave coal seams unmined or to remove only a limited percentage of the coal beneath the surface feature to be protected. Partial extraction can be achieved through room-and-pillar, board-and-pillar, or panel-and-pillar methods. The extent of the mine in which partial extraction must be practiced in order to protect a surface feature can be calculated relatively easily. At least 50 percent

\textsuperscript{120} Jernejcic, F. West Virginia Department of Natural Resources. Personal communication, January 10, 1989.

\textsuperscript{121} Holbrook, J., Chief, Anthracite Reclamation Programs Branch, U.S. Office of Surface Mining Reclamation and Enforcement, Wilkes Barre, Pennsylvania. Personal communication, January 9, 1989.

of the coal seam must be left unmined in order to prevent noticeable subsidence. This percentage may be higher for very deep seams, as greater vertical stress may cause deformation of the pillars.\textsuperscript{123}

Rapid mining and harmonic extraction are two techniques that have potential for reducing structural damage. Rapid mining capitalizes on the fact that the faster mining proceeds, the smaller is the tensile strain at the surface travelling with an advancing mining face.\textsuperscript{124} Harmonic extraction uses a coordinated advance of two adjacent faces such that the surface strains generated by one panel are to some extent canceled out by the other. This method requires, first, two longwall systems; and second, very close coordination between the two. Rock stresses and the rate of face advance must be closely monitored, and if one operation is stopped by equipment failure, the other must also be stopped. These requirements translate into higher costs and lower productivity, and for these reasons may not be economically feasible for mining companies to adopt. More importantly, these methods are best adapted to protection of a small surface area, such as the area beneath a structure, or at most a stream. The area-wide protection from subsidence that one would expect to be necessary to prevent damage to the hydrologic balance could only be achieved by foregoing high-extraction mining. Whether complete extraction will achieve the minimization of damage and prevention of long-term damage to water resources, and particularly groundwater, that is the criterion endorsed by SMCRA, is still an open question that depends very much upon local conditions.

\footnotesize
\begin{itemize}
\item \textsuperscript{123} Peng, S. S. \textit{Coal Mine Ground Control.} New York: John Wiley and Sons, 1986, p.458.
\item \textsuperscript{124} Peng, \textit{ibid.}, p.460.
\end{itemize}
Ability to Prevent Damage Through Regulation

This section will consider DMLR's possibilities for preventing damage to the hydrologic balance caused by high-extraction mining. DMLR's requirement that mining operations minimize the disturbance to the hydrologic balance within the permit and adjacent areas, prevent material damage outside these areas, and support approved postmining land uses, is subject to a range of possible interpretations. It should be noted here that "permit and adjacent areas" includes subsidence-impact areas and occasionally more if DMLR deems it necessary. As was pointed out in an earlier section, "to minimize" is "to do the least possible"; however, the least possible may be a very great disturbance indeed. The clause stating that the hydrologic balance must be able to support approved postmining land uses at least imposes a limitation on the damage allowed: even if it is major, it must at least be temporary. Furthermore, "material damage" must be confined to the permit and adjacent areas. Thus, DMLR has statutory authority to circumscribe the damage to the hydrologic balance in space and time, but not to prevent it. Only if the aquifer in question is "a significant source of water supply to any public water system" does it receive special protection, and then only if DMLR determines that subsidence will probably cause material damage. Thus, DMLR cannot prohibit mining which may damage an aquifer, even though it may supply a number of domestic wells, if it is not used for a public water supply.

Similarly, since a change in the regulations under VCSMCRA was made in October 1986, DMLR is no longer required to prohibit mining under perennial streams (although this remains an option to the agency if it expects serious damage, based on its review of the information submitted by the mining company). Perennial streams had been afforded that protection under the subsidence control performance requirements, but the change in the regulations placed perennial streams under the performance standards for protection of the hydrologic balance; i.e., the mining operation is to be conducted so as to minimize disturbance within the
permit and adjacent areas, to prevent material damage outside these areas, and to leave the hydrologic balance capable of supporting approved postmining land uses.

**Lack of Options When Damage Is Found**

Subsidence damage to the hydrologic balance usually comes to DMLR’s attention by way of complaints from surface land owners. When a complaint is received, a complaint investigation is undertaken. The investigation may include review of materials in the permit file, field investigations, and interviews with complainants. If significant adverse hydrologic impacts of subsidence are found that were not predicted by the PHC determination, or if damage is found outside the permit and adjacent areas, DMLR may issue a Revision Order Notice (RON), requiring the mining company to revise either its PHC, its subsidence control plan, or both. In most cases, increased monitoring is required. If the damage is judged by DMLR to be serious enough, it might require the mining company to modify its operations; for example, to designate a “buffer zone” in which undermining would not take place, or to leave enough coal to prevent subsidence. However, such measures would be taken to detect or prevent further damage. For damage already done, there may be no remedy, even in the case of streams; a groundwater system damaged by subsidence definitely cannot be repaired.

Under VCSMCR, DMLR has several options for action against mining companies whose operations violate permit conditions or performance standards. Upon finding that a coal company is violating the terms of its permit, either the performance standards or reclamation plan, DMLR can issue a notice of violation which gives the company a reasonable time to bring its

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138 It is worth repeating at this point that an unknown number of water loss cases, perhaps most of them, never come to DMLR’s attention. The larger mining companies follow a policy of replacing water supplies they believe their operations have damaged. As a rule, only those cases that cannot be resolved between the landowner and the mining company result in complaints.
operations into compliance. The Division may also assess a civil penalty with the violation, the amount depending on the severity of the violation’s impacts, the culpability of the company, and its good faith efforts to comply, as well as past violations and time taken to comply. Civil penalties are unlikely ever to exceed $5,000, and may be considerably less. If the company does not comply, it may forfeit part or all of the bond it had to post to receive a permit. If more damage is occurring than was predicted, DMLR may require an increase in the bond.

DMLR can order a cessation of coal mining operations if it determines that the operations create an imminent danger to the public health or safety; or are causing or can reasonably be expected to cause significant, imminent harm to land, air, or water resources. A cessation order can also be issued if a company, having received a notice of violation, fails to comply in a timely fashion. DMLR must also assess a penalty for each cessation order, the amount being determined according to the factors described earlier.

A mining operation or company which has established a pattern of violations of any of its permit conditions may be served with a “show cause order,” which essentially requires the company to explain why its permit should not be suspended or revoked. If the company fails to do so to DMLR’s satisfaction, DMLR may take the threatened action.

DMLR has no authority under VCSMCRA to require that mining operators replace water supplies (wells and springs) destroyed or damaged by subsidence. Under Judge Flannery’s rulings, water replacement is only required in the case of surface mining.

128 Sec. 480-03-19.843.11
Economic Constraints on DMLR Action

Congress, in passing SMCRA, was aiming not only to control the adverse environmental impacts of mining, particularly surface mining, but also to ensure the continued vigor of the coal mining industry as a hedge against dependence on unreliable foreign energy sources. More specifically, Congress intended to encourage the expansion of underground coal mining, and said so explicitly: 127

... the overwhelming percentage of the Nation’s coal reserves can only be extracted by underground mining methods, and it is, therefore, essential to the national interest to ensure the existence of an expanding and economically healthy underground coal mining industry.

SMCRA aims at balancing environmental protection and encouraging the expansion of coal mining, especially underground coal mining. Thus, there is no justification in Congressional intent or statutory language for regulatory requirements so stringent that they would make mining impossible.

The preponderance of the evidence presented in this thesis supports the conclusion that the only certain way to prevent subsidence damage to the hydrologic balance is to prevent subsidence. This would require prohibiting all high-extraction mining. As noted above, there is nothing in SMCRA to suggest that Congress envisioned or intended such an outcome. Indeed, there is ample evidence that the framers of SMCRA considered longwall mining, with its immediate and final subsidence, to be an environmentally superior method of underground mining. 128 It should be noted, however, that nearly all of the literature on hydrologic effects of longwall mine subsidence appeared well after SMCRA became law; one can only speculate about what effect the research would have had on Congress’ view of longwall mining.

127 30 U.S.C. 1201(b)

128 Congressman Udall, debating one of SMCRA’s predecessors, stated, “In fact the bill’s sponsors consider longwall mining ecologically preferable, and it and other methods of controlled subsidence are explicitly endorsed.” 123 Congressional Record H22731 (July 10, 1974); quoted in Gorell, G. R.; McGuire, K. M., ibid., p. 21.
The economic importance of longwall mining to the coal counties of Southwest Virginia, discussed in Section 2 of this thesis, cannot be denied. According to Gene Mathis, former President of Pittston Coal Group, Inc., which operates longwall mines McClure No. 1 in Dickenson County and Splashdam in Buchanan County, longwall mining makes mines profitable that would be unprofitable with conventional mining methods. Both of these mines, according to Mathis, would be shut down if longwall mining were not available.\footnote{129} This is not only due to the productivity of longwall mining, but due to the fact that deep coal seams cannot be mined safely using conventional methods. It appears that much of Virginia’s coal cannot be mined any other way.

Longwall mining’s critical importance to Virginia coal production, and that coal production’s critical importance to the economic health, indeed survival, of the coal counties (especially Buchanan, Dickenson, and Wise), constitute the “bottom line” constraint to DMLR’s protection of the hydrologic balance. This constraint makes it extremely improbable that DMLR will feel justified in taking a hard line toward enforcement of the regulations, certainly not to the extent that production would be interrupted or seriously impaired. It encourages rather a conciliatory regulatory approach based on negotiation and “working together” to achieve compliance with SMCRA’s requirements; and DMLR’s approach could certainly be characterized in these terms.\footnote{130}


Summary

This chapter has examined a number of factors that act as constraints on DMLR's ability to protect the hydrologic balance. The agency's ability to understand, track, and predict hydrologic impacts is constrained by the state of the art of hydrologic modeling. The lack of mining engineering paths to prevention of hydrologic damage may force the agency into "all or nothing" choices: either longwall mining in a particular area is allowed, or it is not. Subsidence damage to a structure or even a stream can be avoided by limiting the amount of coal extracted from an area beneath it, but an aquifer or "the hydrologic balance" cannot be protected in this way. Moreover, though DMLR has the authority to order coal operators to repair or mitigate damage to surface water bodies in some circumstances, the technology for doing so may be lacking.

Lack of statutory authority constrains DMLR's responses in some cases. The agency cannot require replacement of water supplies damaged by subsidence from underground mining. And, although a range of sanctions is available to DMLR, their imposition would likely be triggered by damage rather than preventing damage before it happens.

The lack of data, at this point, may be an example of a constraint that results from past decisions and practices by the agency. It would appear that under current regulations, DMLR could have required more data from permit applicants than it did in the first half of this decade. The agency could have refused to accept Inadequate PHCs. Some of the difficulties the technical personnel have had in determining the significance of observed effects, and in ascertaining their cause (as mining-related or not), have their roots in these past practices. A later section will show how DMLR has responded to the problems of Inadequate and insufficient data.
Finally, the economic importance of longwall mining to the region and to the state cannot but operate as a constraint to regulatory action. It is the constraint that does not need to be named or invoked; rather, it permeates the very air of the coalfields. To shut down a longwall mine because of a few springs and wells would be very difficult to justify. Damage to the hydrologic balance would have to be severe, widespread, and obvious before anything so drastic were done.

111 And, as we have recently seen, the corridors of the Capitol in Richmond as well.
The scope of protection of property rights in groundwater afforded by the common law in Virginia is limited with respect to potential damages caused by underground coal mining. When mining does not cause subsidence, the coal company is not liable for damage to groundwater. However, with respect to the high-extraction mining methods that are the focus of this thesis, the legal principle is well-established that mining companies are liable for damages to groundwater supplies when subsidence is the proximate cause, unless the right to subjacent support was waived when the mineral estate was severed.

There are several important points to remember in reference to the protection afforded by such an established legal principle. First, even where liability is clear, it is difficult under the common law to prevent the damage for which a party is liable. Except in those extreme circumstances in which a court is willing to grant an injunction to prevent damage from occurring, to pursue a case in torts there must already be injury. Typically, this means that whatever damage to the hydrologic balance results from subsidence must already have occurred.132

132 The case of Gerald and Betty Large v. Clinchfield Coal Co. is testing whether a surface owner may, under any circumstances, enjoin a longwall operation beneath their land. The outcome of this case,
Second, there is nothing automatic about the assignment of liability, even where there is an established legal principle. The coal company is liable for damages if it can be shown that the coal mining operation caused the injury. For the same reasons discussed in the previous section of this report, demonstrating proximate cause is not a simple matter. In each case there are similar constraints operating: lack of monitoring data; lack of a rigorous understanding of highly localized hydrogeologic conditions; and the confounding effects of drought.

The policy of water replacement in such cases followed by the larger mining companies operating in the state reflects a recognition of the established common law principle of liability for subsidence-caused water supply damages, as well as the "good neighbor" policy that these mining companies espouse. Westmoreland Coal Co., for example, uses the term, "good neighbor" in its 1987 draft subsidence policy statement for its Virginia operations. The policy goes on to say that if a surface owner's water supplies are affected by the company's operations, Westmoreland will "take appropriate action which could include providing a temporary water supply until the water returns or until repairs can be made, or developing an alternate water supply." Island Creek Coal Co. has applied a similar policy to settle water supply damage claims. The company purchased a water truck to serve surface owners who had lost water supplies; others were hooked up to public water supplies. However, Island Creek does

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which is presently being appealed to the Virginia Supreme Court, could change the assumptions under which longwall mining is conducted in Virginia.

12 More it should be noted that there are perhaps different standards of proof operating. The technical staff at DMLR are, almost without exception, geologists and hydrologists — i.e., people trained as scientists. To demonstrate conclusively to a scientist that an observed phenomenon was caused by subsidence would require a different level of proof, or perhaps a different kind of proof, than to convince a judge or jury of a causal relationship between the observed effect and coal mine subsidence. And, although consultant geologists used as expert witnesses are also scientists, they are reportedly more comfortable in taking a definite position on causation than are DMLR technical staff. Personal communication, Gerald Gray, attorney, Clintwood, Virginia. January 4, 1989.

124 Westmoreland Coal Company, Big Stone Gap, Virginia.
not pay the water bill after hookup. Consolidation Coal Co. and Pittston Coal Group, Inc. (Clinchfield) have similar policies.

It should be remembered, however, that liability for subsidence damage to water supplies is intertwined with the right of subjacent support. If this right was waived when the mineral rights were severed, it is questionable whether such liability would be upheld in court.

As was stated earlier, the number of settlements for water replacement or compensation as a result of longwall and other high-extraction mining, and the dollar amounts involved, are fully known only to the individual mining companies. Gerald Gray, a Clintwood, Virginia, attorney who has represented a number of surface owners in subsidence damage cases, stated that in the eight water loss cases in which he has been involved (all were alleged to result from subsidence caused by pillar retreat mining), the settlements ranged from $5,000 to $45,000. He stated that he knew of another 15-20 cases represented by other attorneys in the area.

The types of water replacement measures accepted by some surface owners have included installation and maintenance of cistern systems; drilling new wells and installing filters if necessary; and connection to a public water supply system. There are three important points to be made with respect to the water replacements offered by the coal companies. First, spokespeople for surface owners question whether the measures described above constitute

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135 General Assembly of Virginia. Report of the Joint Subcommittee Studying the Effects of Longwall Mining. Richmond, Virginia, January 1989, p. 10. Island Creek has settled 55 percent of 300 subsidence damage claims, but it is not known what proportion of these involved water supplies.

136 Ibid.

137 In Virginia, courts normally require that the contract severing the surface and mineral estates contain either explicit language or language clearly implying the intent to waive subjacent support in order to uphold waiver claims.

adequate replacement for dependable water supplies that were essentially free. Second, these water replacement measures are made voluntarily by the coal companies and at their discretion. Finally, voluntary water replacement by the coal companies may turn out to be a short-term fix for a long-term problem, and, depending on the nature of the agreement reached, may not be enforceable.

For their part, coal company executives feel that they are not only doing more than they have to, but that they are sometimes victimized by spurious claims. This sentiment has been expressed by others as well. Commenting on coal companies' liability in Kentucky, Smith and Smith argue that legal requirements for proof of causation in cases of hydrologic damage, which formerly favored the coal operators, now favor the surface owner. The situation is such that "property owners can claim practically anything and have a reasonable chance of collecting a handsome amount of money."

In cases where there is disagreement between the surface owner and the coal operator as to whether the mining operation caused damage to water supplies, the surface owner may file a complaint with DMLR. DMLR will conduct an investigation, and may even find that the damage complained of was the result of the mining operation. However, DMLR's ability to attribute damages definitely to mining operations are limited in many cases, in particular where adequate premining hydrologic monitoring was not required. The effects of the long-standing drought in the region make it particularly difficult to determine the cause of failure of wells and springs.

Even if DMLR does make a positive determination, it does not have statutory authority to order the mining company to remediate or replace the water supply, or compensate the surface

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Constraints to Protection of Water Rights Under the Common Law
owner, although a DMLR finding would undoubtedly strengthen the surface owner’s position in bargaining with the mining company. In cases in which the mining operator does not believe that it caused the damage, the surface owner has only two options: accept the damage and do nothing, or file a claim against the mining company in court.

There are a number of reasons why surface owners might choose to accept damage rather than take a mining company to court. The first, and most obvious, is cost. Pursuing a court claim against a mining company for water supply damage costs $1,500 to $10,000, according to Gerald Gray. Expenses include attorney's fees as well as fees for consulting geologists or hydrologists, if necessary. This might seem to be a reasonable investment, if the outcome were certain; but it is not.

The economic situation in the coal counties has been described earlier in this report. There are so many unemployed, disabled, and retired individuals living in the area on pensions, social security, and unemployment benefits that a significant component of its economy has been called a "mailbox economy." The rural areas under which mining is frequently conducted are not populated, on average, by well-informed people of means.

The ability and willingness of a surface owner to challenge a mining company in court depend not only on financial means, but on information and attitude. Speaking of the problems of seeking restitution for subsidence damages in Dickenson County, Judy McKinney, President of Dickenson County Concerned Citizens (a citizens’ group organized in opposition to longwall mining), offered the following characterization:

A lot of people don’t know what to do. I mean it gets to the point that a lot of people get really depressed. They don’t know what to do. A lot of people don’t understand the steps that they have to go through. [Many] are old people, and they don’t know what to do. The only thing they’ve ever done is just worked real hard all their life and minded their own business. They don’t know who to turn to. They don’t know all these different agencies. They don’t even know [the agencies] exist.142

This illustrates not only the lack of information available to the rural people of the coalfields, but hints at a kind of defeatist attitude noted by many in connection with this population. And from the point of view of a surface owner, perhaps elderly and with little formal education, the economic and political clout of the coal companies would seem to make the outcome of a court battle a foregone conclusion.

**Summary**

The protection of water rights under the common law is limited by the very nature of the operation of the common law. Its remedies are primarily after the fact and are reached through costly litigation whose outcome is inherently uncertain. Thus, the surface owner is forced to make a substantial investment for an uncertain return, just to retain or be compensated for what he already had. And, if some previous owner of the property sold the right to subjacent support along with the mineral estate, there may be no protection of the water right whatsoever.
Progress Made at DMLR

It is only in the past five years that longwall mining has operated on a large scale in Virginia, so it is perhaps understandable that DMLR has only recently begun to focus attention on its potential for subsidence damage to the hydrologic balance. As indicated at various points in this report, DMLR appears to have made substantial progress toward addressing deficiencies in the regulations applying to full-extraction underground mines, and in their implementation.

At the same time, it should be recalled that, as described in Section 4, there have been two changes in the regulations at the federal and state levels that reduce DMLR’s authority and ability to protect the hydrologic balance. One was the decision at the federal level not to require underground coal mine operators to replace water supplies. The other was the decision to remove the protection afforded perennial streams under the subsidence control regulations (in essence, mining was not permitted under perennial streams) by applying to them only the standards for protection of the hydrologic balance (minimization of disturbance, which, as noted, does not imply any particular level of protection).

143 In Re: Permanent Surface Mining Regulation Litigation. 19 BNA Environment Reporter, Cases, 1477, 1495, May 18, 1980.
Nevertheless, progress has occurred in other important areas. As was noted earlier, prior to February 15, 1987, the PHC determination submitted to DMLR as part of a mine permit application only needed to cover the permit area. The permit area in the case of underground mines is generally the area in which the direct surface impacts of the mine operation are contained, with the exception of subsidence impacts. The permit area would include staging areas, the mine entrance, roads, and coal processing buildings. In most cases, the surface area subject to subsidence impacts is outside the permit area. However, in February 1987, DMLR changed its permitting requirements. Sec. 480-03-19.784.22, which lists the requirements for geologic information to be included in permit applications, was changed as follows:

Each application shall include geologic information in sufficient detail to assist in (1) determining the probable hydrologic consequences of the operation upon the quality and quantity of surface and ground water in the permit and adjacent areas, including the extent to which surface- and ground-water monitoring is necessary.

The language of Sec. 480-03-19.784.14, which sets out the hydrologic information required as part of the permit application, was likewise modified to include both the permit and adjacent areas. The adjacent areas include, at a minimum, all subsidence impact areas, calculated by using a 28 degree angle of draw.

These changes, which were made in order to make Virginia's regulations as effective as those of the federal Office of Surface Mining Enforcement and Regulation, allow DMLR to require mining companies to provide data for areas outside the permit area that may be affected by subsidence. Since the lack of monitoring data has been an important constraint on protection of the hydrologic balance, this change is highly significant and should enhance DMLR's ability to predict and respond to subsidence impacts on water resources.

In accordance with its increased regulatory authority to require monitoring outside the permit area, DMLR's hydrologic monitoring requirements for high extraction mines have become

more extensive. DMLR is not only requiring hydrologic monitoring over subsidence impact areas for new permit applications but for significant revisions of existing permits as well. Additionally, since most existing permits are for five years, and most were approved under VCSMCRA in the early- to mid-1980s, the post-1987 monitoring requirements will be applied to the permits now or soon being reviewed for renewal.\(^{146}\)

A hydrologic study being conducted by Island Creek Coal Co. demonstrates DMLR's willingness to use its enhanced authority to require more complete and adequate data on hydrologic impacts of longwall mining. As part of a permit revision agreement, DMLR and Island Creek cooperatively designed the study, and Island Creek has been implementing it. Island Creek operates several longwall mining operations in the Pocahontas coal seam in Buchanan County. The seam is deep: 1200 to 1500 feet below drainage (i.e., below the valley floors) in some places, with up to 2400 feet of overburden. The study involves monitoring of static water levels in three test wells placed in strategic locations over a longwall panel in the VP-6 mine in Buchanan County. Water quality samples are also being taken, and water levels in nearby domestic wells are being monitored. Subsidence and seismic monitoring will provide data to be correlated with hydrologic data. Mining of the panel was completed in August 1988, and hydrologic monitoring, which began before mining of the panel, continues. A final report, due in June 1989, should provide some much-needed information on the specific hydrologic effects of longwall mining in Virginia.

The February 1987 changes to the regulations also allowed DMLR to begin an instream monitoring program. Under this program, mining companies are required continuously to monitor both streamflow and water quality upstream and downstream of the permit and adjacent areas, including, in some cases, subsidence impact areas. Monitoring, which prior to the

\(^{146}\) Haynes, L., ibid.
regulatory changes was only required for 6 months prior to mining to establish a baseline, is now required both before and during active mining.\footnote{146}

Recognizing the need for a more complete information base for its regulatory program, DMLR has undertaken a comprehensive research and information management effort. A cooperative project involving DMME and two of its divisions, DMLR and the Department of Mineral Resources; the Powell River Project; selected coal companies; the U.S. OSMRE; and the U.S. Geological Survey was undertaken to characterize and evaluate the groundwater system of the coalfields of southwest Virginia, establish geologic and hydrologic databases for the coalfields, and produce geologic maps of the area. The hydrologic study was described in Section 3 of this report.\footnote{147} This system will contain information on static water levels, stratigraphy, rock types (including acidification potential), and some water quality parameters at hundreds of geologic data points throughout the coalfields. Based on a minicomputer at DMME’s Big Stone Gap offices, the system will comprise a geologic database compatible with the USGS National Coal Resources Data System, and a custom-designed water resources database. Outputs include reports, maps, fence diagrams, and three-dimensional perspective maps.\footnote{148} The system should provide DMME and its divisions (DMLR, DMR), as well as coal companies with a much improved information base for planning and permitting of mining operations, reclamation, and mitigation.

Another perspective on DMLR’s progress can be found in the annual oversight reports on Virginia’s regulatory program compiled by the U.S. Office of Surface Mining Reclamation and Enforcement (OSM). In its fiscal year 1985 report, OSM notes that in the previous review period (FY 1984), deficiencies were found in subsidence control plans approved by DMLR. Ac-

\footnote{146}{Haynes, L. DMLR Technical Services Division, Big Stone Gap, Virginia. Personal communication, February 6, 1989.}

\footnote{147}{See note 33, supra.}

cording to OSM, "subsidence survey summaries and proposed monitoring plans for surface structures and features did not specify how the degree of damage was to be determined." By 1985, DMLR agreed to require more complete information on subsidence surveys, and to include the surveys in the permit. OSM in its FY 1985 report noted "significant improvement" in subsidence control plans compared to FY 1984.

It was also noted in the FY 1985 report that in 1984, the data used to prepare cumulative hydrologic impact assessments (CHIAs) were inadequate, and that DMLR's groundwater monitoring requirements were deficient. This problem, according to OSM, was corrected the following year. The groundwater monitoring problem that OSM noted concerned DMLR's narrow interpretation of "permit area" in connection with hydrologic monitoring. DMLR, according to OSM, was considering only the impacts of surface disturbances of underground mines on ground water quality and quantity, resulting in permitting "in a manner which does not insure protection of the hydrologic balance outside the permit area." OSM notes that Federal regulations require that ground water monitoring be performed to protect those waters within the permit and adjacent areas which may be adversely impacted. The definition of "adjacent area" at 30 CFR 701.5 includes the "area outside the permit area where a resource of resources are or reasonably could be expected to be adversely impacted by proposed mining operations, including probable impacts from underground workings," a definition which the preamble states was designed to specifically include the probable impacts from underground workings.

In response to OSM's concern, DMLR agreed to make all changes necessary to make its regulation on hydrology as effective as the federal rule. OSM was also concerned about DMLR's waiver of groundwater monitoring in certain cases, and again, DMLR agreed to make the necessary regulatory changes to respond to this criticism.

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149 It should be noted that DMLR disagreed with this assessment.


151 Ibid.
However, in its FY 1986 evaluation, OSM again expressed concern over DMLR’s permitting of underground mines, specifically with respect to subsidence and hydrology information. While the subsidence surveys in the permits had improved with respect to surface structures, renewable resource lands were not fully addressed in any of the permits to the extent that this term includes aquifers and aquifer recharge zones in areas overlying underground workings. Detailed information on geology and hydrology was absent in six permits. The remaining four permits contained technically inadequate information or presented unsubstantiated statements that mining would not appreciably impact the hydrologic regimes.

The report notes that DMLR had developed official policy and procedural modifications to address these concerns during the evaluation period, and that they were under review by OSMRE.

The FY 1987 evaluation report states that DMLR had resolved the deficiencies in its subsidence control plan requirements with respect to technically adequate information and consideration of aquifers and aquifer recharge areas as renewable resource lands. The FY 1988 evaluation report, examining permit applications approved after the effective date (November 25, 1986) of the regulatory amendment addressing this problem, concluded that "aquifers and aquifer recharge areas are discussed in sufficient detail to justify the absence of, or need for, a subsidence control plan." Through a program amendment, the problem noted in the FY 1985 report with respect to inappropriate or unjustified waivers of groundwater monitoring was also resolved.

It is worth noting that, in the last four fiscal years, OSMRE has found DMLR’s inspection and enforcement program to be satisfactory in most areas. In the FY 1988 report, for example, OSMRE makes the following statement: “DMLR made 100 percent of all mandated in-


spections. Inspections were adequately documented and complete inspections appeared to cover all applicable performance standards. Enforcement actions and follow-up actions were appropriate, effective, and timely.\textsuperscript{155} OSMRE found that DMLR's record for citing violations had improved in FY 1988.

**Summary**

DMLR has made significant progress toward addressing those constraints on its ability to protect the hydrologic balance over which it has some control. One of the constraints identified earlier in this report was the lack of data, which stemmed in part from DMLR's failure to require adequate data from permit applicants. DMLR has recognized the need for more complete data, and has learned to scrutinize PHC determinations more carefully. It has changed its regulations in order to require monitoring in subsidence areas. Furthermore, the agency has been building what one attorney in the Environmental Law Institute has called an "enviable" information base for regulatory decisionmaking.\textsuperscript{155}

A knowledge of what is actually happening in the field is an absolute precondition to any attempts to control the environmental effects of coal mining, so DMLR's recognition of the inadequacy of its knowledge base and efforts to remedy the situation are laudatory. It must be concluded that the agency has come to recognize the disruptive potential of longwall mining and is taking its task — protection of the environment from the effects of coal mining — seriously. Nevertheless, it must be recalled that there remain constraints on the agency's ability

\textsuperscript{155} Ibid., p. 3.

to do so that are beyond its control, and so the protection of water resources by the agency is not assured.
Progress and Problems in Four States

One of the goals of the Surface Mine Control and Reclamation Act, and the Office of Surface Mining program implementing it, has been to achieve a degree of uniformity among the states in the regulation of the effects of coal mining, so that individual states could not gain a competitive advantage through lax environmental standards. In order to receive authority from OSM to implement their own programs under the Surface Mine Control and Reclamation Act of 1977, states have had to enact laws and promulgate regulations that are as effective as OSM’s. While the states’ programs are now more alike than before SMCRA, differences result from differing laws, regulations, court decisions, interpretations of property rights, and implementation by the regulating state agency. Moreover, in none of the states surveyed has the body of laws and regulations stabilized; regulation of surface and underground coal mining continues to evolve in each.187

In the following sections, the regulations under SMCRA in the states examined are described as they apply to subsidence and the protection of the hydrologic balance. This is not intended to be an exhaustive survey of all coal-mining states. The states included were chosen either

187 This is not surprising, considering that the federal regulations under SMCRA are still in a state of flux more than a decade after the law was signed.
because, as in the case of Kentucky and West Virginia, the geology of their coal-mining regions is similar to that of Virginia's; or because their regulatory schemes are noteworthy. Nor is an indepth examination of each state possible within the scope of this thesis; rather, this section will highlight some of the salient features of each of the four states' coal mining regulatory programs and related activities.

**Pennsylvania**

Pennsylvania is a state with a long history of both coal mining and coal mine subsidence problems. In 1913, Pennsylvania passed a law limiting coal mining beneath streets and highways, and later expanded this law to provide protection from subsidence to public facilities and dwellings. This law was declared unconstitutional in *Pennsylvania Coal Co. v. Mahon*, a landmark Supreme Court decision on the taking issue. However, the constitutionality of Pennsylvania's current coal mining subsidence control program was recently upheld by the U.S. Supreme Court, in *Keystone Bituminous Coal Association, et al., v. Nicholas DeBenedictis, et al.* Pennsylvania’s program reflects the state’s long acquaintance with subsidence damage to both structures and the land. It goes farther than the federal primacy requirements in protection of both surface owners and water resources.

Pennsylvania’s regulatory program for the environmental effects of coal mining are authorized under the Coal Refuse Disposal Control Act, the Surface Mining Conservation and Recla-
mation Act, the Bituminous Mine Subsidence and Land Conservation Act, and the Clean Streams Law. Under the revised federal primacy subsidence control program that came into effect on July 1, 1983, surface structures are no longer included in the definition of surface lands and so are not protected at the federal level by the requirement that operators protect surface lands from subsidence damage. However, the state’s Bituminous Mine Subsidence and Land Conservation Act establishes the operator’s duty to “remedy damage to structures” of surface owners. The regulations effective March 30, 1985, in the section on performance standards, state that mining shall be conducted in such a way as to prevent subsidence damage to, among other things, dwellings “in place on April 27, 1966.” The prohibition of subsidence damage to structures may be waived by the current owner. Coal operators must, within 10 days of being advised of a claim of subsidence damage to a structure or surface feature, provide the Department of Environmental Resources (DER) with pertinent information. Settlement of claims must be made within 6 months or an amount determined by the DER to be equal the reasonable cost of remedying the damage must be deposited with the DER, to be held in escrow until the operator submits evidence that the claim has been settled.

For the purposes of subsidence control, streams and springs that flow continuously during all of the calendar year as a result of groundwater discharge or surface runoff are defined as perennial streams. Section 89.143(b.1.iv.) states that underground mining activities “shall be planned and conducted in a manner which prevents subsidence damage to ...Aquifers, perennial streams, and bodies of water which serve as a significant source for a public water supply system.” The regulations implementing the Federal primacy program, just quoted, do not require the protection of perennial streams that do not serve as a public water supply.

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181 52 P.S. Sec. 1396.1-1396.25
182 52 P.S. Sec. 1406.1-1406.21
183 35 P.S. Sec. 691.1 et seq.
184 Sect. 89.143 b.1.i
However, protection of such streams was adopted under a separate state law. Under the performance standard an operator is required to maintain the premining uses of the stream, including aquatic life support, water supply and recreational uses. The operator determines the necessity for and the appropriate measures to be taken to prevent subsidence damage to the stream. If the stream is damaged by subsidence then the operator is required to restore the stream to its premining condition. If the measures taken to protect the stream are ineffective, the operator must submit revised plans or other data to demonstrate that future mining activities will meet the performance standard.165

The U.S. Office of Surface Mining Reclamation and Enforcement (OSMRE) made the following statement in its annual report for fiscal year 1986:

Combined efforts of DER and OSMRE during 1986 have resulted in the modification of the bituminous surface mine permit application to solicit an adequate Probable Hydrologic Consequence (PHC) determination. In turn, the PHC provides supportive information for the proper implementation of an administratively complete and technically proficient Cumulative Hydrologic Impact Assessment (CHIA) process. Based upon the CHIA process, DER will be able to conduct an evaluation of a proposed mining operation in concert with existing and anticipated mining operations to assure the hydrologic balance of the entire area is properly protected.166

Pennsylvania has experienced instances of hydrologic damage resulting from longwall mine subsidence. Pumping and treating water flowing into a longwall mine resulted in an interbasin diversion and consequent periodic dewatering of a trout stream. High extraction mining subsidence has resulted in dewatering or suspected dewatering of streams in Cambria, Indiana, Washington, and Greene Counties, and individual water wells have also been affected.167

The Division of Fisheries Environmental Services identified some problems in the state’s regulatory program. The regulations concerning permit application requirements with respect to subsidence control contain a definition of perennial stream that is different from that contained in the general definitions section. The definition in the latter section (Sec. 89.5) identifies a perennial stream as "a body of water flowing in a channel or bed composed primarily of substrates associated with flowing waters and ...capable ...of supporting a benthic macroinvertebrate community..." In the subsidence control application section, by contrast, the definition is more restrictive: "a stream or part of a stream that flows continuously throughout the calendar year as a result of ground-water discharge or surface runoff." According to the Division, this definition change results in a lower degree of protection for some streams that support aquatic life but do not necessarily flow every day of the year.

Moreover, according to the Division, although mining is to be conducted in such a way as to protect from subsidence damage perennial streams which are not significant sources of public water supply, "the prediction of subsidence damage [for such streams] may be more of an art than a science. Usually damage must occur prior to DER intervention and then it is a long drawn out process to definitively prove damage." And even with the regulations protecting perennial streams, it is still possible that perennial streams not undermined may be dewatered into intermittent streams because of subsidence-induced water table reductions or diversions from nonperennial streams in headwater zones.

As in Virginia, the regulatory agency in Pennsylvania cannot require replacement of subsidence-damaged water supplies to individual surface property owners. Most water damage cases are resolved outside the regulatory system, and the larger coal companies maintain voluntary water replacement policies. And again, as is the case in Virginia, the lack

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189 Sec. 89.141(b)2

170 Ibid., p. 2.
of data available to the regulatory agency makes it difficult to determine the cause of well
dewatering. Groundwater monitoring has been largely limited to determining the effects of the
surface facilities for underground mines because of a restrictive regulatory interpretation
similar to the one that Virginia recently abandoned.171

Kentucky

In 1985, Kentucky's coal production accounted for over 17 percent of all coal produced in the
U.S. Underground mines alone produced 81.2 million tons. Despite the size of the coal mining
industry in Kentucky, there are only a few longwall operations, according to an official at the
Department for Surface Mining Reclamation and Enforcement of the Natural Resources and
Environmental Protection Cabinet.7

In 1986, the National Wildlife Federation filed a suit against the regulatory agency, the De-
partment for Surface Mining Reclamation and Enforcement of the Natural Resources and En-
vironmental Protection Cabinet. The allegations contained in the suit included failure to cite
all violations, failure to take alternative enforcement action, and failure to provide information
on pre-mining rate of recharge of ground water.172

The 1987 report by OSMRE on Kentucky's program mentions that "there are several complex
issues dealing with hydrology relating to underground mining which have not been addressed
sufficiently by Kentucky."173 Perhaps most revealing of the state of Kentucky's regulation of

172 U.S. Office of Surface Mining Reclamation and Enforcement. Fifth Annual Report: Kentucky Perma-
173 Ibid., p. 6.
the environmental impacts of subsidence is the following statement from the OSMRE 1987 report:

Subsidence above underground works is another complex technical issue which needs to be addressed. Large crevices, some as broad as eight feet, have been noted, and on occasion made public roads impassable and dangerous. Kentucky needs to recognize this as a serious problem and begin to deal with it as a mining impact which must be addressed through proper planning and correction by the operator.174

While the preceding quote suggests that Kentucky's implementation of its regulations may have been inadequate, at least in 1987, the regulations themselves are similar to those of other states. Kentucky's subsidence control regulations essentially parallel the federal regulations, except that mine operators are liable for subsidence damage to structures. Subsidence control must be addressed in the mining and reclamation plan to be submitted as part of a permit application for underground mining. Existing structures and the anticipated effects of subsidence on them must be addressed. The operator has several options to "mitigate the effects of any material damage or diminution of value or foreseeable use of lands" that may occur as a result of subsidence:175 1) "Restoration or rehabilitation of structures and features ...to premining condition"; 2) replacement of structures destroyed by subsidence; 3) purchase of structures prior to mining and restoration of land after subsidence; or 4) purchase of noncancellable insurance policies payable to the surface owner in the full amount of the possible material damage or other comparable measures.

The section on performance standards for subsidence control (KAR 18:210, Sect. 3) states that each permittee "who conducts underground mining which results in subsidence that causes material damage or reduces the value or reasonably foreseeable use of the surface lands shall, with respect to each surface area affected by subsidence," either restore each damaged "structure, feature, or value," purchase it, or compensate the owner as described above.

174 Ibid., p. 7.
175 405 KAR 8:040, Sect. 26
Kentucky's regulations, like the federal regulations, require a determination of the probable hydrologic consequences (PHC) of mining operations. For ground water systems, the PHC must include impacts on water quantity, "emphasizing water levels and the potential for water supply diminution for existing users, and dewatering of aquifers which are not currently being used for water supply but have the potential to be developed as a water supply source";¹⁷⁸ and water quality. Submission of baseline data to support the Cabinet's determination of cumulative hydrologic impacts is required.

The section on hydrology in the performance standards for underground mining is couched in relatively general terms similar to those found in the federal regulations. Underground mining is to be conducted to "minimize disturbance of the hydrologic balance in both the permit area and adjacent areas," in order to prevent "material damage" to the hydrologic balance outside the permit area, and support the approved postmining land uses.¹⁷⁷ Changes in water quality and quantity "shall be minimized." Most of the language on hydrologic effects is geared toward those expected to result from surface operations.

Under the section on subsidence control in the performance standards (405 KAR 18:210), mining beneath or adjacent to perennial streams is prohibited unless the Cabinet finds that subsidence will not cause "material damage." If it does, "measures will be taken" to the extent technologically and economically feasible, to correct the damage and prevent additional subsidence from occurring. Underground mining is also prohibited beneath any aquifer that serves as a significant source of water supply to any public water system. According to DSMRE geologist Tim Sullivan, coal operators are required to identify an alternate water supply if damage to an existing one is anticipated.¹⁷⁹ However, as with the federal regulations, Kentucky's regulations do not require replacement of private water supplies.

¹⁷⁸ 405 KAR 8:040, Sect. 32
¹⁷⁷ 405 KAR 18:060, Sect. 1
¹⁷⁹ Sullivan, T. Kentucky Department of Surface Mining Reclamation and Enforcement, Frankfort. Personal communication, August 18, 1988.
Ohio

Although Ohio has relatively few longwalls (five in 1986), there has been considerable activity relating to the regulation of their effects. This is attributable, at least in part, to two factors. One is that the economic contribution of coal mining, statewide and even in the coal mining regions of the state, does not loom as large as it does in the coalfields of Virginia. The land being undermined is productive agricultural land, typically used for dairy farm operations. Surface subsidence and, especially, hydrologic impacts can have serious economic consequences on such operations. Second, while Ohio was in the process of rulemaking under their then-new primacy program, a number of unexpected and well-publicized adverse impacts of subsidence over longwall mines created a negative image that has stayed with longwall mining in Ohio. The state's caution in dealing with these impacts, attributable in part to a lack of clear authority under the state's regulations, helped galvanize local opposition. A group called Citizens Organized Against Longwalling (COAL) formed and has had a significant influence on the development of regulations dealing with subsidence in Ohio. The organization's success has encouraged the formation of local groups in other parts of the state affected by longwall subsidence; there is now "essentially a group for each longwall mine in the state."178

Underground coal mining is regulated in Ohio under Chapter 1513 of the Ohio Revised Code (O.R.C. 1513). Chapter 1513 predated SMCRA, and was amended in 1978 to extend regulation to the surface effects of underground coal mining. The state's regulatory program is administered by the Department of Natural Resources (DNR), Division of Reclamation. While SMCRA, per the Flannery rulings, does not require replacement of water supplies affected by underground mining, Ohio law (O.R.C. 1513) does. Repair of perennial stream reaches dam-

178 Payne, H., Ohio Division of Reclamation, Athens, Ohio. Personal communication, October 6, 1988.
aged by mine subsidence is included in subsidence control plans; however, Rothwell and Payne note that "the actual feasibility of such repairs remains to be tested."\(^{100}\)

The state has recently (January, 1989) put new policies into effect with respect to structural damage resulting from subsidence. The Governor of Ohio, by executive order, gave the regulatory agency the power to require repair of such damage. This policy, which under the executive order will remain in effect for 90 days, may be made permanent by the Ohio legislators, who are considering a bill aimed at longwall mining.\(^{101}\) Under the current rules, mining companies using longwall technology must undertake detailed presubsidence surveys, including photographic evidence, to establish a baseline against which DNR can judge the extent and cause of structural damage. In order to receive, revise, or renew a permit, coal operators must commit themselves to either repair or compensate surface owners for subsidence damage regardless of whether the right to subside was deeded to the coal operator.\(^{102}\)

Insufficient data for assessing potential hydrologic impacts of longwall mining has been a continuing problem for the regulatory agency. This problem has been addressed through changes in the regulations and through sponsored research. DNR now requires, for new mines or significant extensions in existing mines, a year of premining well monitoring (static water levels and water quality) as well as data correlating well data and the progress of the longwall face.\(^{103}\) DNR is considering requiring pump tests (although there is some disagreement among the agency's hydrologists about the value of such tests, given their expense) and

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\(^{102}\) Payne, H., Ohio Division of Reclamation, Athens, Ohio. Personal communication, October 6, 1988; and Coal Outlook 13(5):4, February 8, 1989.

\(^{103}\) Payne, H., ibid.
aquifer modeling from mining companies using longwalls. The companies' position has been that the aquifers in question cannot be adequately modeled.164

Two studies of hydrologic effects of longwall mining in Ohio have been conducted. In 1984, Coe and Stowe examined effects of longwall mining on well levels and spring and stream flow rates in eastern Ohio.165 In this study, dug and drilled wells, ponds, developed springs, and a stream were monitored over two different longwall mines. In one case, "nearly all water sources were affected as the result of surface fracturing of a shallow sandstone aquifer, which effectively drained the aquifer."166 In the second case, several wells were partially or completely dewatered, one of three ponds showed water level decline, and a stream was affected by fracturing so that its flow was sporadic after mining. The hydrologic disturbance in the second case was described as less severe than in the first due to a higher proportion of plastic shales and claystones in the overburden. More recently, the USGS studied the cumulative impacts of longwall mine subsidence on streamflow, water quality, and benthic populations; however, a severe drought in 1988 rendered the study inconclusive so far.167

West Virginia

West Virginia, which accounted for nearly one third of the nation's underground coal production in 1985, has more active longwall mines in operation (about 30) than any other state.168

164 Payne, H., ibid. Mr. Payne notes that the companies seem to share a concern that the more data they supply, the more likely it is that it will be used against them.


166 Ibid., p.402.

167 Swisshelm, R., USGS, Columbus, Ohio. Personal communication, January 6, 1989.
Following the passage of the West Virginia Surface Coal Mining and Reclamation Act in 1981, West Virginia was granted primacy in implementing SMCRA. The state's Department of Natural Resources (DNR) originally was given authority for implementing the regulations, but in 1985 the West Virginia Energy Act created the Department of Energy, which took over regulation of the coal industry, including subsidence regulation.

The implementation of subsidence control regulations in West Virginia did not proceed smoothly. The DNR, in implementing the first set of subsidence control regulations, attempted to apply them only prospectively, with existing underground mining operations (as of July 15, 1983) "grandfathered" in. A subsequent court decision found that this was invalid, and in 1985 DNR ordered all underground mining operations to submit subsidence control plans. If a preliminary survey indicates that no material damage or diminution in value or foreseeable use of the land will result from subsidence, the subsidence control plan requirement may be waived. And, since many West Virginia mines are located in sparsely populated mountainous areas, they qualify for subsidence control plan waivers.180

During the permit application review process, the subsidence control plan undergoes a two-level review. High extraction mine operators (greater than 80 percent) must submit data over and above that required for lower extraction mines, to include: maps of subsidence areas; predicted subsidence profile; measures to prevent material damage to land and structures (unless operator has the right to subside); and a description of the effects of planned subsidence.

In cases where a coal operator can demonstrate in the subsidence control plan submitted during the application process that a legal "right to subside" exists, the operator does not have to detail measures taken to prevent subsidence damage to structures, and does not have

to remedy damage to structures caused by mining operations. This absolute "right to subside" has recently been the subject of litigation, but according to Mark Scott, head of Administration and Enforcement in the DoE, in the case of leases that give the operator the right to subside there is no legal recourse for damaged property owners. A mine subsidence insurance program makes protection for structures available in West Virginia. For cases where this right does not exist, the DoE provides the following guidance for its regulatory personnel:

Dwellings without the right to subside become extremely sensitive issues to handle. The only acceptable mitigative measure appears to be leaving coal to prevent material damage, unless the company and the resident has worked out some mutually acceptable remedial measure.109

Although aquifer mapping was required for the subsidence control plans, currently only narrative descriptions of "significant" aquifers are required. Subsidence control plans are required to identify alternative water supplies for individual landowners whose wells and springs are likely to be damaged by underground mining. Provision of alternate water supplies is required in West Virginia.110 Cases in which there is disagreement between the landowner and the coal operator as to whether the mining operation caused the water loss are decided by the regulatory agency.111 As in most states (following the federal regulations), the terms, "significant aquifer" and "hydrologic balance" are not clearly defined for purposes of regulation.

West Virginia, in its guidelines for subsidence control plans, takes a position that seems to grant a presumption of no damage to coal operators. First, the Department says that "if the


110 Scott, M., Deputy Director for Administration and Enforcement, Department of Energy, Charleston, West Virginia. Personal communication, August 26, 1988.

overburden is more than 250-300 feet and is at least 60 times the seam thickness, material damage to streams is unlikely. It takes a similar position with respect to aquifers:

The effects of subsidence on aquifers are very much site specific based on stratigraphy or lithology. When the ground subsides due to mining, depending on the nature of the overburden, there is a fracture zone, extending above the mined seam, about 35-60 times the seam thickness. If the aquifer and the well bottom are above this zone, and there is a well developed shale bed below the aquifer, the chances of material damage are minimal. Even if there is a temporary loss during mining, the shale bed tries to seal itself after mining, forming an aquiclude, and the aquifer returned more or less to the original level.

The state is requiring increasingly detailed premining hydrologic data. Mining companies have shown a willingness to implement monitoring, since good monitoring data can provide them with protection against spurious water claims. The DoE has had problems managing the data they receive, however, and there are concerns over the quality of the monitoring data. The agency has contracted with West Virginia University for data validation and management assistance.

The summary of West Virginia’s mining regulatory program in OSMRE’s 1986 Annual Report noted that “the State has made only minimal progress in implementing the hydrologic protection provisions of SMCRA. Cumulative Hydrologic Impact Assessments (CHIAs) are not being prepared by DOE and problems continue to exist in the adequacy of statements of probable hydrologic consequences (PHCs) and in the use of inadequate baseline hydrologic data.” A CHIA process has since been implemented in West Virginia, according to Dennis Boyles of the OSMRE field office in Charleston. Each of the DoE’s seven field offices now has a CHIA leader, and all permits have undergone a CHIA. The CHIAs are not based on

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184 Scott, M., *ibid.*

185 Boyles, D., *ibid.*


187 Personal communication, February 23, 1989.
hydrologic modeling, but rather professional judgement of the regulatory personnel. OSMRE still has some concerns about the quality of the CHlAs being produced by the agency, however.

West Virginia’s program recently has been criticized by others as well. A coalition of environmental organizations has recently filed suit against the Department of Energy for failing to properly implement SMCRA. A source within the West Virginia Department of Natural Resources described the environmental impacts of coal mining in the state as worse than they were before SMCRA; and an environmental attorney familiar with coal mine regulation claims that West Virginia’s lax enforcement of its regulations is giving the state a competitive advantage of about three dollars per ton over Kentucky coal.

Summary

In a recent presentation on activities related to longwall mining subsidence in different states, in particular activities perceived by the mining industry as threats to longwall mining, Gerald McPhee of Island Creek Coal Co. identified two recurring themes: concern over subsidence damage to structures, and concern over effects on water resources. In all but a few of the states in which longwall mining is practiced, subsidence has received political recognition as a problem. In several states, citizens’ groups opposing the practice have attempted to influ-


186 Jernejcic, F., Department of Natural Resources, Charleston, West Virginia. Personal communication, February 6, 1989.

200 Galloway, T., id.

ence governmental policy. And on the national level, a battle is taking shape over the application of certain provisions of SMCRA to subsidence effects of underground mining.

The four states reviewed in this section have responded in different ways to the problems posed by longwall mining. The problems, however, are substantially the same: damage to surface structures, surface water bodies, and water supplies making use of groundwater. An attempt to account for the varying responses among the states would be constitute a thesis in itself. For example, what political, social, economic, or institutional factors account for the fact that Ohio and West Virginia require replacement of damaged water supplies while Pennsylvania and Kentucky do not?

What is perhaps more important is to look at the experience in other states for lessons that could be of use to both the coal industry and the regulatory agency in Virginia. The clearest lesson is that if longwall mining is practiced on a large scale, there is strong potential for subsidence damage and conflicts between coal companies and landowners. This fact, and the necessity of resolving the conflicts, make monitoring of both subsidence development and hydrology essential; and the more data that are available, the better, both for the regulatory agency and the coal companies. The experience in these states suggests that unless coal operators and landowners can come to some basic agreement over longwall mining, which is unlikely unless the landowners feel fully compensated, conflicts over liability for both damage to structures and water supply impairment will not go away, nor will pressures on the agency, which will tend to be caught in the middle. Development of a consensus between coal operators and surface owners on both the necessity of longwall mining and the necessity of full compensation for damages is viewed not only as a practical necessity by the Chief of Ohio’s Division of Reclamation, but as a real possibility as well.202 Ohio, perhaps because of the presence of well-organized and politically active groups opposed to longwall mining.

seems to have made more progress toward a resolution of the conflict between coal operators and surface owners than any other state. The need for building a consensus in which surface owners and coal operators each recognize the legitimate claims of the other, is the most valuable lesson for Virginia in this review of other states' experiences with longwall mining.
Conclusions and Recommendations

This thesis has considered the hydrologic impacts of longwall mining and the adequacy of the controls over those impacts. Specifically, it has addressed the following question: Are the available control mechanisms (technical, regulatory, and legal) adequate for protection of the hydrologic balance from the adverse effects of subsidence caused by high-extraction underground coal mining? This section draws conclusions and presents recommendations based on them.

**Ability to Protect Hydrologic Balance Through Technical Means**

From a review of the literature and interviews with numerous federal and state officials, as well as representatives of citizens' groups and environmental organizations, the conclusion is inescapable that longwall mining, through the action of subsidence, inevitably disturbs the hydrologic balance. Though the effects, and their impacts, are determined by site-specific
factors, it is safe to say that groundwater levels over longwall panels are likely to decline, and that developed water sources (wells and springs) will be adversely affected. Surface water bodies may be damaged as well. Although the hydrologic impacts are limited in most cases to the surface area subject to subsidence, this area, for Virginia mines using longwall systems, is quite large. The adverse impacts upon developed water sources are particularly burdensome in the coalfield region because of the reliance of rural residents upon relatively scarce groundwater for water supply.

The only reliable method of protecting a surface feature from the damaging effects of subsidence is to prevent subsidence by not extracting more than 50 percent of the coal beneath the feature. Damages to structures can be prevented in some cases by premining precautions, such as jacking; structural damage can also be repaired, although in some rare cases the damage is so severe that it is not economical to do so. However, it appears likely that alteration of the hydrologic balance cannot be prevented except by preventing subsidence. This may be practical in the case of streams, but for groundwater, which is diffused over broad areas, it is not. Likewise, while in some cases a damaged streambed might be repaired, damaged groundwater cannot be. The adversely affected water user can only wait and hope that water levels recover. It is likely that recovery will occur eventually, and in the long run there may even be beneficial effects such as increased groundwater availability and stream baseflows. Nonetheless, recovery and enhancement are far from certain.

**Adequacy of Protection Under the Common Law**

The common law does not, and cannot, provide adequate protection for water resources from the effects of subsidence. In the first place, as a rule, damage must have occurred already before there is cause for suit. Second, in some cases, the surface owner’s predecessors in
interest may have ceded the right to subjacent support, so that the surface owner has no legal recourse. Third, litigating is inherently risky and requires substantial investment. Rural residents of the coalfields, on whom the burden of proof is placed, may not have the resources, either in terms of time, money, or information, to enter into a court battle with a coal company. Finally, there is the question of whether the protection of water rights of surface owners is the same thing as protection of the hydrologic balance. I contend that it is not. If a spring is not used for water supply by a surface owner, and it is dewatered, is this therefore a negligible impact? The short-term and long-term effects of subsidence dewatering of springs, seeps, and surface water bodies on the ecological balance have yet to be determined.

Leaving aside the question of whether the common law provides adequate protection to the hydrologic balance, one can ask whether the common law even provides adequate protection to property rights. There are several related questions here. The first is a question of equity: is it right that surface owners should have to bear a part of the cost of coal production without compensation? Clearly, I think, it is not, and in this the common law would agree. In cases where the deed severing the mineral and surface estates ceded the right to subjacent support, the coal companies argue that the owner or his predecessor in interest has already received compensation. Whether the surface owner, or his predecessor, entered into the agreement with full information about the consequences, or received adequate compensation, is open to question, and has been raised in lawsuits involving longwall mining. The coal industry’s answer to this question, as expressed by an attorney who has represented coal companies in such suits, is “wise or not, a deal is a deal.” On the other hand, the coal companies using longwalls recognize, through their policies, that corporate responsibility and “good citizenship” require them to provide repair or replacement of water supplies damaged by subsidence, irrespective of the terms of the deed. This inconsistency can be explained, I think,

in terms of the companies' recognition of the requirements of equity and public relations on the one hand, and their desire to maintain control by repairing or replacing water voluntarily, on the other.

The second question has to do with the adequacy of compensation. A rural resident who has had a dependable source of water, free, from a spring or well is unlikely to feel completely satisfied with hookup to a public water supply if he then has to pay for the water he uses. Or, if a cistern is installed and filled regularly by the coal company until, perhaps, a replacement well can be installed, the surface owner still suffers inconvenience, invasion of privacy, and uncertainty. If he is dissatisfied, his only recourse is the courts. And in those cases where a surface owner's well or spring has gone dry or become unusable, and the coal company feels it is not responsible and so refuses to take any action, the surface owner is again faced with either going to court or simply accepting his fate.

The foregoing leads to a recommendation for legislative action. Following the examples of Ohio and West Virginia, Virginia should enact legislation requiring replacement of water supplies damaged by subsidence by the coal company responsible. Such an assignment of liability would have the beneficial effect of including in the coal company's accounts a cost of production that may under current law be fobbed off onto the surface owner. The additional burden on the coal companies should be slight since it is already their policy to replace water supplies. What such a law would accomplish is to remove the uncertainty that is one of the most burdensome aspects of the situation for the surface owner.

The law should provide that in cases where there is a dispute as to the company's causing the damage, the regulatory agency, DMLR, would make the determination. An appeals process could be set up to resolve those cases, which should be few, where either the surface owner

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204 Virginia State Senator Buchanan, at one of the hearings on subsidence in Southwest Virginia held by the Joint Subcommittee Studying the Effects of Longwall Mining, compared such compensation to shooting a farmer's cow, and then giving him a bucket to go to town and buy milk.
or the coal company is dissatisfied with the result. Shifting responsibility for these determinations to the regulatory agency removes another cost from the surface owner, that referred to by economists as the transaction cost. DMLR, with its staff expertise and the monitoring data it receives from coal companies, is better equipped to make such determinations than the courts.

**Adequacy of Regulatory Protection**

The question of whether the regulatory apparatus adequately protects the hydrologic balance may be resolved in two parts. The first has to do with the regulations themselves — do they provide adequate authority to the implementing agency? Do they address the necessary areas? Do they have any "teeth"? If the regulatory scheme passes this first test, the question then becomes whether the implementation is adequate. The question of the adequacy of implementation again depends on certain conditions being met. Before getting into that question, however, let us examine the first.

The regulations established for the carrying out of VCSMCRA are a curious mixture of detail, specificity, and comprehensiveness together with vagueness and ambiguity at a number of crucial points. They are so complex as to be nearly incomprehensible, according to at least one observer who has been involved in the litigation of SMCRA for a decade. It is clear from a reading of the regulations that they were designed first and foremost for controlling the effects of surface mining, and only secondarily for controlling the surface effects of underground mining.

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As discussed earlier, the level of protection endorsed by Congress in enacting SMCRA was partial. Effects of mining were to be minimized, limited to the permit area, and temporary (hence the bonding and reclamation requirements). The law recognizes that mining will necessarily entail certain impacts, but these are to be kept to a minimum. The permitting requirements of the regulations establish a spatial boundary beyond which significant effects on water quantity and quality are not allowed. They require an attempt to predict hydrologic (and other) impacts, and in addition require that the applicant demonstrate how such impacts will be minimized or mitigated. Based on the expected impacts, the regulations require planning and implementation of monitoring to ensure that there are no unexpected or uncontained impacts. So far, so good.

A graduated series of mandatory warnings and sanctions of increasing severity is provided for by the regulations to ensure that mining operators comply with the provisions of the approved permit and the performance standards. As noted earlier, the lack of technical options for repair of hydrologic damage limits DMLR's responses when unexpected damage occurs. In other words, if a mining operation, following its approved plan, generates some unanticipated adverse impact, DMLR can only order the mining company to repair it if it is technically feasible. In the case of hydrologic impacts, it may not be. It is at this point that the agency's options are limited to trying to prevent further damage, perhaps by ordering some revision of the operation plan. In general, however, it can be concluded that the regulations have sufficient "teeth" to ensure a high level of compliance. This conclusion is borne out by the low number of violations discovered by OSMRE in its site inspections of 25 percent of the coal mining operations permitted under the Virginia program.²⁰⁸

In their hydrologic performance standards for underground mining operations, the regulations, by virtue of their use of terms borrowed from SMCRA itself, give a great deal of discretion to

the implementing agency. Such terms as "minimize the damage to the hydrologic balance," "an aquifer which significantly ensures the hydrologic balance," and "material damage to the hydrologic balance" are not given precise operational definitions, and probably cannot be defined precisely at the general level of regulations which apply to a variety of hydrogeologic regimes. Thus, their meaning is left to DMLR to determine in specific situations. How much damage constitutes material damage? For that matter, what exactly is the hydrologic balance? Such determinations are left, in the final analysis, to the professional judgement of the regulatory personnel. It must also be emphasized that they depend on the availability of monitoring data and a sufficient understanding of the hydrologic system to interpret available data.

There are, however, two specific areas in which the Virginia regulations appear to be unnecessarily permissive of hydrologic damage. The removal of the prohibition of high extraction mining beneath perennial streams, and its replacement with a standard of minimization of damage, is the most conspicuous. This change allows DMLR greater latitude in determining the level of protection from subsidence damage to be applied to particular perennial streams. However, it may increase the risk that some streams will be damaged by subsidence. Actual effects of mining operations on such streams will need to be closely monitored.

The striking down of the federal regulations' requirement of provision of alternative water sources in the case of underground mines, and subsequent deletion of this requirement from the Virginia program, mentioned above in connection with assignment of liability, constitutes not so much a weakening of DMLR's ability to protect the hydrologic balance as it does a diminution of the agency's involvement in controlling the social impacts of disturbance to the hydrologic balance. As argued above, this change has shifted costs inequitably to surface owners, and it should be corrected.

With this exception, however, it appears that the regulatory framework is adequate on paper for protection of water resources in Virginia. This brings us to the question of implementation.
Implementation is crucial to the success of any regulatory program, and is doubly so where a great deal of discretion is left to the implementing agency. As shown above, this is the case with respect to the interpretation of the performance standards for protection of the hydrologic balance.

With respect to the implementation of the permitting requirements for prediction of hydrologic effects and their impacts, and for monitoring, the research reported herein supports the conclusion that DMLR's performance has improved substantially in the past two to three years. Standards for the determination of probable hydrologic consequences (PHC) have improved, hydrologic monitoring requirements have been extended beyond the permit area to include adjacent areas subject to subsidence, and the agency has instituted a CHIA process that is at least acceptable to OSMRE. Moreover, recognizing the need for a better knowledge base for its permitting decisions, DMLR has begun to assemble a comprehensive geologic and hydrologic computerized data management system. There is still a need for information in two areas, however. One is the long-term effects of subsidence on groundwater; the other is the ecological impacts of subsidence's hydrologic effects. Not until more is known about these two areas can permitting decisions be made with confidence.

OSMRE, in its annual oversight evaluation reports, has noted steady improvement on the part of the agency with respect to deficiencies noted in 1984 and 1985 regarding the technical adequacy of subsidence control plan requirements and the granting of waivers of groundwater monitoring requirements. As noted earlier, OSMRE has given the agency high marks for inspection and enforcement. Their evaluations looked specifically at DMLR's inspections relative to applicable performance standards, and at the timeliness, effectiveness, and appropriateness of enforcement actions taken in response to violations discovered.

In conclusion, DMLR appears to be doing what it takes to implement the regulations under VCSMCRA. The agency has what could be viewed as a thankless task, in that it has no "constituency" to lend it support. It finds itself in the unenviable position of enforcing a law
that is not popular with the mining industry and acting in a role whose limitations are perhaps poorly understood by the people who live in the coalfields.

**Recommendations**

The limitations to the regulatory protection of water resources from the effects of coal mining identified in this research are the following:

1. **Lack of authority to require water replacement.**
2. **Lack of data for resolving water supply damage claims.**
3. **Lack of understanding of the long-term implications of hydrologic disturbance consequent to subsidence.**
4. **Lack of knowledge of the biological and ecological impacts of subsidence damage to the hydrologic balance.**

In order to address these deficiencies, the following recommendations are made.

1. **Amend the Virginia Code to require water replacement.** Underground coal mining permit applicants would be required to identify alternative water sources that would be provided in the event of damage to existing sources. Then, as a condition of bond release, if monitoring of developed water sources showed substantial subsidence damage to quantity or quality, such that the source was no longer adequate, the coal operator would be required to provide water from alternative sources as identified in the application. Further, cases where there was disagreement over causation would be resolved by DMLR,
with appropriate appeals process provisions. Such a measure should not be viewed as onerous by the coal companies, who after all have stated their willingness to replace damaged water supplies. It would have the salutary effect of reducing the uncertainty over one of life’s primary necessities that is felt by surface dwellers affected by subsidence. It would also remove some of the burden of transaction costs from surface owners.

2. **Require effective monitoring of water levels and flow rates of all developed water sources likely to be affected by high extraction underground mining, and require correlation of monitoring data with the proximity and passage of the longwall face.** If DMLR is to determine whether mining operations have affected individual water supplies, the agency will need a solid information base for doing so. As noted earlier, monitoring of developed water supplies and correlation with mining operations can benefit not only surface owners but mine operators as well, protecting the latter from spurious damage claims. Although such monitoring would represent an additional expense for mine operators, increased monitoring is already being required by DMLR, and in some cases monitoring existing wells may be an adequate substitute for installing new monitoring wells. No new statutory authority would be necessary for DMLR to implement this requirement.

3. **Begin long-term hydrologic monitoring of groundwater and surface water in strategic locations above representative longwall operations.** To support its CHIA process and to be able to assure that future uses of the land above high-extraction mining operations will not be impaired, DMLR needs information on the longterm effects of subsidence on water resources. One year of postmining monitoring is not enough to support conclusions about long-term hydrologic effects. Therefore, monitoring should continue, perhaps at a reduced level (i.e., fewer locations, less frequent reporting than during active mining), for a long enough period to allow DMLR to draw firm conclusions with respect to longterm effects of subsidence on both water quality and quantity. Monitoring should be designed to detect changes in water chemistry as well as changes in quantity. If possible, the
monitoring should be implemented at points for which premining baseline data are available. Aquifer testing should be part of such a longterm monitoring program, particularly since it has been suggested that longwall mining may actually improve groundwater development potential in the long run.

4. **Sponsor research.** One of the unanswered questions with respect to the effects of mining subsidence concerns its effects on fish and wildlife. DMLR should consider sponsoring a study of the effects of subsidence, with its attendant hydrologic balance disturbance, on biological productivity. Such a study could be co-sponsored by the Virginia Department of Game and Inland Fisheries, one of whose spokesmen has expressed concern over potential impacts, and conducted either by the Department or by one of the state universities. One of the areas of particular interest is the effect of subsidence on streams, springs, and seeps, which provide drinking water for wildlife as well as habitat for both plants and animals. Both the literature and the experience of regulatory agencies in other states show that subsidence can damage streams, and that such damage is difficult or impossible to mitigate. Perennial streams in the coalfields not only provide important habitat but also contribute to the area's potential for outdoor recreation.

What the above recommendations aim at is primarily the reduction of the uncertainty that now surrounds longwall mining. There is uncertainty over its longterm hydrologic effects and the impacts of these effects on future land use and on the ecology of the area. Furthermore, uncertainty over both immediate and lasting impacts on water supplies, and over the remediation or compensation for such impacts, plagues landowners above the mines.

If this rampant uncertainty could be reduced, it could help to repair the rift between the coal companies and the citizens of the area. The positions and desires of surface residents and the coal companies are actually not far apart. It is, I believe, the habit of opposition born of long years of controversy and class struggle in the coalfields that now stands in the way of consensus. The coal companies, by their water replacement and structure damage policies,
demonstrate that they believe these actions are right, regardless of the legal rights to mine without liability that they claim in some cases. The residents, even those who initially organized to oppose longwall mining, recognize the economic necessity of keeping mining economically viable. Barney Reilly, President of Dickenson County Citizens Committee, an organization formed out of concern over subsidence effects from the McClure mine operated by Clinchfield Coal Company, was recently quoted as saying, "We don't expect mining to stop. We don't want mining to stop."\textsuperscript{207} Of course, they would prefer not to suffer the effects of subsidence; but they recognize the economic need for longwall mining. What residents do want is assurance that the land will remain productive for future generations, that the damages they suffer will be compensated, and that the disruption to their lives will be minimized.

\textsuperscript{207} "Longwall renewal disappoints residents." Coalfield Progress, April 11, 1989.
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Appendix A. Acronyms Used

CFR  Code of Federal Regulations

CHIA  Cumulative Hydrologic Impact Assessment

DER  Department of Environmental Resources (Pennsylvania)

DMLR  Division of Mined Land Reclamation (Virginia)

DMME  Department of Mines, Minerals, and Energy (Virginia)

DMR  Division of Mineral Resources (Virginia)

DNR  Department of Natural Resources (Ohio, West Virginia)

DoE  Department of Energy (West Virginia)

OSM  Office of Surface Mining (U.S. Department of the Interior); renamed Office of Surface Mining Reclamation and Enforcement (OSMRE)
| **OSMRE** | Office of Surface Mining Reclamation and Enforcement (U.S. Department of the Interior) |
| **RON** | Revision Order Notice; issued by DMLR in Virginia when a change in mine permit conditions is indicated |
| **USGS** | U.S. Geological Survey |
| **VCCER** | Virginia Center for Coal and Energy Research, Virginia Polytechnic Institute and State University, Blacksburg, Virginia |
| **VCSMCRA** | Virginia Coal Surface Mining Control and Reclamation Act |
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