CHAPTER 1. OVERVIEW: COAL ASH BENEFICIAL USE AND MINE LAND RECLAMATION

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1.1 INTRODUCTION—PENNSYLVANIA'S ABANDONED MINE LAND PROBLEM

Since commercial coal mining began in Pennsylvania prior to 1800 (Dodge & Edwards, 2003), the Commonwealth's miners have extracted approximately 16.3 billion tons of coal from the Anthracite and Bituminous Coal Fields combined (PA DEP, 2002). The efforts of Pennsylvania's miners helped fuel the nation's industrial revolution and fed families for generations. However, the other legacy of the state's rich mining heritage is an unparalleled abandoned mine land (AML) problem.

Prior to the enactment of the federal Surface Mining Control and Reclamation Act (SMCRA) in August 1977, laws and regulations governing surface mining and the surface effects of underground mining, were largely ineffective in achieving reclamation of mined lands. SCMRA, which applies to all surface mining conducted after August 1977, requires complete reclamation of surface mine-affected lands and requires the posting of financial assurances, usually in the form of bonds, to ensure reclamation. While present-day mine sites are occasionally abandoned, the Pennsylvania Department of Environmental Protection (DEP) has well-established programs in place to reclaim those sites.

However, much of the vast AML problem from the pre-1977 mining remains. There are more than 5000 abandoned, unreclaimed mine problem areas encompassing more than 189,000 acres in Pennsylvania, according to the DEP Bureau of Abandoned Mine Reclamation (BAMR). BAMR's inventory of abandoned mine sites also identifies over 820 abandoned coal refuse piles. Often called culm in the anthracite fields and gob in the bituminous fields, these refuse piles encompass over 8,500 acres and have a volume of over 212,465,000 cubic yards (NALIS, 2003). These numbers are likely conservative in that many smaller piles are not fully accounted for. It is estimated that Pennsylvania suffers from up to 3,100 miles of streams degraded by acid mine drainage (AMD) as a result of abandoned mines. AMD is Pennsylvania's most serious stream pollution problem. The BAMR-estimated price tag to eliminate Pennsylvania's AML problems is a staggering $14.6 billion.

Over the years, both the federal and state governments have attempted to tackle Pennsylvania's AML problem. For example, Pennsylvania authorized the expenditure of more than $200 million for the Operation Scarlift Program in 1967. Under Operation Scarlift, the former Departments of Mines and Mineral Industries and Environmental Resources funded abandoned mine reclamation projects, including mine fire suppression and surface subsidence repair. Currently, Pennsylvania operates a program called Growing Greener, which funds environmental clean-up efforts through grants to nonprofit groups and local governments. While not all Growing Greener funds go to AML problems, a significant portion do, especially for projects that use passive treatment technologies to clean up abandoned mine discharges. At the federal level, since 1977, the Office of Surface Mining (OSM) has allocated to BAMR approximately $587 million for abandoned mine reclamation projects. This funding, currently averaging about $30 million annually is obtained from a per-ton fee paid to OSM from active mine operators, which is then distributed back to states with AML problems. The abandoned mine reclamation fund will expire in 2004, but will likely be re-authorized in some form by Congress. While substantial, these reclamation efforts to date have only dented Pennsylvania's $14.6 billion AML problem.

One approach Pennsylvania has taken to help address the AML problem is to encourage private funding of the reclamation of abandoned mine lands. To this end, Pennsylvania has encouraged re-mining of abandoned mine lands in settings where technical data show that additional problems are unlikely to occur, and, where in the normal course of re-mining, abandoned mine features will be reclaimed. Pennsylvania uses a program of re-mining incentives called Reclaim PA to encourage reclamation through re-mining in appropriate settings under appropriate conditions.

Waste coal piles represent a significant subset of AML sites in Pennsylvania. These sites present both some unique problems and opportunities. The piles are typically toxic to plant life, and thus are barren and highly erosive. The bituminous piles in particular can leach highly concentrated AMD with acidity values in the thousands of mg/L, and which can include, in addition to typical AMD parameters, elevated levels of some trace metals such as arsenic, lead, copper, and chromium. The cost of reclaiming these piles using conventional AML techniques is high, and the extremely poor water quality is often beyond the reach of current passive treatment technology. However, the key to reclamation of many of the piles may be in the fuel-value of the material.

1.2 FLUIDIZED BED COMBUSTION (FBC) POWER PLANTS

There have been sixteen fluidized bed combustion (FBC) power plants constructed in Pennsylvania in the past seventeen years. The locations of these plants are shown on Figure 1.1. The Kimberly Clark FBC plant is an industrial site-power plant, and the remaining plants are all commercial power producers. Some are also cogeneration facilities in that they supply heat to one or more customers. (An FBC power plant is also considered a cogeneration project if it markets at least five percent of its steam to a thermal energy user.) The Archbald power plant was decommissioned in June 1997, and the Reliant Energy Seward FBC power plant started operating in the spring of 2004, so there currently are 15 FBC plants operating in Pennsylvania.

1.2.1 Creation of the FBC Power-Generating Industry

In response to oil and gasoline shortages and significant price increases during the 1970's, the United States Congress passed The Public Utility Regulatory Policies Act (PURPA) in 1978. This act required that the electric utility companies buy the electric power produced by facilities that met certain qualifications, such as the use of non-traditional fuels. Coal mine refuse is considered a non-traditional fuel. The electric industries were required to pay for this electricity at a rate that matched the traditional power plant cost to produce the electricity.

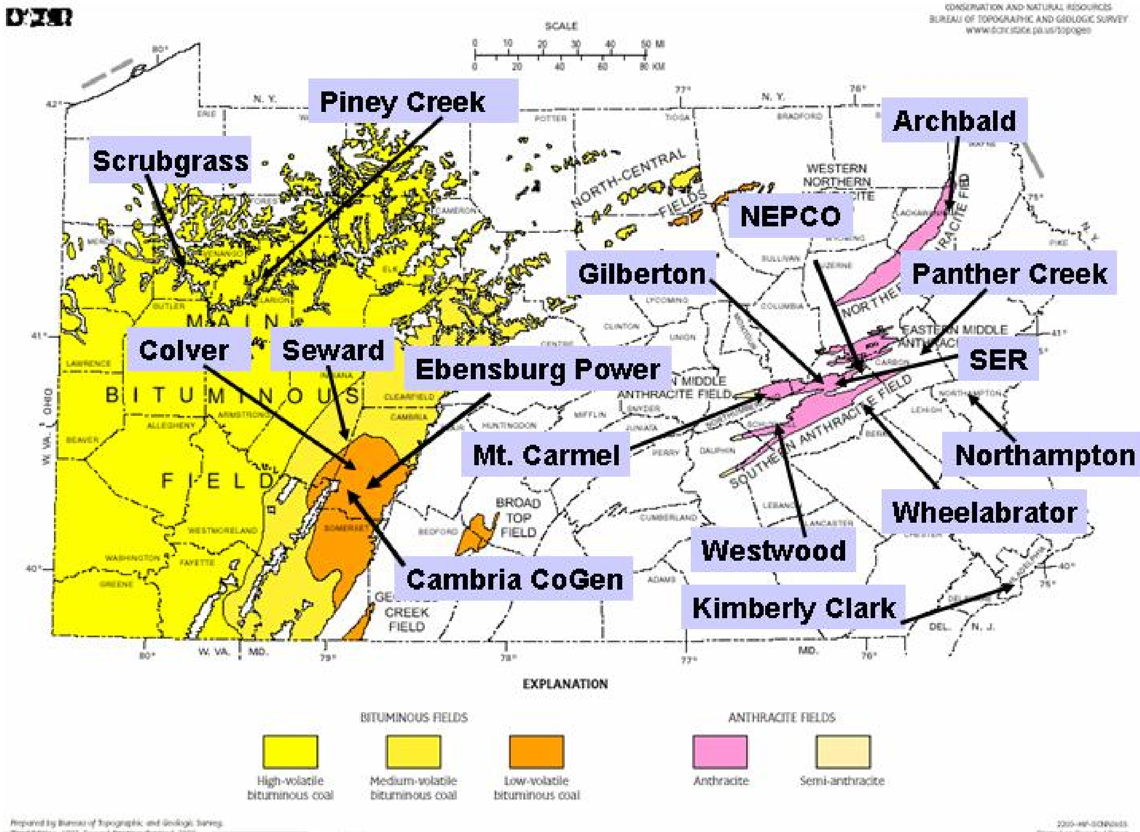

Figure 1.1. Distribution of the 16 FBC power plants in Pennsylvania.

PURPA thus created a great deal of financial interest in the production of electricity by using the waste coal in Pennsylvania's abandoned refuse piles

At about the same time, researchers in the United States and in Europe were developing a new kind of combustion unit capable of utilizing low heating value waste material to produce the steam necessary to drive a steam turbine-generator. The new combustion technology, circulating fluidized bed combustion, was also capable of emissions control that enabled these combustion units to meet the most stringent of the emissions regulations mandated by the Clean Air Act of 1970.

1.2.2 Operation of FBC Power Plants

FBC boilers are atmospheric pressure combustion units capable of burning fuels that contain as little as one-quarter of the heating value of commercial coal, while controlling the emissions of sulfur oxides and nitrogen oxides, the two primary causes of acid rain. These combustion units are designed to burn coal refuse that is crushed to a top-size of approximately five millimeters. The fuel particles are introduced into the bottom of the combustion chamber and high-pressure air is forced through nozzles in the bottom, or bed plate, of the chamber, suspending the fuel particles in mid-air. The fuel particles then swirl around, acting like a fluid, hence the fluidized bed part of the name. With this process all surfaces of the particles are in intimate contact with the air necessary for combustion. This bubbling mass of air and fuel is then heated to the ignition temperature of the fuel by a start-up burner system. Upon reaching its ignition temperature, the primary fuel ignites and the start-up burners are turned off. The primary fuel temperature is then increased to the design combustion unit temperature of approximately 800 to 900 degrees centigrade by the addition of more coal refuse fuel and more air. These relatively low combustion temperatures allow the units to operate with very low emissions of nitrogen oxides.

Along with the fuel, crushed limestone is injected into the bottom of the combustion chamber where the calcium carbonate in the limestone is converted into calcium oxide. The calcium oxide then reacts with the sulfur in the coal refuse, thereby reducing the sulfur oxides emissions. The calcium sulfate, formed by the reaction of calcium oxide and sulfur, is an inert substance that in the presence of water becomes gypsum, which is captured in the particulate control system.

The heavier waste fuel and limestone particles that cannot be retained in the circulating fluidized bed drop to the bottom of the chamber. This burned fuel, known as the bottom ash, is removed from the combustion chamber.

At the top of the combustion chamber, the gasses created by burning the coal refuse fuel and the smallest particles of burned fuel, exit the combustion chamber and enter a solids separation device called a cyclone. Here, the smallest of the particles of burned fuel are separated from the larger particles by centrifugal force, as the hot gasses swirl around in a circular path. The hot gasses and smaller particles of burned fuel, fly ash, are then directed into the convection section or back passes of the combustion unit, where the heat contained in the hot gasses is used to create the high-temperature high-pressure steam necessary to turn a steam turbine and generator. The larger particles are returned, or circulated, back to the bottom part of the combustion chamber where they are reheated and any remaining carbon in the coal refuse fuel is burned. This circulation cycle may take place many times over several hours and greatly contribute to the complete combustion of the carbon in the waste coal fuel, and hence the inclusion of the word "circulation" in the name of this combustion system.

1.2.3 Distribution of FBC Plants in Pennsylvania

Fifteen of the sixteen FBC plants range in size from 18 megawatts to 107 megawatts, however the most recent FBC plant (Seward) to come on line is 520 megawatts. The FBC power industry in Pennsylvania began in the Anthracite Region in 1987 when the Kimberly Clark plant in Chester, Pennsylvania went on line. This industrial plant was quickly followed by the start up of the Westwood Energy power plant in Tremont in July 1988. The Gilberton FBC power plant, which quickly followed, started operation in the fall of 1988. The Wheelabrator plant began operating in June 1989. In 1990, the Mount Carmel plant began operating in February, the Schuylkill Energy Resources plant in July, and the Archbald plant in September. (The Archbald FBC power plant was decommissioned in June 1997.) The most recent FBC plants to go on line in the Anthracite Region were the Panther Creek plant, in June 1992, and the Northampton plant, in August 1995 (Inners et al., 1996).

In the Bituminous Region the Cambria CoGen FBC power plant started operation in March 1991, followed by the Ebensburg Power Company plant in May 1991. The Piney Creek FBC power plant started operating in December 1992, the Scrubgrass plant in June 1993, and the Colver (Inter-Power/Ahlcon Partners) plant in October 1995. The Seward FBC power plant, which started operating in spring, 2004, is the most recent addition. The locations of all sixteen FBC power plants are shown in Figure 1.1.

1.2.4 Coal Refuse Consumption by FBC Power Plants in Pennsylvania

The FBC power plants in Pennsylvania have been consuming coal refuse since the first one began operations in 1987. Collectively, they have burned more than 88,551,000 tons of refuse up through 2002, the last full year for which figures are currently available. The re-mining of coal refuse piles for use as fuel for FBC plants has increased the rate of AML reclamation in Pennsylvania with no cost to the taxpayer. Figure 1.2 shows the amount of waste coal consumed per year by Pennsylvania's FBC plants and Figure 1.3 displays the same data on a cumulative basis. Currently, the FBC plants consume an average of 7,500,000 tons of coal refuse annually. However, with the addition of Reliant Energy Seward's FBC power plant, another 4,000,000 tons of coal refuse will be burned yearly, which is about a 50% increase to 11,500,000 tons per year.

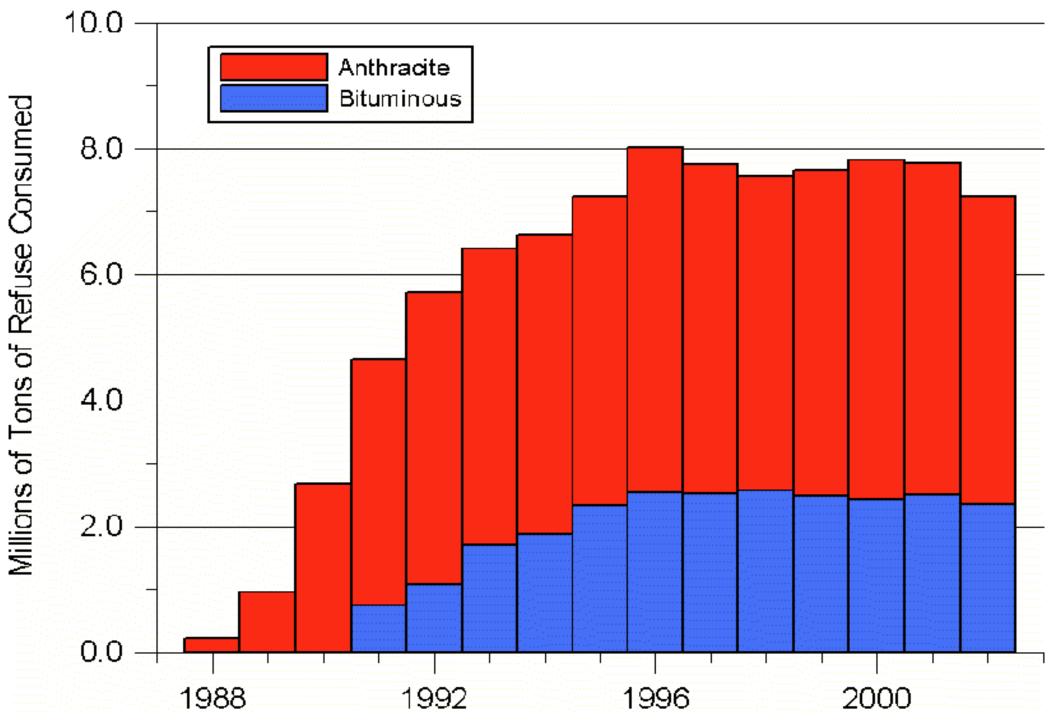

Figure 1.2. Annual consumption of coal refuse by FBC power plants.

1.2.5 Ash Production by FBC Plants in Pennsylvania

The FBC industry in Pennsylvania has generated over 58,188,000 tons of ash between 1988 and 2002, as shown in Table 1.1. Reliant Energy's Seward project, which started generating ash in spring 2004, is not included in Table 1.1.

Because limestone is injected into FBC boilers during combustion, FBC ash is typically highly alkaline. The availability of large volumes of this material has provided a feasible method for restoring some abandoned mine lands, the reclamation of which, until recently seemed almost out of reach.

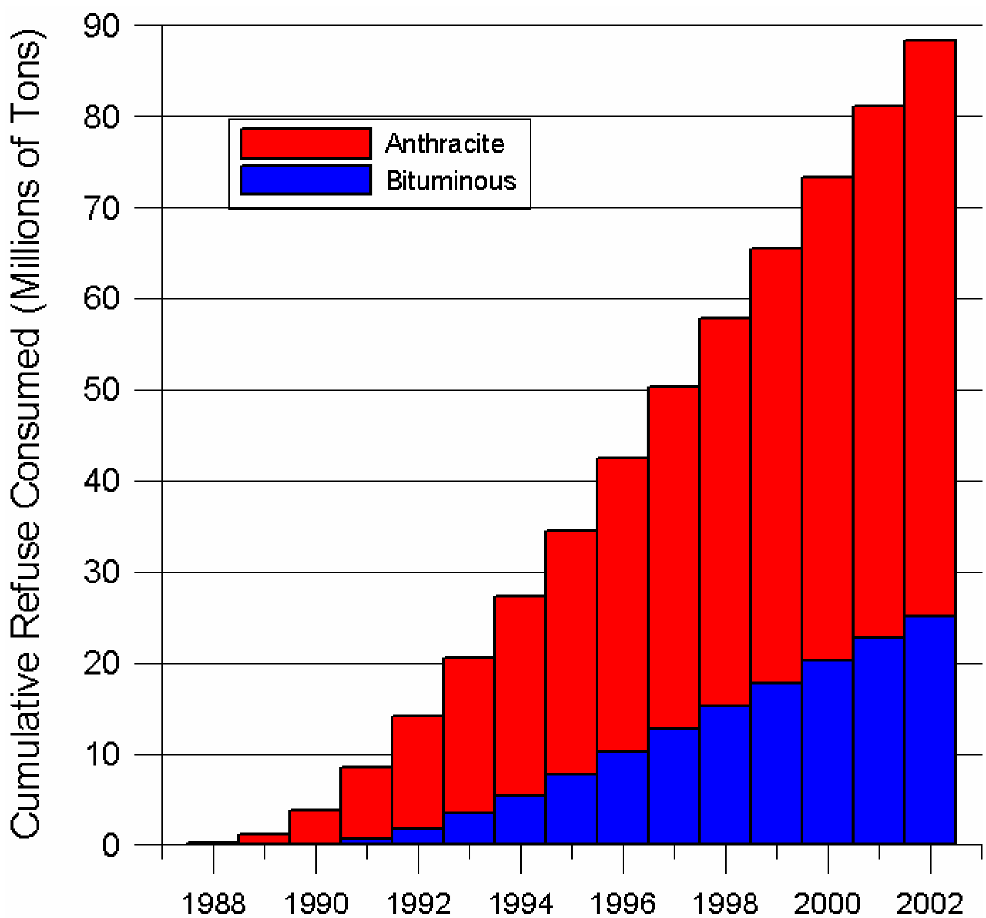

Figure 1.3. Cumulative consumption of coal refuse in the Anthracite and Bituminous Regions.

The case for returning suitable (as determined by proper testing procedures) FBC ash to abandoned or active mine lands for use in reclamation is compelling:

- The alkaline nature and encapsulating ability of the material make it particularly useful for some mine reclamation applications.

- Reclaiming waste coal piles without the benefit of adding FBC ash does little to address the often-severe water quality problems that emanate from some of the piles.
- Putting the FBC ash to a valuable use, often on areas from which it was derived, is classic recycling, virtually eliminating a potential waste stream and converting it into a useful material.
- The reclamation of AML with FBC ash is often completely privately funded, freeing up scarce government AML resources for other applications.
- Not only are abandoned mine lands reclaimed on the back end of the process through utilization of FBC ash; the reclamation realized at the front end of the process, converting polluting waste coal into an energy resource, could not economically occur if the FBC ash was landfilled.
- The ash from FBC plants has chemical and physical properties that greatly limit the potential for the ash itself to become a source of environmental contamination.

For the above listed reasons, most of the FBC ash that has been produced by Pennsylvania's waste coal industry has been beneficially used rather than landfilled.

The sixteen FBC power plants in Pennsylvania have contributed to the reclamation of approximately 3,400 acres of abandoned mine lands within the past fifteen years. See Figure 1.4 for the annual number of acres reclaimed by the ten anthracite FBC power plants and the six bituminous FBC power plants as of the end of 2002. In the Anthracite Region, where the abandoned mine pits are significantly deeper than in the Bituminous Region, the number of acres of abandoned mine acres reclaimed is less, but the depth of the pits are greater.

1.3 CONVENTIONAL COAL-FIRED POWER PLANTS

Conventional pulverized coal-fired power plants burn high heat value coal that is usually crushed and pulverized (75% less than 74 microns in particle size) before being fed into the combustion unit. Although both anthracite and bituminous coal is burned for energy, only bituminous coal is used in Pennsylvania for fuel for electrical power. The coal varies in heating value, in moisture content, percent of ash, and percent of sulfur. Most plants vary in size, operate at around 1400^{o}C, and have a combustion zone retention time less than a fraction of a second. Burning of coal generates both fly ash and bottom ash. The fly ash is captured from the flue gas by pollution control devices, primarily electrostatic precipitators (ESPs), fabric filters, or baghouses.

The bottom ash is the heavier component that is collected at the bottom of the combustion unit. The relative amount of fly ash to bottom ash produced by coal-fired power plants varies, but a typical breakdown between the two is about 80% fly ash to 20% bottom ash.

1.3.1 Distribution of Conventional Coal-Fired Power Plants

In Pennsylvania, there are 21 coal-fired electric generating power plants ranging in size from 100 megawatt (Mw) to 2700 Mw. The locations of the power plants are shown in Figure 1.5. These coal-fired power plants burn about 45 million tons of coal annually, resulting in the production of about 5 million tons of coal ash (Bidden, personal communication, 2004). The wet scrubber sludge generation is about another 2.0 million tons. Pulverized coal-fired plants produce much less ash per ton of fuel burned than do waste coal plants because waste coal contains much more noncombustible material, and because the FBC process includes the addition of lime into the boiler.

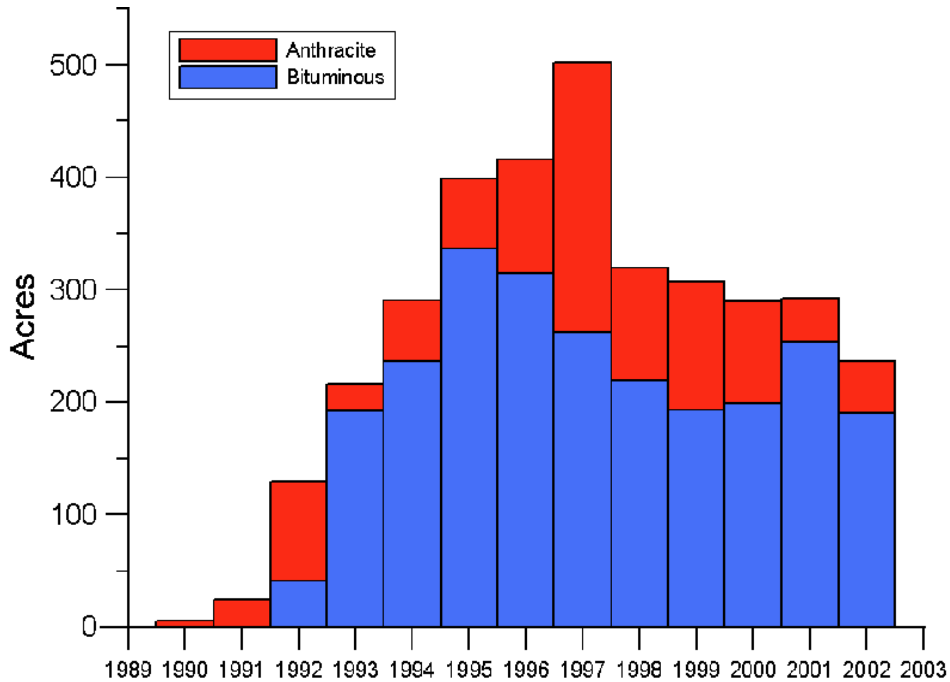

Figure 1.4. Acres of abandoned mine lands reclaimed by FBC plants in the Anthracite and Bituminous Regions.

1.3.2 Beneficial Use of Coal Ash from Conventional Coal-Fired Power Plants

While coal ash from conventional power plants is sometimes used beneficially on mine sites in Pennsylvania, much more FBC ash is so used. In 2002, the last full year for which figures are currently available, about 6.4 million tons of ash were beneficially used on mine sites, of which about 5 million tons were FBC ash. Of the approximate 5,000,000 tons of conventional coal ash produced that year in Pennsylvania, only a little over 1,000,000 tons or twenty percent was used beneficially. For that reason, much of the information provided in the remainder of this book focuses on FBC ash. However, opportunities do exist for the beneficial use of traditional PC ash on mine sites, where the ash has appropriate chemical and physical properties.

1.4 THE BENFICIAL USE OF COAL ASH ON PENNSYLVANIA MINE SITES

Each year Pennsylvania's power plants presently generate approximately ten million tons of coal ash, with about half coming from traditional plants and half coming from FBC plants. Table 1.2 shows the amounts of coal ash beneficially used on mine sites for the years 1998-2002.

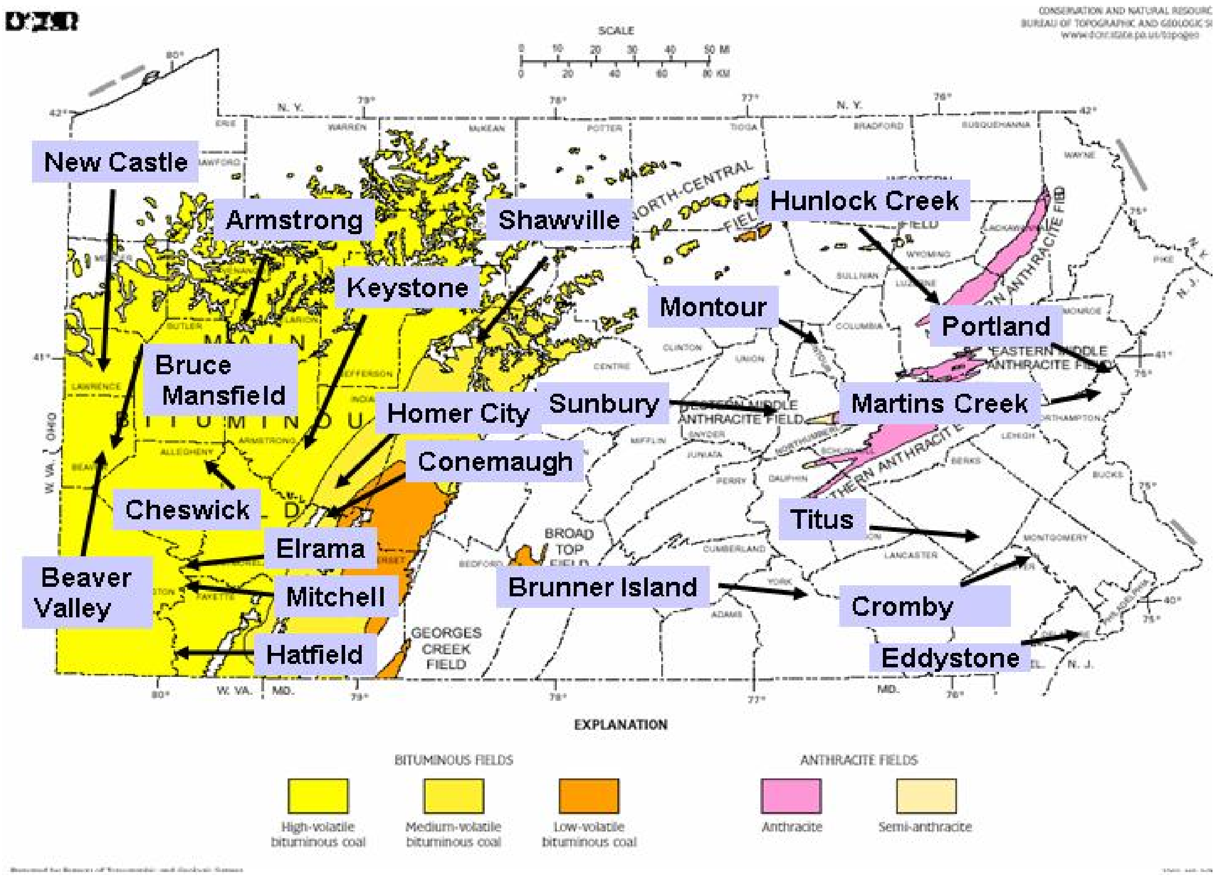

Figure 1.5. Distribution of 21 conventional PC coal-fired power plants in Pennsylvania.

Not all coal ash and other by-products are suitable for beneficial use. Those wastes that are not beneficially used are disposed in landfills or surface disposal impoundments. There are three classes of residual waste landfills in Pennsylvania: natural attenuation (unlined), single-lined, and double lined landfills. The class of landfill required for a waste's disposal depends on the levels of leachability of toxic waste constituents. Most coal combustion ash in Pennsylvania is disposed in natural-attenuation or single-lined landfills

Table 1.1 Annual and total summary of FBC ash generated in Pennsylvania to date.

Facility	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	*	*	50,000	117,000	132,000	149,000	159,000	145,000	144,000	75,000	#	#	#	#	#
2	*	*	*	422,000	554,000	563,000	563,000	563,000	478,000	499,364	555,333	513,982	515,562	517,974	538,538
3	*	*	*	*	*	*	*	300,000	443,492	507,318	540,655	508,458	431,562	536,694	572,224
4	*	*	*	130,000	296,000	284,000	274,000	288,000	310,000	331,450	349,568	345,583	341,207	316,024	310,141
5	88,643	163,379	198,051	235,229	240,948	239,531	287,306	301,724	304,000	316,537	310,000	295,350	288,290	281,460	283,994
6	?	?	?	?	?	?	?	?	?	210,000	187,000	205,000	223,995	195,994	
7	*	*	136,677	470,322	484,699	496,242	480,377	443,442	433,785	440,899	450,178	425,211	467,249	439,380	264,514
8	*	*	*	294,949	308,000	280,000	254,471	293,637	306,955	283,713	325,090	320,831	326,619	337,669	332,392
9	*	*	*	*	*	*	*	122,000	400,056	405,423	416,024	409,887	421,106	407,531	442,105
10	*	*	*	*	75,000	243,626	356,366	394,094	299,775	305,777	349,259	343,655	355,452	364,860	346,392
11	*	*	*	*	14,000	165,055	159,116	140,000	175,000	173,324	166,000	168,583	174,535	175,281	174,885
12	*	29,315	626,889	940,345	1,040,604	963,208	867,030	817,773	844,352	825,177	790,296	858,616	857,345	857,068	904,066
13	*	*	*	*	*	231,000	454,751	356,862	381,847	362,558	384,008	385,262	394,372	425,441	269,144
14	?	?	231,961	229,058	241,200	197,642	258,309	253,177	224,552	110,019	#	132,667	221,105	217,780	189,281
15	*	134,750	365,904	299,448	334,671	313,355	314,575	274,493	284,358	279,741	311,992	295,107	268,647	280,675	287,356
Total by Year	88,643	327,444	1,609,482	3,138,351	3,721,122	4,125,659	4,428,301	4,693,202	5,030,172	5,126,300	5,135,403	5,208,192	5,287,046	5,353,831	4,915,032
Total to Date	**58,188,180**														

Table 1.2 Coal ash use at mine sites in Pennsylvania (annual use rates).

Year	1998	1999	2000	2001	2002
Tons Of Ash Used	6,068,000	5,965,000	6,460,000	6,628,000	6,390,000

1.4.1 Identification of Beneficial Use Sites Discussed in This Book

This book will discuss fourteen of the many mine sites where coal ash has been beneficially used in Pennsylvania. The locations of the fourteen sites are shown on Figure 1.6. The Alden, Wheelabrator, B-D, and Susquehanna mine sites are discussed in Chapter 4. The Relvoc, McDermott and Abel-Dreshman sites are discussed in Chapter 5. Centralia (mine fire), Sharp Mountain, McClosky, and Fran are discussed in Chapter 6. The demonstration projects, Shen Penn, Knickbocker, and Big Gorilla are discussed in Chapters 7, 8, and 9, respectively.

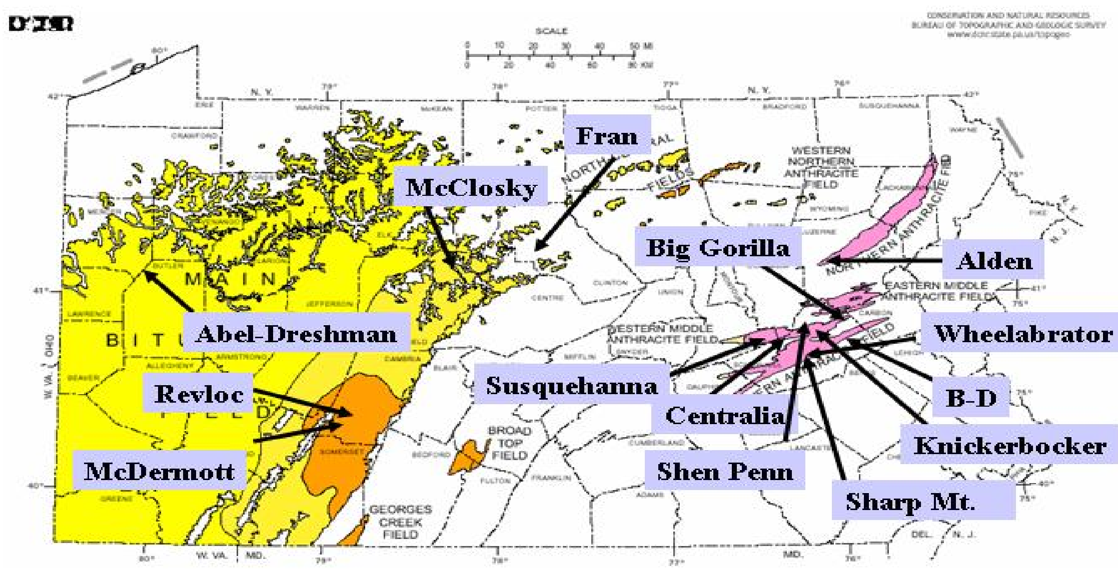

Figure 1.6. Locations of beneficial use sites discussed in this book.

1.4.2 Regulatory Framework

Coal ash is defined in Pennsylvania's Solid Waste Management Act as fly ash, bottom ash, or boiler slag resulting from the combustion of coal. This includes the ash generated from coal refuse; however, ash generated from burning waste material (e.g. petroleum coke) with coal is not considered coal ash under this definition. The addition of waste from pollution devices (e.g. wet scrubber sludge) to the coal ash also excludes that ash by this definition.

The beneficial use of coal ash in Pennsylvania is regulated under the Solid Waste Management Act, the Surface Mining Conservation and Reclamation Act, the Coal Refuse Disposal Act, the Clean Stream Law, and Air Quality Control Act.

Beneficial use of coal ash was authorized under the 1986 amendment to the Solid Waste Management Act (SWMA). SWMA authorized the beneficial use of coal ash for mine site reclamation along with other beneficial uses. Prior to 1986, DEP required a waste disposal permit for the use of coal ash at mine sites. In 1992, the residual waste management regulations were amended in accordance with SWMA to regulate the beneficial use of coal ash at mine sites (under 25 Pa. Code Sections 287.661 to 287.666). The regulations were further revised in 1997 in regard to water monitoring, volumes of ash that may be used at mine sites, and certification guidelines for ash. In addition, the DEP developed a Memorandum of Understanding between its waste and mining programs and three technical guidance documents to further coordinate and manage the beneficial use of coal ash on both active and abandoned mine sites.

1.4.3 Types of Beneficial Uses Permitted on Mine Sites

Pennsylvania currently defines the following four uses of coal ash on active mine sites as beneficial uses: 1) alkaline addition; 2) low permeability material; 3) soil substitute or additive; 4) placement.

Alkaline addition takes advantage of the potential for some coal ashes to generate alkaline leachate and is used to offset the potential for on-site materials to generate acid mine drainage. Brady and Hornberger. (1990), Perry and Brady (1995) and Skousen et al. (2002) have shown in empirical studies of completed mine sites that post mining water quality correlates more strongly with the amount of alkaline material on a mine site than with the amount of sulfur in the rocks. According to Pennsylvania's current guidelines, to qualify for use as an alkaline addition agent the ash should have a neutralization potential (NP) of at least 100 parts per thousand and a pH of between 7.0 and 12.5. (NP and its determination will be discussed in more detail in section 5.2.2.1 of chapter 5.) The amount of coal ash needed to offset potential acid production can be calculated using the methods described by Smith and Brady (1998).

Using ash as a low permeability material usually entails sealing or encapsulating materials on site that have the potential to produce acid mine drainage. Potential uses for ash as a low permeability material on a mine site include, paving the pit floor, capping material segregated from the rest of the mine spoil due to its potential to generate AMD, encapsulating reject material on coal refuse reprocessing operations, and in some cases capping entire sites or significant parts of sites. For use as a low permeability material on a mine site an ash should have pozzolonic characteristics and should be capable of achieving permeability equal to or less than 1.0×10^{-6} cm/sec under laboratory conditions.

As a soil supplement, alkaline coal ash is used as a liming agent and also to improve the physical characteristics of the soil or soil substitute being used as site cover. In some re-mining settings soil is not readily available, especially on coal refuse reprocessing operations, and coal ash can be used to enhance the characteristics of other on-site material to produce an acceptable growth medium. The soil/ash mixture must result in a pH between 6.5 and 8.0 to be considered suitable, and the amount of ash used must otherwise be commensurate with the need to establish a growth medium.

The term "ash placement" involves the use of coal ash on a mine site to backfill pits or re-contour refuse piles on re-mining sites. The pH of the coal ash must be in the range of 7.0 to 12.5 at the generator's site for placement approval.

In practice, coal ash use on a mine site typically fulfills more than one of the above beneficial use criteria. For example, coal ash being returned to a refuse reprocessing site may serve as an alkaline addition agent, an encapsulating agent (capping), as a soil additive, and for re-contouring.

1.4.4 Summary of Present Permitting Requirements

The following discussion presents only some of the most significant of the permitting requirements for coal ash use on mine sites. For more detailed information the reader should view the program guidance documents, permit modules and regulations, (especially 25 Pa Code Chapter 287.661-287.666) that are pertinent to ash use on mine sites and that are available on DEP's website at www.dep.state.pa.us. The reader should keep in mind that each mine site is different, and the data and information requirements may vary according to site-specific considerations.

1.4.4.1 Administrative requirements

Beneficial use of coal ash on a surface mine site can be requested as part of an original permit application or as a permit amendment. Either way, public notice and public participation are an integral part of the review process for all beneficial uses of coal ash on mine sites, with the exception of use as a soil amendment or supplement, which involves the use of very small volumes of ash.

For mine sites where ash is used as an alkaline addition agent, low permeability material or for placement, the applicant must place a public notice in a local newspaper explaining the proposal. The public has the right to comment on the proposal and may request a public meeting, if desired. The applicant must provide written approval from the landowner for the proposal, and the DEP office reviewing the application provides notice of the proposal to the local municipality, the county planning agency, and other state agencies. The review process is an open one with opportunity for input from individuals and local governments and other state agencies.

The application for use of coal ash on a mine site must include a detailed operational plan, which includes:

- Identification of the ash source(s);
- A certification from the ash generator(s);

- Amount of ash to be used;
- Purposes(s) of ash utilization;
- Operational details of how the ash is to be handled and incorporated into the site;
- A demonstration that the ash is chemically and/or physically suitable for the proposed use;
- Documentation of the hydrogeology of the ash-use area;
- A monitoring program, including background data collection, designed to show any influence of ash use on surface and groundwater quality.

1.4.4.2 Pre-testing of ash

An application for use of coal ash on mine sites must include chemical analyses of the ash proposed for use. Appendix 5.A includes a copy of the detailed quality analyses required. Analyses are performed on a dry-weight basis for pH plus sixteen metals. An SPLP [synthetic precipitation leach procedure] leachate analysis is required for pH, sulfate, chloride, plus seventeen metals. Coal ash must meet the maximum acceptable leachate limits for contaminants, based on the minimum requirements for an acceptable waste at a Pennsylvania Class III residual waste landfill. In addition, results of a neutralization potential test must be provided if the proposed use is for alkaline addition, and a hydraulic conductivity test must be provided when the proposed use is as a low conductivity material. Ash generators may obtain pre-certification of their ashes for specific uses through DEP's Bureau of Mining and Reclamation by submitting a request along with the analyses discussed herein, or the analyses data may be submitted to a DEP district mining office as part of a specific mine permit proposal. Periodic (typically biannual) re-certification and/or monitoring of the ash quality are required as long as the ash is being used on the mine site. The ash shipped from most power plants usually includes proportions of both fly ash and bottom ash, and analyses should be provided of both.

When the proposed use of ash on a site is as a soil supplement or additive, the applicant must also provide a soil analysis for pH, PCB's, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc so that potential plant up-take levels may be considered as part of the permitting process.

1.4.4.3 Monitoring

Groundwater monitoring is required for all ash applications on mine sites, except for sites where the only application is as a soil amendment. The volume of ash used on soil application sites is so small as to negate the need for water monitoring.

For all other applications of coal ash on mine sites, groundwater monitoring is required before, during and after ash placement on the site. Monitoring points are chosen so as to best show the effects, if any, of ash placement on the site. On many sites, especially re-mining sites, directly downgradient groundwater seeps, springs and discharges may provide the most representative monitoring points for the site. Typically, the hydrologic connection of such groundwater discharges to the site is relatively clear, especially in re-mining cases, where the water quality data often prove the connection. Care should be taken to choose points that are perennial under most climatic conditions and that are not subject to complicating influences. The monitoring program should include monitoring wells, where existing groundwater discharge points are inadequate in number or character to fully monitor the site. Special attention should be given to well location, depth and construction to ensure that what is being monitored will reflect any influence from the ash placement site that may occur. Upgradient wells, while they may not need to be as numerous as the downgradient points are important, especially in an area where potential upgradient influences on water quality, such as other mine sites are present. In some upland settings, upgradient groundwater monitoring is not possible.

For most mine sites, Pennsylvania requires a minimum of six monthly background samples for each monitoring point, and ash monitoring points are no exception. The ash monitoring points must be sampled for a suite of standard mine drainage parameters plus aluminum, arsenic, cadmium, calcium, chloride, chromium, copper, lead, magnesium, mercury, nickel, potassium, selenium, sodium, and zinc. During operations, monitoring must be done, at a minimum, quarterly for the mine drainage parameters and annually for the additional metals and chloride. More frequent monitoring is required on some sites. Once the site is completed, monitoring continues until the site is judged stable.

Coal ash generally must be placed no closer than within eight feet of the top of the regional groundwater table. However, this requirement may be waived under the regulations if there is a demonstration that contamination will not occur or if DEP approves the placement as part of a demonstration project.

1.5 DEMONSTRATION PROJECTS

Under requirements of 25 Pa. Code Sections 287.501-287.506, waste management permit applications have been approved as Waste Management Demonstration Permits which may allow the demonstration of new or unique technologies for the processing or disposal of residual waste at permitted facilities. The remainder of this chapter will discuss the role of demonstration projects in the beneficial use of ash on mine sites.

1.5.1 Regulatory Requirements for Waste Management Demonstration Projects

Each application for a demonstration project permit must include the following:

1) An economic analysis indicating benefits to the Commonwealth and the applicant from the proposed project, including an economic analysis of the benefits of alternative methods of processing or disposal.
2) A technical analysis of the proposed project in comparison to the existing state-of-the-art for processing or disposal of the waste that will be received by the project.
3) A complete operational plan, including design details and a timetable for completing various phases of the project from initiation of construction to completion of the project.

4) An evaluation of the anticipated contribution of the project to the field of solid waste management.
5) An evaluation of the potential applicability to the Commonwealth of the technology to be demonstrated.
6) A demonstration that the applicant has the financial ability to remove the project and clean up the affected area in the event of pollution.
7) A plan for corrective action utilizing conventional technology in the event of pollution.
8) A statement of the optimal size and capacity for a project using the proposed technology.
9) A plan for assessing the effectiveness and environmental effect of the proposed project.

Three such demonstration project permits have been issued in the Anthracite Region of Pennsylvania. One project is for the placement of high-density ash/water slurry into standing mine water (wet-to-wet placement) in the Shen Penn Demonstration Project. The second is for placement of a high-density ash/water slurry into a dry mine pit (wet-to-dry placement) in the Knickerbocker Demonstration Project. The third is for dry ash placement into standing mine water (dry-to-wet placement), the Big Gorilla Demonstration Project. If DEP determines that these demonstration facilities adequately achieved their objectives and satisfactorily protected public health, safety, welfare, and the environment, the agency subsequently may grant a permit for the new or unique technologies.

1.5.2 The Need for Demonstration Projects

Pennsylvania's residual waste regulations include the requirement that any waste, which is placed on a site, must be a minimum of 8 feet above the regional groundwater table and 4 feet above any perched water table. The regulations concerning waste demonstration permits enable DEP to issue permits that deviate from these required separation distances (among other things), providing that the demonstration project is a justifiable evaluation of alternative methods of solid waste management, and that an economic and technical analysis of benefits is considered as well as potential environmental effects.

In July 1994, an eleven-year-old boy drowned while swimming in the shallow end of the Shen Penn mine pool impoundment adjacent to the city of Shenandoah, PA. The water depth at the site of the drowning accident was approximately 11 feet; the deepest portion of the 40-acre impoundment has been measured at 238 feet depth by DEP staff. The Shen Penn mine water impoundment is in a very large abandoned surface mine pit connected to the abandoned underground mine workings of the Kehley Run, Indian Ridge and Shenandoah City collieries. It is also the site of the Kehley Run mine fire extinguishment project that was completed by the DEP Bureau of Abandoned Mine Reclamation in the 1970's. In the aftermath of the drowning tragedy, a State Senator and DEP were presented with a petition signed by thousands of local residents, imploring the Commonwealth to backfill the pit to eliminate the mine hazard and prevent further fatalities.

The Director of the Office of Surface Mining Reclamation and Enforcement from Washington, D.C. and the DEP Deputy Secretary of Mineral Resources Management toured the Shen Penn abandoned mine site shortly after the fatality and expressed interest in backfilling the impoundment and reclaiming the site. However, they also announced that the reclamation estimates for that single project ranged from $20 million to $28 million, which is about the annual appropriation for all abandoned mine reclamation projects in Pennsylvania. Therefore, they stated that it was nearly impossible to fund a project that large, and it would be a long time before the project could be undertaken with federal AML funds.

An overlook adjacent to Route 924 north of Shenandoah provides a view of the Shen Penn pit below and three FBC power plants to the south. The Schuylkill Energy Resources (SER) FBC plant is so close to the Shen Penn pit that the reflection of the stack at the plant can sometimes be seen on the surface of the mine water impoundment. The corporate officers of SER and Reading Anthracite Coal Co. (RAC) contacted DEP with a proposal to backfill the Shen Penn pit, at no cost to the state or federal government, with an ash slurry from the SER FBC power plant. The abandoned pit and the FBC power plant are located within a large surface mining permit issued to Reading Anthracite. RAC is the landowner of the Shen Penn pit, but the company has no legal obligation to backfill the pit under the state and federal surface mining laws because the mine pit existed prior to these laws. The Reading Anthracite/SER proposal was timely because it suggested an innovative method of eliminating the mine hazard, and possibly providing environmental, social, and economic benefits in a win/win solution for the community, the company and the DEP.

Two significant challenges confronted the Executive Staff of DEP: 1) the problems of significant abandoned mine hazards that threaten public health and safety, without sufficient funding to remediate them; 2) the challenge of advancing acceptable ash disposal practices to allow a promising but untried technology of filling an acid mine water impoundment. In 1995, after much deliberation, the Executive Staff and the technical staff of the waste management and mining programs made two key decisions: 1) a testing phase for three waste demonstration projects would be established to test the range of coal ash/mine pool interactions; 2) DEP would fund a research project to scientifically evaluate the physical and chemical properties of these coal ash demonstration permit sites. This book is the product of those two prudent decisions.

The Shen Penn proposal was for a wet coal ash slurry pipeline to transport ash from the SER FBC plant and emplace it in the wet mine pool environment (i.e. wet-to-wet alternative). Conventional coal ash placement in beneficial use mine reclamation involves the placement of relatively dry (i.e. optimum moisture content) coal ash into a relatively “high and dry” mine environment. The other two alternatives are the placement of relatively dry ash into a wet mine, and the placement of a wet coal ash into a relatively dry mine. The DEP Executive Staff recognized that if the Shen Penn proposal was approved other mining companies, who had to comply with the eight-foot separation distance, would file requests for similar approvals. Hence, the decision was made to limit the waste demonstration permit approvals to one example of each of the three alternative placement techniques, until the three alternatives could be tested through extensive monitoring and data analysis of the demonstration sites.

On September 22, 1995 DEP entered into an Agreement with SER and RAC to approve the proposal and, provide among other things, $5 million in comprehensive general liability insurance and an additional $2 million in third-party environmental impairment liability insurance covering non-sudden pollution occurrences for the Shen Penn site. That agreement was followed by a Waste Management Demonstration Permit (No. 301289) which was issued on August 6, 1996, that included details on testing and monitoring the physical and chemical properties of the coal ash slurry and its interactions with the mine pool impoundment. Unfortunately, Waste Management Demonstration Permit No. 301289 was never activated, due to the impediment of a $5 per ton coal ash tax imposed by the local school district. That tax may have been established to generate revenue for the school system, but it essentially prevents the beneficial use of ash and revenue generation from cogeneration plants within the district, due to the costs it adds to reclamation projects. Chapter 7 describes the small-scale ash slurry demonstration project completed within the permitted ash placement area on the Ellengowen permit (at the SER cogen site) that was conducted as a precursor to the Shen Penn project, and also provides additional information on the mine pool chemistry and monitoring data relevant to the Shen Penn and Knickerbocker sites.

On June 16, 1997, DEP issued Waste Demonstration Permit No. 303104 to Northeastern Power Co. (NEPCO) for the second of the three coal ash placement alternatives. This project placed optimum moisture content ash into an abandoned water-filled pit known as the Big Gorilla pit, a 16.6 acre area within the 876 acre surface mining permit site at the NEPCO FBC power plant site near the borough of McAdoo. The mine water impoundment in the Big Gorilla pit was 80 feet deep in most places. It has been completely eliminated by the coal ash placement project. As described in Chapter 9, the coal ash was placed directly in the acid mine drainage impoundment and the physical and chemical results were excellent.

On July 21, 1998, DEP issued the third of this series of permits, Waste Demonstration Permit No. 301301, to Reading Anthracite Co. for the 44-acre Knickerbocker pit area within the Ellengowan surface mining permit near the SER FBC power plant site. The Knickerbocker pit is a dry abandoned surface mine above the mine pool level, located on the same surface mine permit as the Shen Penn pit to the east along the strike of the syncline, and in West Mahanoy Township (outside of the boundaries of the school district and the ash tax). This permit approval authorized RAC and SER to demonstrate their coal ash slurry concept in a dry pit. It also enabled DEP to obtain scientific and engineering data on a relatively large-scale slurry project, for possible future use into a water-filled pit (i.e. the original wet-to-wet alternative). The results of the Knickerbocker demonstration project, including an evaluation of the effectiveness of the use of various percentages of a cement kiln dust (CKD) admixture as an activator for cementitious behavior of the ash in test cells, are described in Chapter 8.

The second key decision of the DEP Executive Staff in 1995 was realized by executing a contract with the Materials Research Institute (MRI) of the Pennsylvania State University to conduct scientific study of these three waste demonstration permit sites. MRI is an interdisciplinary, intercollegiate research consortium at Penn State that has top-level scientists, state-of-the-art laboratory equipment, and 40 years of advances in the material sciences, including nuclear waste management and leaching behavior, cement chemistry and coal ash utilization. Dr. Barry E. Scheetz, Dr. William B. White and Dr. Caroline M. Loop of MRI conducted the coal ash research presented in Chapters 7 to 9, and summarized in Chapter 11. Dr. Loop's M.S. Thesis and a large part of her Ph.D. Dissertation are devoted to the study of the NEPCO site. The participation of MRI in the demonstration projects has assured the scientific rigor of the evaluation of those sites.

1.6 CONCLUSION

It was out of the collaboration between MRI and DEP that the concept for this book originated. The initial intent was to produce a publication that presented the results of the demonstration projects. From there the scope broadened to include the results from other active and abandoned mine sites where coal ash has been beneficially used in Pennsylvania. One reason for broadening the scope of this publication is that the beneficial use of coal ash on mine sites has become somewhat controversial on a national level. That controversy has been fed, in part, by the misreporting and partial reporting of information and data, some of which have been from sites in Pennsylvania. Thus, it became even more important to present the facts and the science behind the beneficial use of coal ash in Pennsylvania. While the scope of the book grew, the underlying goal remained the same, and that is to present the results of Pennsylvania's experience with recycling coal ash for beneficial use in mine site reclamation to others in the scientific, government, business, and public-interest communities. It is the shared hope of all the authors that this book advances understanding of the potential uses for coal ash in mine site reclamation.