

## **CHAPTER 2: METHODOLOGY FOR EXAMINATION; SUMMARY OF SITES, MONITORING DATA, TRENDS AND EVIDENCE OBSERVED**

### **2.1 Introduction**

Pennsylvania permits “beneficial use” of coal ash in active and abandoned coal mines and at coal refuse sites for the following four purposes: coal ash placement, alkaline addition, soil additive or substitution, and as a low permeability material. Most coal ash placement in Pennsylvania coal mines falls under the first two categories; either the coal ash is placed in the mine for reclamation purposes to fill voids and/or achieve ground contours that blend with surrounding topography or it is used as an alkaline addition to improve water quality degraded from acid mine drainage. This report examines water quality impacts from coal ash used for these two beneficial uses in 14 active coal mining permits and one coal refuse disposal permit and also as a low permeability material in one of those mining permits, that for the Wildwood site. The use of coal ash used as a soil additive was assessed preliminarily in the mining permit for the RFI Energy site and the use of coal ash as a low permeability cap was assessed preliminarily at the McCloskey site. However the reviews of these sites as well as those for two other ash minefill sites, the Penn State and Gamelands sites, could not be completed due to limits in project resources.

Requirements applying to these beneficial uses are contained in the Pennsylvania Clean Streams Law, Surface Mining Conservation and Reclamation Act, and Coal Refuse Disposal Act and applicable regulations. The primary regulations addressing ash placement in coal mines are found at 25 Pa. Code §287.663, which governs beneficial use of coal ash in active mines, and 25 Pa. Code Chapter 87 Subchapter F and 88 Subchapter G, which govern requirements for the re-mining of previously mined and abandoned mine lands with seriously impaired water quality. A more detailed summary of the laws and regulations applying to coal ash placement is found in Appendix 2, *infra*.

Regardless of whether coal ash is being placed in an active or abandoned coal mine, the following requirements must be met:

- 1) The coal ash must meet physical and chemical characteristics outlined in the Certification Guidelines for Beneficial Uses of Coal Ash, 563-2112-224 (BMR PGM Section II, Part 2, Subpart 24). The key requirement is that the ash not leach more than 25 times Pennsylvania Drinking Water Standards for metals and 10 times these Standards for nonmetals and cations in a leaching test (see discussion on pages 9 & 10, Chapter 1);
- 2) Use of the ash shall be designed to achieve an improvement in water quality or prevent water quality degradation;
- 3) Ash cannot be placed within eight feet of the regional groundwater table unless PADEP approves a demonstration that groundwater contamination will

not occur or the placement is approved as part of a mine drainage abatement permit.

Applications for surface coal mining permits in Pennsylvania contain as many as 27 “Modules,” each of which provides information on a different aspect of the permit. This report focused primarily on Module 25 that identifies and characterizes coal ash proposed for use and outlines plans for placing the ash in the mine and for monitoring its impacts on water quality. The report also relies on information from Module 6 - Environmental Resources Maps, Module 7 - Geology, Module 8 - Hydrology, Module 9 - Operations Map, Module 10 - Operational Information, Module 11 - Coal Refuse Disposal, Module 26 - Remining of Areas with Pre-existing Pollutational Discharges, and Module 27 - Sewage Sludge/Coal Ash Beneficial Use.

The following three chapters (Chapters 3 through 5) will include a discussion, on a permit by permit basis, that contains information about each site’s geology, geography, hydrology (ground and surface), history of ash placement (with tonnages and ash types), groundwater chemistry trend graphs from ash monitoring data and in some cases, graphs of pollutant loads in surface waters.

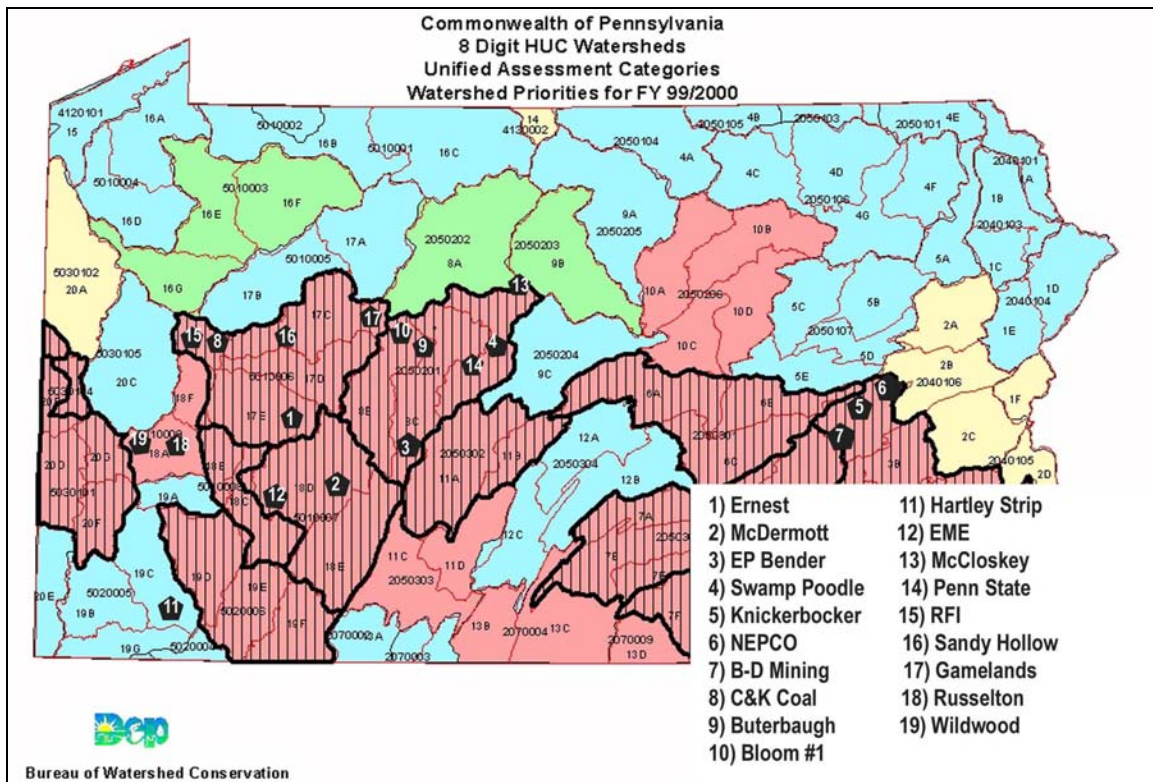
## **2.2. Selection of Permits**

Out of 110 coal mines permitted by PADEP to accept the placement of coal ash in Pennsylvania coal mines, 12 mine sites in Western Pennsylvania and three in Eastern Pennsylvania were selected for study in this report. These sites met the following criteria developed by the Project Director, Project Researchers and the Advisory Committee for this report:

1. At least 10,000 tons of CCW were dumped or placed in the site (the greater the volume of ash the greater the pollution potential);
2. At least two monitoring points were installed to monitor water quality downgradient and/or downstream from the CCW; and
3. The duration of the total monitoring period extended for at least 5 years.

Many sites meeting these criteria were eliminated because the quality and quantity of the monitoring data were insufficient. Some permits collected considerably more baseline (before ash placement) data than others. The frequency of monitoring at these sites varied considerably. At some sites, operators failed to collect multiple samples prescribed by the permits’ monitoring provisions. Given these factors, it was not possible to make credible assessments on the impacts to water quality at certain sites. In addition, limits on project resources and time led to the aborting of examinations at four sites.

While this report’s authors were specifically looking for evidence of impacts from ash in the monitoring data for these sites and were aware, prior to researching the report, that three of the sites may have been impacted, it is important to note that the other 16 sites examined in this report were selected entirely on the criteria above rather than any previous knowledge of water quality impacts.



This map of Priority Watersheds in Pennsylvania identifies the locations for the minefill sites studied in this report. Site 5) Knickerbocker is the demonstration site that is part of the Ellengowan Mine where additional ash placement was also studied. Final studies for the 13) McCloskey, 14) Penn State, 15) RFI and 17) Gamelands sites could not be completed as part of this report.

### 2.3. Description of Site-by-Site Permit Analysis

The report examines impacts to water quality primarily by comparing concentrations of CCW constituents in groundwater and surface waters before and after the placement of CCW at points established in the permits specifically to monitor the effects of that placement. At every site, constituent concentrations are examined for three minor elements: iron, manganese and sulfur, and four trace metals: arsenic, selenium, lead and cadmium. Where data were available, concentrations for parameters indicative more exclusively of ash leachate than of leachate from coal refuse and mine spoils (particularly at sites deficient in alkalinity)) were assessed and often graphed. These parameters include calcium, magnesium, chloride, sodium, and potassium. Concentrations of aluminum, nickel, zinc and copper, metals frequently soluble from both coal refuse and coal ash, were examined to a lesser extent. In a few instances concentrations of fluoride, silver, and barium were also examined. At one mine site managed partly by PADEP's solid waste program (Hartley, SMP# 30713008), concentrations of antimony, boron, mercury and molybdenum were examined. Antimony, boron and molybdenum are notable markers for many coal ash leachates but are rarely monitored at PADEP

minefills. Finally, concentrations of broader parameters such as TDS (total dissolved solids), acidity, alkalinity, pH and in several instances, specific conductance were examined at every site to gain a better understanding of overall water quality impacts.

Constituent loadings in surface waters were also examined in seven permits (for the Ernest, EP Bender, EME Generation, Bloom #1, TDK Sandy Hollow, Russelton and Wildwood sites); all of which were located in western Pennsylvania. Loadings are the amount by weight of a constituent flowing past a given point in surface water measured over a given period of time. PADEP requires the monitoring of pollutant loads in remining permits issued under its subchapter F program. Nonetheless, most permits examined did not contain loading data and those that did usually contained such data only for acidity/alkalinity, iron, manganese, sulfate, and sometimes aluminum. Furthermore many of the loading data were collected from monitoring points in locations that did not effectively measure impacts from ash placement sites. Finally many ash monitoring points are wells or mine pool monitoring points that do not produce flow measurements that can be used to calculate loads of trace elements and other ash parameters monitored under Module 25. For these reasons as well as the fact that concentrations, not loads, are what determine toxicity to biota in surface waters, the assessments in this report focused more on concentrations than loads.

Changing precipitation patterns affected the assessment of loadings at these sites and these patterns are noted in the reviews. A reduction in average loads measured from ash monitoring points at several permit sites potentially resulted from declining levels of precipitation in western Pennsylvania from the first half of the 1990s to the latter half of the 1990s through 2002. Regional climate data maintained by Penn State University indicates that average annual precipitation levels in three of four designated climate regions in western Pennsylvania were five inches higher in 1991 to 1996 than in 1997 to 2002 and three inches higher in the earlier than the latter years in the fourth region.<sup>1</sup> It is particularly notable that in these four regions there was a very large drop (ranging from 11.37 to 15.45 inches) in annual precipitation from 1996 to 1997.<sup>2</sup> According to the database, total precipitation levels in western Pennsylvania declined even further in 1998 and 1999 in all four climate regions. Reduced precipitation results in lower flows that in turn can reduce pollutant loads even if concentrations are increasing significantly at ash monitoring points. Thus reductions in pollutant loads at these sites may have been only a deceptive, at best temporary, benefit that had little to do with the ash.

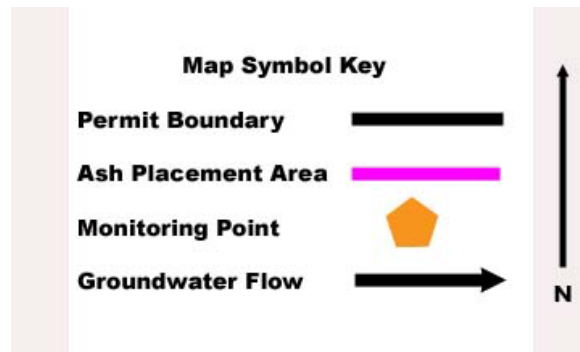
Each permit description is accompanied by graphs showing the concentrations in milligrams of the constituent per liter of water (mg/L) plotted against the sample date. Loadings are graphed in pounds of the constituent per day plotted against the sample date. Each permit also has a map showing the location of each site. These maps were derived from the applicable USGS topographic 7.5-minute quadrangle. A key (shown below) depicts the permit boundary in black, the boundary of the ash placement area in

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<sup>1</sup> See <http://climate.met.psu.edu/data/state.php>.

<sup>2</sup> This drop appears to have contributed to sharp reductions in flow volumes from the period right before ash placement began at the Ernest, EME Generation and Bloom #1 sites (most of 1996) to the period after ash placement (1997).

pink, the groundwater flow direction by black arrows, and the water monitoring points by orange pentagons. As they are on the USGS maps, wooded areas are shown in green, previously mined areas in pink/purple shading, water bodies in blue and topographic contours in brown. All maps are oriented with the north direction towards the top of the page. The scale is indicated at the bottom of each map along with the name and PADEP permit number of the site.



Each of the permit descriptions contain a short site-specific paragraph that outlines the local geology, including the coal beds mined (also called seams or layers) and the attitude or structure of the coal bed(s) and the surrounding rock layers. The coal beds are described with their formal names and the geological structure or slope using dip measurements. For an explanation of dip and other geologic features, see Appendix 1 of this report.

Each permit discussion also includes a short description of the site's geography and topography. The surface and groundwater hydrology are addressed for each permit, with a site-specific discourse on the flow directions, relationships (if any) with geological structures, placement of monitoring points, and any water flow barriers and conduits, both natural or man-made. Natural groundwater flow barriers include shale layers that do not transmit water effectively, and clay layers on which perched water tables can form.<sup>3</sup> Past human activities such as mining can greatly alter flow directions and provide major conduits or pathways for water flow. Much of the water flow pertinent to the discussion of these permits involves surface water and shallow groundwater that accumulates at the base of deposits of spoils and refuse in previously mined areas where there is sharp difference in the permeability between the unmined ground, old mine floor or side walls of the mine and the broken up spoils and refuse. In these cases, the shallow groundwater usually follows the contour of the less permeable unmined earth and the surface water

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<sup>3</sup> A *perched* water table is an aquifer that occurs higher in elevation than the surrounding regional water table, caused by an underlying impermeable sedimentary layer. The underclay that is usually directly beneath many of the Western Pennsylvania's coal beds often carries a perched water table above it. An example of a naturally occurring groundwater *conduit* is a large vertical fracture, or joint, in the bedrock that enhances downward flow.

generally follows the contour of the surface lands. Major water movement in mine pools created by past underground mines often dominates deeper groundwater systems at these sites. While the permits identify these flow systems, in most permits the authors could find little site specific details or discussion of the connections between the shallow and deeper systems at these sites.

Most of the permit data sets contain an initial baseline monitoring period, usually less than a year, during which groundwater data were collected before ash was placed and usually also before any mining or re-mining commenced. Thus the baseline monitoring data show conditions before ash placement. The Module 25 of the permit establishes monitoring points located specifically to detect any changes in water chemistry after the baseline monitoring period attributable to contamination from ash leachate. This report's examination focuses on the data from these monitoring points, collected according to the requirements in Module 25 Coal Ash Groundwater Monitoring provisions, as opposed to the data collected from other monitoring points in the mine established under Module 8 primarily to discern the effects of mining on water quality.

“Degradation” is considered to have occurred when the monitoring of pollutants indicates concentrations above drinking water standards or water quality standards at downgradient or downstream coal ash monitoring points that did not occur during baseline monitoring. In addition, the degradation cannot have not occurred at monitoring points that are clearly upgradient or upstream of the ash as shown by water level elevations, the locations of ash in the mine and flow paths discussed in the permits if such monitoring points were established.<sup>4</sup>

Our analysis did not attempt to ascertain whether degradation beyond baseline concentrations and DWS or whether changes in concentrations between upgradient and downgradient points is “statistically significant.” Aside from time constraints, such analysis would not have generated meaningful assessments given the failure of most baseline monitoring at these sites to characterize the seasonal variability of ash pollutants in the monitored waters before ash placement. Subsequent gaps in data, short monitoring periods, and annual sampling for most ash constituents during ash placement also does not generate enough points to make meaningful statistical comparisons. The absence of corrective action standards requiring enhanced monitoring (at greater frequencies, from more points, and/or for more parameters) when higher concentrations of ash pollutants are detected and the absence of monitoring that extends beyond surface reclamation of sites are two additional basic deficiencies that prevent sophisticated statistical comparisons from being conducted.

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<sup>4</sup> This is consistent with, if not more conservative than PADEP's definition of “groundwater degradation” found at 25 Pa. Code §287.1, namely “a measurable increase in the concentration of one or more contaminants in groundwater above background concentrations for these contaminants.” PADEP does not similarly define surface water degradation in state regulations, but extrapolation of the groundwater degradation standard would indicate that PADEP would consider surface water degraded if there was a measurable increase in the concentration of one of more contaminants in surface water above upstream concentrations for these contaminants.

This does not, however, prevent valid conclusions from being drawn from the data when those data are evaluated with methods they do support. For most sites, the only methods available are simple comparisons and identifying the temporal trends within the data. Each site evaluation provides extensive discussion comparing the data from a particular monitoring location after placement began to the baseline data that is available. For those sites with upgradient locations, discussion comparing the data from a particular monitoring location to the upgradient location is provided. For sites where there is more extensive baseline and more complete post-placement data, a comparison of pre- and post-placement average concentrations is made.

For several parameters, namely pH, acidity/alkalinity, iron, manganese, and sulfate which usually had at least semiannual if not quarterly monitoring results in the data, the transient variability of water quality has been plotted. This allows observation of seasonal variation and changes in seasonal variation for these parameters. This was rarely possible to plot for many of the more exclusive ash parameters such as trace elements and calcium and magnesium due to the limited annual analyses that were done in most cases for these constituents. For parameters for which semiannual or quarterly data was gathered for more than a few years, graphs reveal longer-term temporal trends and any changes in those trends. When sufficient data exist, trend lines are computed from these data. The nearly ubiquitous occurrence of temporal trends in the post-placement data underscores the invalidity of simply using pre- and post-placement population statistics based upon assumptions of random data variation as assessment tools.

The use of simple comparative assessment as a primary means of evaluating the data, supplemented with the evaluation of temporal trends, makes for tedious reading. Unfortunately, for these sites, that is all the limited data support. It would be possible to compute standard population statistics such as means, variances, standard deviations, and confidence limits to make statistical comparisons. But for the deficient data collected under these permits, such computations for most parameters monitored are not meaningful and could be misleading.

Graphs that represent the element concentrations in water from monitoring data are labeled with the permit number and name, along with the constituent whose concentrations are expressed in mg/L and the collection date. A vertical red line usually demarcates the end of the baseline monitoring period and the beginning of the ash placement monitoring period. To best discern impacts from ash, this line has been placed as close as possible to the dates at which inspection reports, other permit information or PADEP staff indicate that mining and ash placement actually began which can sometimes be months if not years after baseline monitoring data was gathered and the permit was approved. Where the concentrations rise or fall over time, provided there is enough data, the graph will usually have a trend line imposed on the data points, representing the average rise or fall over the monitoring period. Usually unless indicated in the legend of the figures or the text, the trend line will only depict that rise or fall from concentrations measured after the baseline period. This trend line is calculated from the statistical least common fit (LCF) method that uses the equation:

$$y = mx + b$$

where m is the slope of the trend line, and b is the y-axis intercept. Often where an increasing or decreasing trend was obvious, trend lines were not inserted in the graphs.

## 2.4 Summary of Water Quality Impacts by Site

Table 1 below provides a summary of each coal mine ash placement site analyzed in this report. The analysis of permits in this report reveals clearly and decisively that the assertion made by PADEP that there is *no evidence* of water quality degradation from coal ash placement in Pennsylvania coal mines is not borne out by the monitoring data. ***The data indicates overall that degradation of groundwater quality has occurred or is occurring at 14 sites and degradation of surface water quality has occurred or is occurring at 9 sites out of the 15 sites for which reviews have been completed. At ten of these sites, the data presents clear evidence that ash is the source or one of the sources of this degradation. At three sites the data does not provide sufficient evidence to differentiate coal ash from mining or coal refuse as a source of degradation occurring. Only at two sites are the predominating trends reflecting improved water quality with concentrations of most pollutants below concentrations measured during baseline monitoring. Yet even in one of those sites, there are also trends of degradation that appear to be caused by the ash.***

In Table 1 and throughout this report, concentrations of contaminants in groundwater and surface water are usually compared to drinking water standards (DWS). For the purposes of this report, these standards are EPA's primary and secondary maximum contaminant levels (MCL and SMCL, respectively) established under the federal Safe Drinking Water Act. In a number of instances, the state drinking water standards are referenced also. In cases involving surface waters particularly at stream monitoring points, comparisons to water quality standards under the federal Clean Water Act were used.<sup>5</sup> For contaminants in groundwater that do not have a MCL or SMCL (aka, primary or secondary DWS), such as boron and molybdenum, the report uses the Removal Action Levels established under the Superfund program and Health Advisories established pursuant to the Safe Drinking Water Act.<sup>6</sup> For nickel, the DWS was considered to be the former MCL of 0.10 mg/L established under the Safe Drinking Water Act. This standard was reconsidered and remanded in 1995.<sup>7</sup>

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<sup>5</sup> These standards are from *National Recommended Water Quality Criteria*, USEPA Office of Water, 2006. These criteria are published pursuant to Section 304(a) of the Clean Water Act (CWA) and provide guidance to states and tribes to use in adopting water quality standards. See <http://www.epa.gov/waterscience/criteria/wqcriteria.html>. In most cases, these criteria are similar or identical to PA water quality standards (approved by EPA under the CWA) found in 25 Pa. Code Chapters 93 and 96.

<sup>6</sup> Health Advisories are concentrations in drinking water not expected to cause any adverse noncarcinogenic effects from defined periods of exposure. See *Drinking Water Regulations and Health Advisories*, USEPA Office of Water, October 1996.

<sup>7</sup> Following chronic exposure to nickel above the former MCL, nickel has the potential to cause decreased body weight, heart or liver damage, or dermatitis. Brookhaven National Laboratory, *2003 BNL Water Quality Consumer Confidence Report*, May 30, 2003, page 4.

Federal drinking water standards were used for purposes of evaluation and do not necessarily represent the legal limit for contaminants in groundwater or surface water at a particular site. For example, there were no numeric corrective action standards for contaminant concentrations in groundwater currently identified or enforced in the permits examined and Pennsylvania law allows considerably greater amounts of surface water contamination if the surface water in question is not at the point of withdrawal for a potable water supply.<sup>8</sup> The goal of this report, however, was not to evaluate whether particular state standards were being met, but to determine whether monitoring data suggests degradation of groundwater or surface water was occurring due to placement of coal ash. Thus water quality before and after ash placement is consistently described in reference to the above federal standards. Rather than representing enforceable standards, the report uses these standards as reference points for what the federal government considers to be levels above which adverse impacts occur to aquatic life, to the taste or usefulness of water or to human health from its consumption. Furthermore, use of these standards for trace metals in groundwater is appropriate as most state groundwater standards mirror the DWS promulgated under the federal Safe Drinking Water Act.

This report also did not examine whether technology-based effluent limits for iron, manganese, and other major mine drainage parameters in coal mines were exceeded. In a large number of instances, we observed that these concentrations were exceeded at downgradient seeps or other downgradient monitoring points, but we did not determine the applicability of the standards at those points.<sup>9</sup>

Table 1 (below)

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<sup>8</sup> See 25 Pa. Code § 96.3(d).

<sup>9</sup> Nonetheless, one can also use these standards as a reference with which to compare concentrations documented and graphed in the analysis of permits. These technology-based effluent limits for coal mine discharges of wastewater to streams are set forth in 25 PA Code Sec. 87.102.

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type &amp; Placement Purpose</u>	<u>Ash Type &amp; Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/Alkalinity</u>	<u>Monitoring Deficiencies &amp; Other Problems, PADEP Responses to Problems</u>
<b>Ernest Mine</b> <b>32950201CM</b>  <b>Indiana County</b>	Subchapter F Refuse remining, alkaline addition affecting 100 acres of 256 acre site.	FBC ash (waste bituminous coal) 7-9 million tons authorized, 1,400,000 tons dumped from 1998 to 2004	Yes. <u>Data indicate ash is responsible.</u> Rises in trace elements at all downgradient ash monitoring points: lead – 11 times DWS, cadmium – 16 time DWS, chromium – 2.4 times DWS, arsenic – 53 times DWS, nickel – 34 times DWS. Peak concentrations of aluminum and 6 trace metals reached at two ash monitoring points when acidity dropped by 4000 mg/l. Chloride, calcium, and magnesium rise at all ash monitoring points. Loads for aluminum, manganese, sulfate & alkalinity rose. Loads for trace elements such as arsenic, chromium, cadmium and zinc rose or are rising at downgradient seep. Aluminum, sulfate and Specific Conductance rose in McKee Run. Remining and ash placement were contaminating underlying minepool.	Acid. rose 4000 mg/L at 1 down-grad mon well, stayed same at other downgrad mon well and rose 1,000 mg/L at downgrad seep. Field pH rose to 4.5 units while, lab pHs dropped to ~ 3 units.	Too few wells. No well upgradient, or in or under ash. Downgrad wells too far from ash. Relevant GW flow rate unknown. No monitoring for B, Mo & Sb.
<b>McDermott</b> <b>11950102 CM</b>  <b>Cambria County</b>	Active mining, Subchapter F, alkaline addition on 73 acres	FBC ash (waste bituminous coal) 316,930 tons	Yes. <u>Data indicate ash is responsible.</u> Private water supply – offsite spring – contaminated by iron, manganese, sulfate and lead to 4 times DWS. Concentrations of Iron, manganese, sulfate, TDS, and lead rose beyond DWS at downgradient monitoring points. Cadmium rose beyond DWS in groundwater and rose to 76 times higher and selenium 36 times higher than water quality standards at seeps and mine discharges at or well beyond the property line. Neither trace element was detected in baseline data. Calcium and magnesium rose sharply and chloride and sodium steadily at all downgradient points.	Acidity rose by 50-450 mg/L at 4 of 5 mon pts. & dropped by 50 mg/L at one point. Drainage dominantly acidic (pH 3.1 to 5). Alkalinity increased but less than acidity & then dropped from 140 mg/L to 5 mg/L next to the ash.	No upgradient mon. pts. Offsite spring contaminated. Operator bankrupt. Passive treatment of discharges failed. PADEP doing increased monitoring. No monitoring for B, Mo & Sb.

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<b>EP Bender</b> <b>11930102 CM</b>  Cambria County	Subchapter F, Active mining, alkaline addition, 270 acres permitted, 104 acres affected	FBC ash (waste bituminous coal) 65,000 tons	Yes. <u>Data indicate ash is responsible.</u> Manganese, aluminum, nickel, sulfate, and TDS rose many times higher than DWS and upgradient mine seep concentrations, and manganese and iron contaminated underlying aquifer over 20 times the DWS and possibly the regional water table. Cadmium rose above the DWS at two downgradient points, and chromium rose to the DWS at one of these points and above the DWS at another. Specific conductance, calcium and zinc rose.	Acidity rose at all surface water mon. pts by 8 to 100 mg/L with pH 4.2 to 5.8 units. GW well had pH 6 to 7 units. Alkalinity rose at 1 surface water mon. pt.. Temporary rises in pH occurred, but pH declined overall at all but one surf. pt.	Treatment ponds built to remediate load problem in Clearfield Creek. No pore water monitoring or sampling for B, Mo & Sb.
<b>Swamp Poodle</b> <b>17950115 MO</b>  Clearfield County	Active surface mining, alkaline addition, 50 acres	FBC ash (waste bituminous coal) 214,090 tons	Yes. <u>Data indicate ash is responsible.</u> Trace elements rose at all downgradient monitoring points. Arsenic rose to 389 times DWS, cadmium to 46 times DWS, lead and selenium to 4 to 7 times DWS respectively at downgradient mon pt with steepest acidity drop. Manganese, iron, sulfate, and TDS rose sharply at two downgradient points and fell sharply at a third one. Chloride fell at two points and rose at one point. Calcium and magnesium tripled and doubled at two points. but were flat to declining at the third one.	Acidity declined at one downgradient pt. by 2,000 mg/L but rose at another pt by 800 mg/L and rose by 200 mg/L at a third pt. pH of 2.3 to 3.4 units and declining at all downgradient pts.	Mon period only 3 yrs for trace elem. Too few mon. pts. No pore water mon pts. . No response to rising trace element levels. No monitoring for B, Mo & Sb.

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type</u> <u>&amp; Placement</u> <u>Purpose</u>	<u>Ash Type &amp;</u> <u>Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/</u> <u>Alkalinity</u>	<u>Monitoring</u> <u>Deficiencies &amp;</u> <u>Other</u> <u>Problems,</u> <u>PADEP</u> <u>Responses to</u> <u>Problems</u>
<b>Ellengowan</b> - <b>Knickerbocker</b> <b>54793206 PV</b>  <b>Schuylkill</b> <b>County</b>	Refuse reprocessing, Placement and Demonstration	FBC ash (waste anthracite coal) 12 million tons total, 3 million tons in pit, 9 million tons over 144 acres	Yes. <u>Data indicate ash is responsible.</u> Lead up to 39 times over DWS and cadmium up to 32 times in the downgradient mine pool but not as high upgradient. Culm ashes dumped at Ellengowan and neighboring BD mine leach high levels of these metals. Latest samples from Knickerbocker wells have high lead and cadmium for the first time in 12 years of monitoring. High arsenic and chromium in the baseline period could be from mine fires and previous documented ash disposal into the mine pool in the 1970s. Aluminum, zinc, and nickel are exceeding the DWS. A decisive drop in major/minor constituents in 1999 was followed by steady rise in 2002/2003 back to previous high levels. Calcium and magnesium levels are not high. Very high Total Suspended Solids in mine pool under Knickerbocker Pit, ash slurry project.	Highest rises in pH seen at any site. At an “upgradient” pt and the most downgradient pt. in the permit area, lab pH rose from 5-6 units to 9-10 units in large mine pools over 5-6 years. Other pHs also rose by 1-3 units. All pHs declined in the last two years.	Poor site characterization. Too few mon. pts – seven mine pool sampling pts. for 3 large ash areas over 3,000 acres. “Upgradient” pts. are downgradient of ash. No pore water monitoring. Details, schematics for mon. pts. unavailable. Water elevations not recorded, pumping of mine pool not tracked by the permit and flow direction often unknown. One “downgradient” pt is six miles

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					from site. Monitoring only large volumes of mine pool water. No mon. for B, Mo and Sb.
<b>Silverbrook - Big Gorilla</b>  <b>54920201 PV</b>  <b>Schuylkill &amp; Carbon Counties</b>	Refuse Reprocessing, Placement and Demonstration	FBC ash (waste anthracite coal) > 3 million tons in pit, at least 1.1 million tons on rest of site	Yes. <u>Data indicate ash is responsible</u> . Sulfate, TDS, aluminum, iron, manganese exceed DWS by multiple times at the most downgradient monitoring point, the Silverbrook Discharge. Calcium, magnesium, potassium and specific conductance all high in the Big Gorilla Pit ash pore water and rising at Silverbrook since the Pit was filled with ash. Selenium and lead are 2-3 times higher than the DWS, arsenic is exceeding the DWS and molybdenum has exceeded health advisory levels in the pit pore water by 14 times. Chromium and arsenic found at over 2 times the DWS in the alkaline pit water once ash placement started, higher than ever found in the acidic pit water.	Since Big Gorilla was filled, ash pit water pH dropped in one year from 9.2 to 7.0 units. PH around 5 units at the upgradient well drops to 3.2 to 4.13 units at downgradient well and Silverbrook despite the ash in between in Big Gorilla.	Specific ground- water flow paths not determined. No load monitoring at Silverbrook outfall. Ash may be upgradient to upgradient well. No monitoring for B & Sb.

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type &amp; Placement Purpose</u>	<u>Ash Type &amp; Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/Alkalinity</u>	<u>Monitoring Deficiencies &amp; Other Problems, PADEP Responses to Problems</u>
<b>BD Mining</b>  <b>54850202 PV</b>  <b>Schuylkill County</b>	Refuse Re-processing, Placement for surface reclamation	FBC ash (anthracite waste coal) 3.7 million tons over 125 acres.	Yes. <u>Data indicate ash is responsible.</u> Lead up to 38 times DWS, arsenic more than 6 times DWS, cadmium more than 5 times DWS, chromium and nickel more than 2 times DWS, at downgradient monitoring pts after ash placement starts. Added baseline data from mine pool under neighboring Turkey Run Landfill and background data from other anthracite mine pools does not reveal levels of lead this high. Sharp decline in major/minor constituents, TDS and Spec. Cond. at monitoring pt. closest to the ash in 1997/98 followed by sharp rise in 2002/03 to levels exceeding DWS and by many times for iron and manganese. Small overall rises in calcium, magnesium, sodium and chloride.	pH dropped by .3 to .8 units to ~5.25 at downgradient mon. wells closest to ash, while unchanged at 6 units farther downgradient in mine pool. Acidity declining at all mon. pts. but alkalinity increasing slightly more farther downgradient.	GW flow paths unclear. No upgrad. or pore water mon. pts. Only 1 mine baseline measurement for trace elements. No monitoring for B, Mo & Sb or for lead or other trace elements from the Gilberton Discharge into Mahanoy Creek.
<b>EME Generation</b>  <b>32753702 CA</b>  <b>Indiana County</b>	Refuse Disposal, Alkaline addition, ash disposal	PC bituminous ash, 2-2.8 million tons of ash authorized and most of it placed/disposed in this site, most of which is a lined facility with leachate collection pipes.	Yes. <u>Data indicate ash is responsible.</u> Sulfate concentrations and loads rise beyond highest levels measured in baseline of active gob disposal operation after ash placement starts. Sulfate rises to several times above WQS in Cherry Run if it was a public water supply and rises from under 6 times DWS to over 14 times DWS on tributary draining site to Cherry Run. Iron, manganese and aluminum rising further over standards in tributary and aluminum rising in Cherry Run. Nickel, zinc, chromium, copper, barium, and silver have risen at downgradient ash monitoring points once ash placement starts although cadmium, arsenic and selenium have declined at the	Acidity is falling and alkalinity rising at all downgradient mon. pts. except one ash pt., although pH at that point is climbing beyond baseline from 4.75 to 5.90 units. At all but	No data being collected for ash parameters & trace elements in stream draining site or the stream into which it flows, Cherry Run. No monitoring for B, Mo & Sb

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type &amp; Placement Purpose</u>	<u>Ash Type &amp; Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/Alkalinity</u>	<u>Monitoring Deficiencies &amp; Other Problems, PADEP Responses to Problems</u>
			ash pt monitoring the oldest part of the operation where nearly all the waste is coal refuse. At this point extremely high levels of sulfate and iron and high levels of ash parameters calcium, magnesium, and sodium have been declining while they are rising at the other two ash monitoring points. Manganese and aluminum are slightly rising at this point.	one mon. pt, pH is rising. Still, very high acidity at that point has declined by 2200 mg/L since ash placem. started. Leachate evap. pond pH is ~3.0 units but rising slightly.	at the site.
<b>Hartley Strip Mine</b> <b>30713008 GN</b> <b>Greene County</b>	Active mining. Official purpose for placement unclear, possibly placement to fill pit/achieve AOC. Applicant sited mine disposal as most economical alternative	PC bituminous ash. At least 300,000 tons over 30.3 acres and ash placed on previous area of unknown size	Yes. <u>Data indicate ash is responsible.</u> Manganese exceeded DWS by 95-226 times, iron by 19 times and sulfate by 18.2 times in downgradient wells whereas manganese exceeded DWS by 10 times, iron by 3 times and sulfate by 4.8 times in “upgradient” well inside ash placement area. Boron exceeded Superfund Removal Action Levels by 15.6 times and molybdenum by 19 times in downgradient wells with calcium, magnesium, and potassium rising steadily. Ash generator concedes ash contaminated Hartley site with boron. Antimony, lead, cadmium exceeded DWS by 2 to 18 times although highest exceedances were in the “upgradient” well.	At downgradient wells, pH is rising to ~ 6.8 units and alkalinity. is rising while pH is falling to 6.9 units and alkalinity is falling at upgradient well. Water more alkaline draining to the north from ash than to the south.	Baseline data missing. Six year gap in mine data. Mon. ends despite contamination. Upgradient well appears to be in older ash placement area. No pore water well. More complete data exist from adjacent ash landfill. No monitoring for B at mine mon pts. Little Whitely Creek

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type &amp; Placement Purpose</u>	<u>Ash Type &amp; Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/Alkalinity</u>	<u>Monitoring Deficiencies &amp; Other Problems, PADEP Responses to Problems</u>
					draining area is heavily contaminated with B, Mo, and sulfate.
<b>Bloom #1</b>  <b>17950111MO</b> <b>Clearfield,</b> <b>County</b>	Active surface mining, Subchapter F permit, Alkaline addition	FBC ash (bituminous waste coal) 80,200 tons authorized over ~ 26 acres, 45,000 tons placed	Yes. <u>Data indicate ash is responsible.</u> Manganese rising to 156-360 times DWS at 3 downgradient monitoring pts. Sulfate rising to as much as 7.6 times DWS and TDS 4.4 times DWS at these points. Specific Cond., calcium, magnesium also rising sharply at two out of three downgradient monitoring pts. One lead measurement at a downgradient seep after ash placement started was nearly twice the DWS and many times chronic WQS. A single measurement of arsenic in the ash/spoil pore water well was 2150 times the DWS. The highest measurements of alkalinity, TDS, Spec. Conduct., calcium, magnesium and other ash parameters in this sample indicate the arsenic is from the ash. Subchapter F load triggers for manganese and net acidity exceeded at one seep.	Field pH is rising from 5.5 to 6.8 units in ash-spoil backfill but falling at all downgradient pts by as much 1.5 units to 4.25-5.25 units beyond the ash backfill .	Only 4-5 samples of trace metals during ash placement and high detection limits render marginal results. No monitoring for B, Mo & Sb. PADEP increased monitoring at Sub F pts. for mine parameters.

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type &amp; Placement Purpose</u>	<u>Ash Type &amp; Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/Alkalinity</u>	<u>Monitoring Deficiencies &amp; Other Problems, PADEP Responses to Problems</u>
<b>TDK Sandy Hollow</b>  <b>16910104 KX</b> <b>Clarion County</b>	Active Surface mining, Subchapter F permit, Alkaline addition	FBC and PC ash (bituminous coal and waste coal) 342,000 tons	Yes. <u>Data insufficient to differentiate causes.</u> Iron and manganese rose from DWS to 8 times and 25 times the DWS respectively at downgradient ash well, but declined to baseline levels at end of monitoring. Sulfate and TDS rose from below the DWS to nearly 4 times over and nearly 3 times over the DWS respectively and were still exceeding DWS at the end of monitoring. Calcium and magnesium measurements were higher than baseline but sodium and chloride were lower at this well. Sulfate and TDS levels at upgradient well remained same as baseline concentrations and under DWS except for the last TDS measurement. Manganese and iron also stayed at baseline levels except for one measurement. Concentrations and loads of aluminum, sulfate, iron, and manganese at downgradient Subchapter F seep stayed the same or declined slightly although flows also declined.	pH dropping from 6.7 to 5.8 units at downgradient monitoring well, from 7.2 to 6.5 units at upgradient monitoring well & from 4 to 3.6 units in nearby Subchapter.F seep. Acidity is slightly rising and alkalinity slightly declining in this seep.	Trace elements and ash parameters like calcium and magnesium sampled only 1-3 times over 6.5 yrs. at ash pts. Monitoring stopped despite increases in SO4 and TDS. Upgradient well appears to be in ash placement area. No pore mon. well. No monitoring for B, Mo & Sb.
<b>C&amp;K Coal</b>  <b>16703006KX</b> <b>Clarion County</b>	Active Mining, Placement and soil amendment	FBC and PC bituminous ash 200,000 tons on 135 acres, unspecified “small amount” of coal refuse disposed with the ash	Yes. <u>Data insufficient to differentiate causes.</u> Iron, manganese, sulfate and TDS rise even further over DWS at the upgradient well than at shallow and deeper downgradient wells although concentrations at downgradient wells all rise above baseline levels which is not so for iron at upgradient well. Calcium, magnesium and chloride levels rise substantially higher at the upgradient well than at the downgradient wells. However arsenic is 3.7 times the DWS and selenium is elevated in one measurement at downgradient wells while neither are elevated in the upgradient well.	Acidity rose from 60 to 110 mg/L & pH fell from 6-6.5 to 4.7-5.6 units at upgradient well. At shallow downgradient well, acidity dropped to zero during baseline period, alkalinity	Too few mon pts. Designated upgradient well appears to be affected by mining/ash placement or suggests other sources of constituents than ash.

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type</u> <u>&amp; Placement</u> <u>Purpose</u>	<u>Ash Type &amp;</u> <u>Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/</u> <u>Alkalinity</u>	<u>Monitoring</u> <u>Deficiencies &amp;</u> <u>Other</u> <u>Problems,</u> <u>PADEP</u> <u>Responses to</u> <u>Problems</u>
				rose from 35 to 80 mg/L after ash placement, and pH rose from 6 to 6.3 units. Deeper well's alkalinity probably due to Vanport Limestone.	Possible influence from limestone under the site. Too little trace element and ash parameter data. No data to tell impacts of coal refuse. No monitoring for B, Mo & Sb.

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<b>Buterbaugh</b>  <b>17990112MO</b>  <b>Clearfield</b> <b>County</b>	Active mining, Placement	PC bituminous. ash, 24,538 tons on approx 20 acres and an amount of lime probably equal to or greater than this tonnage	Yes. <u>Data insufficient to differentiate causes.</u> Sulfate and TDS rose above DWS by 1.5 to 3 times, and manganese rose from 82 times the DWS before to 192 times DWS after mining and ash placement at one downgradient seep. Selenium rose to more than 3 times the water quality standard and cadmium to 28 times the WQS (for chronic toxicity) at this seep. Sharp rises occurred in calcium and magnesium, and rises also occurred in sodium, chloride and potassium. Water quality at another downgradient seep was not degraded above DWS.	Acidity & alkalinity levels were small, and changes were slight. pH rose from 4.7 to 5.5 units at one point and fell from 6.2 to 5.4 units at another.	No upgrad monitoring pt, Poorly located downgrad mon pts. Mon. gaps at other points and ash data was inadequate. Little/no monitoring of stream draining area, Banion Run for ash parameters. Cannot differentiate ash from lime and mining impacts. No monitoring for B, Mo & Sb.
<b>Russelton</b>  <b>02930201GN</b>  Allegheny County	Refuse re-processing, Subchapter F permit, Alkaline addition	FBC ash (waste bituminous coal) 1,500,000 tons over 50+ acre gob pile being remined	No. <u>Overall improvement shown from data.</u> Initial rises in concentrations and loads of iron, manganese, sulfate and aluminum decline and disappear in the last four years of monitoring (2000-2004). Ten months into gob remining and ash placement, arsenic and cadmium increased at a discharge from the gob pile into Little Deer Creek to levels higher than baseline and exceeding DWS by 8.7 times and more than 10 times respectively. The cadmium exceedance was also more than 200 times over WQS. Subsequent measurements of trace elements were below baseline levels.	Acidity rises in first 3 yrs. Peaks of 600-900 mg/L disappear in last 4 yrs after ash placement.	Too little trace element monitoring -- only 5 samples in 8 years of mon. despite exceedances of DWS for arsenic & cadmium after

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					ash plcmt. No monitoring for B, Mo & Sb. Given amt. of ash placed, monitoring should have continued well beyond 7-8 yrs.

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type &amp; Placement Purpose</u>	<u>Ash Type &amp; Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/Alkalinity</u>	<u>Monitoring Deficiencies &amp; Other Problems, PADEP Responses to Problems</u>
<b>Wildwood</b> <b>02940201 GN</b>  <b>Allegheny</b> <b>County</b>	Refuse re-processing, Subchapter F permit, Alkaline addition	FBC ash (waste bituminous coal) 454,000 tons over 30+ acre gob pile being remined	No. <u>Overall improvement</u> shown from data with exceptions. Concentrations and/or loads of major and minor constituents (TDS, iron, manganese, sulfate, aluminum) improved to at or below baseline levels at one Subchapter F monitoring point in final two years of monitoring. Trace elements declined from baseline levels at ash monitoring points. However concentrations of aluminum and sulfate and loads of manganese, aluminum and sulfate were higher in the last two years at another Subchapt. F point than they were in baseline monitoring. Concentrations of sulfate and manganese also increased from upstream to downstream in adjacent Pine Creek, a trout stream, in the final year of data, and the increase in sulfate was four times the increase between these points before the operation. Concentrations of fluoride also increased at all ash monitoring points exceeding the primary and secondary DWS at one point and secondary DWS at another multiple times. Concentrations of sodium, chloride and calcium increased above baseline concentrations at some ash points and sulfate increased at one point to more than three times DWS in the last measurement.	Acidity declined sharply in gob ground water and in sandstone aquifer below the pile and fell moderately in the piles more acidic surface discharges. Alkalinity rose sharply from 3 to 13 times in the ash wells in the gob while declining in the sandstone. Only one mon. well, in the sandstone, had pH decrease to below 7 units with all others rising to 7-8 units. Sub F points pH rose tenth unit to 3.2-3.3.	Major gaps in monitoring. No data for major elements in 4 of 7 yrs during ash placement at one ash well. Only one yr of ash placement data at the upgrad. well. Only 7 samples over 7 years comprises the best data set for analysis of ash parameters during ash placement from just one well. 3 wells dried up and/or destroyed by operation which stopped all monitoring illegally and paid no penalties. No pore water mon. done. Mon.

<b>TABLE 1:</b> <u>Permit Name</u> <u>Number</u> <u>County</u>	<u>Permit Type</u> & <u>Placement</u> <u>Purpose</u>	<u>Ash Type &amp;</u> <u>Quantity</u>	<u>Degradation of Water Post-Ash Placement</u>	<u>Acidity/</u> <u>Alkalinity</u>	<u>Monitoring</u> <u>Deficiencies &amp;</u> <u>Other</u> <u>Problems,</u> <u>PADEP</u> <u>Responses to</u> <u>Problems</u>
					stopped in 2004. No trace elem. mon in Pine Creek and no mon. for B, Mo & Sb.

Abbreviations: mon = monitoring  
 plcmt = placement  
 pt = point  
 dngrad = downgradient  
 upgrad = upgradient  
 DWS = Drinking Water Standard  
 B = Boron  
 Mo = Molybdenum  
 Sb = Antimony  
 CA = PADEP California District Mining Office  
 CM = PADEP Cambria District Mining Office  
 GN = PADEP Greensburg District Mining Office  
 KX = PADEP Knox District Mining Office  
 MO = PADEP Moshannon District Mining Office, also called Phillipsburg District Mining Office  
 PV = PADEP Pottsville District Mining Office

Notes: The arsenic (As) DWS in this table is the MCL of 0.010 mg/L, the new federal standard effective January 23, 2006.  
 The nickel (Ni) DWS in this table is the former MCL of 0.100 mg/L remanded in 1995.

The trends discussed in column five of Table 1 are based on average concentrations. For example, in the fifth column describing pH and acidity or alkalinity increases or decreases, the trends inferred and numbers given are based on average concentrations. In the fourth column describing the degradation, peak concentrations are used when the number of times a drinking water standard (DWS) for a trace element is exceeded in a measurement. For example, “Lead rising to 11 times the DWS” means that lead was measured in concentrations that rose up to a maximum measurement of 11 times the DWS.

The degree of the degradation occurring at these sites surpasses the degradation from AMD that is often presented as the justification in PADEP permits for placement of coal ash. Promoters of that placement assert that the alkalinity in the ash will buffer or reduce mine acidity, bringing down concentrations of iron, manganese, aluminum, sulfate and other mine drainage parameters, and that regardless of whether such buffering occurs, the pollution potential posed by the coal ash is unlikely to worsen water quality beyond its already poor condition at these sites. However, monitoring data reveal that at many of these sites, concentrations of iron, aluminum, manganese and sulfates that are several to many times over drinking water standards and water quality standards prior to ash placement reach concentrations even farther beyond those standards after ash placement. Even more troubling is that the monitoring of those increases does not appear to result in any corrective actions, regardless of how high concentrations become. At several sites, monitoring ended amidst upward trends in these parameters indicative of both mine drainage and ash leachate as well as increases in trace metals and other parameters more indicative of ash leachate than mine drainage.

Data from ash monitoring points also indicate the primary benefit sought in most of these permits, i.e., reducing overall AMD through alkaline addition with ash, has not been achieved in half of the sites. In 7 of the 15 permits, average acidity increased and/or average pH decreased at a majority of downgradient monitoring points during the ash placement monitoring period. At 5 of the 15 permits, average acidity decreased and/or average pH increased at a majority of downgradient points. At the remaining three permit sites, acidity and pH rose and fell evenly between monitoring points. ***Most notably, in 6 of the 9 permits examined that used ash expressly as an “alkaline addition” to buffer acidity and maintain or raise pH, the result was decreasing pH and rising acidity at all or a majority of downgradient monitoring points.*** The actual number of data sets examined at monitoring points, discussed in the next section, shows that in the aggregate, while alkalinity increased more often than it decreased at monitoring points where it was examined, acidity also increased more often than it decreased. Perhaps more to the point, pH decreased more often than it increased. While ash appeared to be contributing alkalinity, at the large majority of monitoring points at alkaline addition sites, the increases in alkalinity appeared to be temporary and were not as strong as the acidity generated by mining and remining activities.

The data also showed that concentrations of a range of parameters indicative of both mine drainage and ash leachate increased under both alkaline and acidic pH conditions. Ironically, the increases in pH and alkalinity and decreases in acidity being sought by PADEP from coal ash can often present the best evidence that adverse impacts to water quality, such as a rise in trace elements, are coming from the ash. Considered alone, increases in alkalinity and pH, decreases in acidity, and increases in parameters more exclusive of ash all appear to be evidence of contributions to water quality from ash at a number of these sites. Increases in parameters more exclusive of ash leachate may appear as increases in calcium, magnesium, or chloride, as well as trace elements known to leach from the ashes in question or to leach in more alkaline pH than are found in the baseline water quality at a site. Where there is overlap between these trends in water downgradient from the ash, e.g., increases in calcium and chloride coinciding with increases in pH, the evidence becomes stronger that increases in other parameters indicative of ash leachate and mine drainage are coming from dissolution of the ash. Examples of other parameters indicative of ash leachate and mine drainage include sulfates, TDS, manganese, and aluminum as well as trace metals. At nine of the 13 sites in which water quality became more degraded, higher concentrations of arsenic and selenium were measured in drainages with rising pH values and dropping acidities. It should also be noted, however, that these oxyanions were increasing at five of these sites in water with dropping pH, and both increased temporarily also in water with declining pH at the Russelton site where overall water quality improved by the end of the monitoring period.

The permits studied in this report do not provide enough information to determine whether trace elements or other contaminants detected in groundwater or surface may have been mobilized from waste coal or native mine materials due to basic changes in the geochemical environment occurring from the addition of coal ash. Indeed the objective of many of these permits is to use coal ash to alter the geochemistry of mine sites quickly by reducing acidity, increasing alkalinity or reducing the atmospheric exposure of mine materials at these sites. Furthermore, several of the permits expressly authorized the physical mixing of coal ash with mine spoils to achieve these objectives. It is possible, therefore, that geochemical changes, brought about by the presence of the ash, mobilize trace elements or other contaminants in the gob or spoil.

However, to understand, for example, whether the arsenic in groundwater at an ash monitoring point came from the ash or from gob affected by the ash requires more than a bulk analysis and a laboratory leach test on just the ash. The need for testing, characterization and monitoring to determine whether trace metals in ash/spoil leachate are from ash or from spoil or gob being affected by ash is discussed further in Chapter 6. Nevertheless, even if improvements in permitting reveal that spoil or gob are the source of arsenic, selenium, chromium or other trace metals in the downgradient water at a particular site instead of ash, our concerns would not be diminished given these trace metals would have remained in the gob or spoil but for the introduction of the ash to the microenvironment.

There were a number of deficiencies noted in the monitoring systems at these sites as indicated in the last column of Table 1. They include poor characterization of hydrologic

systems, too few monitoring points, no upgradient monitoring points, no monitoring points in the ash, gaps in data, inadequate baseline data collection, short monitoring periods, insufficient monitoring of streams draining permit areas, and no corrective action responses to rising concentrations of pollutants that would implement increased monitoring to locate sources of degradation.

There is also little or no monitoring for pollutants that are known red flags for ash contamination and documented to leach readily from the coal ashes being placed in these mine sites. Monitoring for such pollutants, which are also known *not* to leach from coal refuse or spoils, would allow regulators to better understand the role of ash in deteriorating water quality at these sites. For example, boron and molybdenum are well-established indicator parameters for contamination from CCW generated from eastern and midwestern bituminous coals, and neither boron nor molybdenum is normally found in acid mine drainage. Nevertheless, there was no regular monitoring for boron or molybdenum in any of these permits. The report's authors were able to examine boron and molybdenum concentrations at the Hartley Mine in two wells downgradient from that site because they serve as monitoring points for the Hatfield's Ferry Coal Ash Landfill. Boron was rising after ash placement to levels as high as 14.042 mg/L, 15.6 times the Removal Action Level in one well and 12.22 mg/L in the other well, 13.6 times the Removal Action Level. These levels are also more than 3 times higher than the Health Advisory for the most acute exposure to boron. Molybdenum had risen to a high of 0.0115 mg/L in one of these wells exceeding the Removal Action Level and Longerterm Child Health Advisory of 0.010 mg/L. Antimony, also generated in elevated concentrations in ash leach tests in several permits in this report, was monitored at only one permit (Hartley), and its concentration rose to more than 16 times above DWS at both the upgradient and downgradient ash monitoring points after ash placement.<sup>10</sup>

Potassium, also documented in many cases as a reliable indicator of coal ash pollution and readily soluble in many leach tests of ashes placed at the sites examined in this report, was monitored at some sites but not others. Basic deficiencies in monitoring were found to varying degrees in all permits studied and are discussed further in Chapter 6.

## 2.5 Overall Trends Observed From Monitoring Data

The aggregate behavior of elements is examined in Tables 3 and 4 which document the number of times the concentrations and trends in average concentrations increased, decreased or did not change at monitoring points after ash placement. The data in these Tables show that significant deterioration of water quality is occurring in the permits studied in this report, and this deterioration worsens as one moves from upgradient to downgradient monitoring points. Taken with Table 1, this deterioration clearly and repeatedly meets the definition of "groundwater degradation" found at 25 Pa. Code §287.1 and recited in the Module 25 of these permits which is "a measurable increase in

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<sup>10</sup> Examination of the Hartley site revealed to the authors that the upgradient well in this instance is probably not upgradient of ash and mining impacts given that it appears to be screened in the spoil within the mining and ash placement area and generating data that reveals rises in other constituents.

the concentration of one or more contaminants in groundwater above background concentrations for these contaminants.”

Tables 3 and 4 include data from 826 data sets for concentrations measured at the 15 sites for which permit reviews were completed in this report. A data set is the concentration of a pollutant measured at a monitoring point for the duration of monitoring at that point. None of the data sets or monitoring points from those sites for which final reviews could not be completed are included in these Tables. Such data would likely exacerbate these trends as higher concentrations suggesting degradation were readily seen at downgradient points in two of those sites.<sup>11</sup>

The data in Tables 3 and 4 were generated by monitoring points described in Table 2. For simplicity, the authors are labeling both surface water and groundwater points in Table 2 as “upgradient” or “downgradient” although technically it would be more accurate to term surface water points as upstream or downstream. Six of the 81 monitoring points examined in the report that are included in Table 2 produced no data after ash placement started or too little data to assess whether increases had occurred and thus their data is not reflected in Tables 3 and 4. Accordingly the data in Tables 3 and 4 comes from 75 monitoring points. Fourteen of these were upgradient, 58 were downgradient, and 3 were pore water points.

A further delineation to note is that 58 of these points were specifically designated as “ash monitoring points” under the Module 25 of the permits.<sup>12</sup> Of these, 48 are downgradient and 10 are upgradient.<sup>13</sup> Thirty one of the ash monitoring points were groundwater wells, 10 were mine pool monitoring points and 17 were surface water points. There was no data collected for trace elements or other ash-exclusive parameters from the 17 other points not designated as ash monitoring points.

Some of the data not used in Tables 3 and 4 come from the four “pore water” monitoring points listed in Table 2. These points were located directly in the ash or sampled leachate from pipes that collect leachate that has percolated through ash without subsequent dilution by ground or surface water at the monitoring point. Some data from these pore water points are reflected in Tables 3 and 4 as “downgradient” data if it was collected over enough duration to generate data from more than a few samples from which a trend can be discerned.<sup>14</sup> An example of pore water data not being used occurred at the pore water well, MW-3 in the Bloom #1 site from which researchers could find only one monitoring report for trace elements from March 2004 which measured total arsenic at an extremely high level of 21.5 mg/l, 2150 times over the DWS. Very high levels of alkalinity and other ash indicator parameters including calcium, magnesium, sodium, chloride and potassium were found in this sample thus strongly pointing to the ash at this

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<sup>11</sup> These are the Penn State site, Permit # 17820104, and the McCloskey site, Permit #17793044.

<sup>12</sup> Actually two of these ash monitoring points, wells at the Hartley Strip site were not mine ash wells but were sampled for ash parameters as part of the neighboring Hatfield coal ash landfill’s monitoring system.

<sup>13</sup> There were two upgradient ash monitoring wells at the Ernest and McDermott sites that went dry at the outset of operations and thus no data from them could be included in these Tables.

<sup>14</sup> Technically the water at these monitoring points is source water quality, i.e., showing what is generated in the pore spaces within the ash deposits and not “downgradient” of the ash.

point as the source of this very toxic level of arsenic. This data was not used in Table's 3 and 4 because only one sample cannot provide evidence of a trend, particularly if there is no baseline data as is the case at MW-3 and other pore water monitoring points given they are installed after the ash has been placed at the site. Similarly data from several samples collected from MW-5 installed in the Big Gorilla Pit ash, revealing levels of selenium 1-3 times over the DWS, was also not used due to the short duration of monitoring at this point.

	<b>Upgradient</b>	<b>Downgradient</b>	<b>Pore Water</b>
<b>Surface Water Monitoring Point</b>			
Seeps / Springs	1	14	0
Streams	4	7	0
Surface mine discharges	0	2	0
Leachate collection pond	0	1	0
<b>Gound Water Monitoring Point</b>			
Wells	10	22	2
Leachate collection pipes	0	0	2
<b>Hybrid Monitoring Point</b>			
Mine pools	2	13	0
Leachate collection pipe and spring	0	1	0
<b>Subtotals:</b>	<b>17</b>	<b>60</b>	<b>4</b>
<b>TOTAL POINTS:</b>	<b>81</b>		

Although the primary constituents studied at all sites were iron, manganese, sulfate, arsenic, selenium, cadmium and lead, there were 29 parameters in all examined at monitoring points in this report, as shown in the far left column of Tables 3 and 4. Five of these were broad parameters for water quality: pH, acidity, alkalinity, TDS and specific conductance. Three were dominant constituents in mine drainage that are also found in drainage from coal ash disposal sites that are not in coal mines: iron, aluminum and manganese. Fourteen were trace elements. All of these trace elements<sup>15</sup> are normally found in concentrated levels in coal ash. Many can leach in elevated levels from coal ashes under varied circumstances. The PADEP requires that the SPLP leach test analyze for each of these trace elements in the permits studied in this report. Some of the elements, such as copper, nickel and zinc are also commonly found in elevated levels in acid mine drainage at eastern coal mines. Finally six of the parameters, calcium,

<sup>15</sup> With the exception of mercury, much of which volatilizes into the atmosphere from coal during combustion.

magnesium, sodium, chloride, potassium and sulfate, readily leach from many CCWs, including the FBC ashes placed in Pennsylvania coal mines in dilute laboratory leach tests such as the SPLP and are thus labeled “Other Ash Indicators” along with TDS and Specific Conductance. These latter two broad parameters are often measured and reported only from ash monitoring points which are also the only monitoring points from which trace elements and the other ash indicators are collected. An exception is sulfate which is usually measured at both mining and ash monitoring points.

<b>TABLE 3</b>		<b>All Sites Monitoring Points Summary</b>				
<b>All Sites CUMULATIVE</b>		<b>Decrease</b>	<b>No Change</b>	<b>Increase</b>	<b>≥ DWS*</b>	<b>≥ 3X DWS</b>
<b>Parameter Group &amp; Parameter</b>						
<b>AMD / Ash</b>						
pH (trend)		30	6	27	2	0
Acidity (trend)		25	1	31	0	0
Alkalinity (trend)		13	8	23	0	0
Fe (iron)		25	3	32	6	57
Al (aluminum)		7	3	19	8	25
Mn (manganese)		22	2	45	5	64
<b>Subtotal</b>		<b>122</b>	<b>23</b>	<b>177</b>	<b>21</b>	<b>146</b>
<b>Parameter Group Share (%)</b>		<b>37.9%</b>	<b>7.1%</b>	<b>55.0%</b>	<b>6.5%</b>	<b>45.3%</b>
<b>Trace Elements</b>						
As (arsenic)		15	4	14	2	13
Se (selenium)		10	2	15	5	6
Pb (lead)		11	2	26	3	21
Cd (cadmium)		11	5	23	13	15
Cr (chromium)		2	1	8	5	1
Ni (nickel)		4	0	16	8	10
Zn (zinc)		3	2	15	2	1
Cu (copper)		0	0	7	1	0
Sb (antimony)		0	0	3	0	2
Mo (molybdenum)		0	0	2	1	1
B (boron)		0	0	2	0	2
Hg (mercury)		0	0	0	0	0
Ba (barium)		0	0	4	0	0
Ag (silver)		0	0	3	1	0
<b>Subtotal</b>		<b>56</b>	<b>16</b>	<b>138</b>	<b>41</b>	<b>72</b>
<b>Parameter Group Share (%)</b>		<b>26.7%</b>	<b>7.6%</b>	<b>65.7%</b>	<b>19.5%</b>	<b>34.3%</b>
<b>Other Ash Indicators</b>						
Ca (calcium)		14	0	33	0	0
Mg (magnesium)		8	1	32	0	0
Na (sodium)		8	5	13	0	0
Cl (chloride)		7	0	29	5	0
K (potassium)		1	1	7	0	0
F (flouride)		0	0	7	2	0
SO4 (sulfates)		21	3	43	19	40
TDS (total dissolved solids)		14	1	31	19	22
S. Cond. (specific conductance)		6	1	8	1	1
<b>Subtotal</b>		<b>79</b>	<b>12</b>	<b>203</b>	<b>46</b>	<b>63</b>
<b>Parameter Group Share (%)</b>		<b>26.9%</b>	<b>4.1%</b>	<b>69.0%</b>	<b>15.6%</b>	<b>21.4%</b>
		<b>Decrease</b>	<b>No Change</b>	<b>Increase</b>	<b>≥ DWS*</b>	<b>≥ 3X DWS</b>
<b>CHANGED SETS TOTALS</b>		<b>257</b>	<b>51</b>	<b>518</b>	<b>108</b>	<b>281</b>
<b>COMPOSITE PARAMETER GROUP SHARE (%)</b>		<b>31.1%</b>	<b>6.2%</b>	<b>62.7%</b>	<b>13.1%</b>	<b>34.0%</b>

\* Note that any measurements depicted as "= DWS" include values equal to or greater than DWS up to immediately under 3X DWS.

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TABLE 4 All Sites CUMULATIVE	Cumulative UPGRADIENT Site Monitoring Points Summary					Cumulative DOWNGRADIENT Site Monitoring Points Summary				
	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS	Decrease	No Change	Increase	≥ DWS*	≥ 3X DWS
<b>AMD / Ash</b>										
pH (trend)	6	1	6	1	0	24	5	21	1	0
Acidity (trend)	3	1	7	0	0	22	0	24	0	0
Alkalinity (trend)	1	3	4	0	0	12	5	19	0	0
Fe (iron)	8	2	3	2	13	17	1	29	4	44
Al (aluminum)	1	1	5	2	6	6	2	14	6	19
Mn (manganese)	5	0	8	2	13	17	2	37	3	51
<b>Subtotal</b>	<b>24</b>	<b>8</b>	<b>33</b>	<b>7</b>	<b>32</b>	<b>98</b>	<b>15</b>	<b>144</b>	<b>14</b>	<b>114</b>
<b>Parameter Group Share (%)</b>	<b>36.9%</b>	<b>12.3%</b>	<b>50.8%</b>	<b>10.8%</b>	<b>49.2%</b>	<b>38.1%</b>	<b>5.8%</b>	<b>56.0%</b>	<b>5.4%</b>	<b>44.4%</b>
<b>Trace Elements</b>										
As (arsenic)	4	0	0	0	0	11	4	14	2	13
Se (selenium)	3	0	2	1	0	7	2	13	4	6
Pb (lead)	3	0	3	0	2	8	2	23	3	19
Cd (cadmium)	1	1	3	1	1	10	4	20	12	14
Cr (chromium)	0	0	0	0	0	2	1	8	5	1
Ni (nickel)	0	0	2	2	0	4	0	14	6	10
Zn (zinc)	1	0	2	0	0	2	2	13	2	1
Cu (copper)	0	0	0	0	0	0	0	7	1	0
Sb (antimony)	0	0	1	0	1	0	0	2	0	1
Mo (molybdenum)	0	0	0	0	0	0	0	2	1	1
B (boron)	0	0	0	0	0	0	0	2	0	2
Hg (mercury)	0	0	0	0	0	0	0	0	0	0
Ba (barium)	0	0	0	0	0	0	0	4	0	0
Ag (silver)	0	0	0	0	0	0	0	3	1	0
<b>Subtotal</b>	<b>12</b>	<b>1</b>	<b>13</b>	<b>4</b>	<b>4</b>	<b>44</b>	<b>15</b>	<b>125</b>	<b>37</b>	<b>68</b>
<b>Parameter Group Share (%)</b>	<b>46.2%</b>	<b>3.8%</b>	<b>50.0%</b>	<b>15.4%</b>	<b>15.4%</b>	<b>23.9%</b>	<b>8.2%</b>	<b>67.9%</b>	<b>20.1%</b>	<b>37.0%</b>
<b>Other Ash Indicators</b>										
Ca (calcium)	2	0	4	0	0	12	0	29	0	0
Mg (magnesium)	1	1	3	0	0	7	0	29	0	0
Na (sodium)	2	1	0	0	0	6	4	13	0	0
Cl (chloride)	2	0	2	1	0	5	0	27	4	0
K (potassium)	1	0	0	0	0	0	1	7	0	0
F (flouride)	0	0	1	0	0	0	0	6	2	0
SO4 (sulfates)	6	2	6	4	4	15	1	37	15	36
TDS (total dissolved solids)	3	1	4	3	2	11	0	27	16	20
S. Cond. (specific conductance)	2	1	0	0	0	4	0	8	1	1
<b>Subtotal</b>	<b>19</b>	<b>6</b>	<b>20</b>	<b>8</b>	<b>6</b>	<b>60</b>	<b>6</b>	<b>183</b>	<b>38</b>	<b>57</b>
<b>Parameter Group Share (%)</b>	<b>42.2%</b>	<b>13.3%</b>	<b>44.4%</b>	<b>17.8%</b>	<b>13.3%</b>	<b>24.1%</b>	<b>2.4%</b>	<b>73.5%</b>	<b>15.3%</b>	<b>22.9%</b>
	<b>Decrease</b>	<b>No Change</b>	<b>Increase</b>	<b>≥ DWS*</b>	<b>≥ 3X DWS</b>	<b>Decrease</b>	<b>No Change</b>	<b>Increase</b>	<b>≥ DWS*</b>	<b>≥ 3X DWS</b>
<b>CHANGED SETS TOTALS</b>	<b>55</b>	<b>15</b>	<b>66</b>	<b>19</b>	<b>42</b>	<b>202</b>	<b>36</b>	<b>452</b>	<b>89</b>	<b>239</b>
<b>COMPOSITE PARAMETER GROUP SHARE (%)</b>	<b>40.4%</b>	<b>11.0%</b>	<b>48.5%</b>	<b>14.0%</b>	<b>30.9%</b>	<b>29.3%</b>	<b>5.2%</b>	<b>65.5%</b>	<b>12.9%</b>	<b>34.6%</b>

\* Note that any measurements depicted as "= DWS" include values equal to or greater than DWS up to immediately under 3X DWS.

There were two methods used for listing increases/decreases in Tables 3 & 4 from the data sets. The first was to discern whether a trend in average concentrations was occurring after ash placement started. Usually a trend line was inserted in graphs for this purpose. This method was used to decide if pH, acidity or alkalinity were increasing, decreasing or staying relatively unchanged subsequent to the commencement of ash placement. The second method which was used for the 26 other parameters in these

Tables 3 & 4 was to determine when the highest concentrations for the parameter occurred. If they occurred during the baseline period, a decrease was listed for the constituent. If they occurred during ash placement, an increase was listed. For data sets in which no baseline data were recorded, averages and trend lines were used to determine if increases, decreases or no changes were occurring in concentrations. In the large majority of cases, there were more than a few concentrations before or during ash placement that would allow for a quick decision on whether the parameter was increasing or not and little question about what trends were occurring in average concentrations. In several instances, the only values for trace elements in data sets would be artifacts of detection limits and not actual concentrations measured. In such cases, the data set was not used.

Most of the sites studied in this report were regulated under Subchapter F permits, which are targeted specifically to abate water pollution from mined sites. At every site studied, ash was being placed in the mine for a “beneficial use”, in other words with the presumption that such placement would help the environment usually by addressing or helping to address acid drainages from past mining practices. Yet the primary parameter that is the focus of this objective, acidity, increased in more of the data sets than it decreased and pH decreased more than it increased. More importantly, notwithstanding this often publicly-stated purpose to abate water pollution with ash, Table 3 shows that the number of data sets showing an increase in the concentrations of pollutants after ash placement (518) is approximately twice the number of data sets showing a decrease (257).<sup>16</sup> Adding to the concern is that in more than one third of the data sets (281 out of 826), the concentration of pollution encountered after ash placement was three or more times higher than relevant federal drinking water standards. The difference in increases versus decreases grows when one examines trace elements and the more soluble ash indicators such as calcium, magnesium, chloride and sulfate. In those groups of parameters, approximately 2.5 times more data sets revealed increases in pollution than decreases.

Rises in certain trace elements adds weight to this concern, particularly when one considers the frequency of monitoring at most ash minefills drops from monthly during the baseline period to annually after ash placement starts, a questionable policy. This should dramatically reduce the likelihood of seeing increased concentrations particularly if trace elements in the water were a result of past mining and acid drainages that the ash placement is supposed to abate. Yet instead of a dramatic reduction, the data reveals significant jumps in the number of increases for nearly all trace elements after ash placement. Those with the most data sets showing increases were lead (26), cadmium (23), nickel (16), zinc (15), selenium (15), arsenic (14), and chromium (8).<sup>17</sup> While lead and cadmium had the highest total number of increases, nickel and zinc rose proportionally in more of the data sets examined. Given the toxicity of lead, the fact that increases for this constituent were to levels 3 or more times higher than the DWS in 21 of

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<sup>16</sup> Granted that the permits were trying to raise pH, but if this parameter is removed from the table, the percentage of data sets with increasing pollution becomes slightly greater.

<sup>17</sup> Table 2 shows that arsenic decreased in more data sets than it increased although Table 3 shows that at downgradient points, arsenic increased in more data sets than it decreased.

39 data sets examined is of concern. Most increases for cadmium, arsenic, and nickel were also to toxic levels, at least three or more times over the DWS. The few data sets found for antimony, molybdenum and boron also revealed increases to toxic levels many times over the DWS or health advisories for these trace elements. Given that trace elements are only sampled for at ash monitoring points, seventeen of which are surface water points, the fact that water quality standards for selenium, cadmium, lead, copper, silver and other trace elements necessary to protect aquatic life are considerably lower than their respective DWS, makes these increases over the DWS that much more of concern. In fact such increases at least several times over the DWS for lead, cadmium and selenium have occurred at ash monitoring points that were springs, seeps and mine discharges to streams at Ernest, McDermott and other sites.

The ten parameters with the largest number of data sets with increased concentrations were manganese (45), sulfates (43), calcium (33), magnesium (32), iron (32), TDS (31), acidity (31), chloride (29), pH (27) and lead (26). Of these, the parameters with the largest number (and proportion) of data sets with decreased values or concentrations were pH (30), acidity (25), and iron (25). The other seven of these parameters all had less than half as many data sets with decreased concentrations as those with increasing concentrations. At downgradient points, the same parameters comprised the ten with the highest number of data sets showing increased concentrations while aluminum, alkalinity and cadmium made this list at upgradient points (see Table 3). Of note also are the fact that there were about as many decreases for pH and acidity (24 and 22 respectively) as there were increases (21 and 24 respectively) at downgradient points. Furthermore cumulatively, alkalinity increased in 23 data sets and decreased in 13. Thus although acidity rose more than it declined and pH declined more than it rose, the alkaline buffering affect often sought by the ash placement was occurring to some extent. However this buffering was not occurring without coinciding increases in other parameters in many instances.

Similar to the cumulative data, when the aggregate upgradient data are analyzed separately from downgradient data in Table 4, the differences between up and downgradient points become more stark if one examines trace elements and other ash indicators rather than AMD/ash parameters. While the increases in mining/ash parameters were between 50-60 percent for both upgradient and downgradient points, the increases in trace metals jumped to more than two thirds of the data sets (67.9% or 125 of 184 data sets) for downgradient points while it remained at half of the data sets for upgradient points (50% or 13 of 26 data sets). The gap between up and downgradient points increased further for other ash parameters (calcium, magnesium, sulfate, etc.). Increases in this group's parameters at downgradient points occurred in nearly three fourths of the data sets (73.5% or 183 of 249 data sets) while increases at upgradient points fell to less than half of the data sets (44.4% or 20 of 45 data sets). The same trace elements experienced increases in the greatest number of data sets at downgradient points, (lead, cadmium, nickel, zinc, selenium, arsenic, and chromium) as occurred in the cumulative data.

Due to the much greater numbers of downgradient than upgradient monitoring points at these sites, Tables 3 and 4 reflect more downgradient data and thus should be biased

toward reflecting ash impacts. It was important to find suitable upgradient and downgradient monitoring points whenever possible to test the veracity of the data. However the authors had great difficulty finding valid upgradient points with adequate data. Only two of 10 ash monitoring points found that were designated as upgradient or upstream were in positions that unquestionably should not have seen influences from ash based on the hydrologic information available in the permit files. The remaining 8 points went dry early in the operation or appeared to be in positions affected by previous ash placement or eventually by ash placement under the permit in operation. This likely resulted in some of the increasing trends seen at “upgradient” points and overstates the aggregate degradation tabulated from upgradient points in Table 4.

There are other limitations to the data in Tables 2 and 3. Clearly not all parameters in monitoring reports were studied equally. The hypothesis being tested was that there is no evidence that ash placement harms water quality in a Pennsylvania coal mine, so the objective was to look for increases in concentrations of trace elements associated with ash and other ash parameters as well as any trends in broad parameters reflective of ash placement. It should not be surprising that this data would be biased toward testing this hypothesis. Some data sets were more complete than others with less gaps and longer monitoring allowing more trends to be discerned. Thus many more data sets for the primary parameters mentioned (iron, manganese, sulfate, arsenic, selenium, lead and cadmium) and well known ash parameters (calcium, magnesium, sodium and chloride) as well as TDS, pH and acidity/alkalinity were studied although the researchers did look for, note and assess noticeable increases in the other parameters in these Tables. The number of parameters and monitoring points examined from the 2005 Draft Report to this Final Report were also substantially increased in response to PADEP criticism that the Draft Report was too narrow in focus. Researchers also discussed and graphed improvements in water quality where they were the predominant pattern found.

While the data tabulated in these Tables do not provide the complete picture of water quality at these sites, in the aggregate they do decisively indicate that the result of these permits was higher levels of water pollution emanating from coal mines after ash was placed in the mines. Data sets showing increased pollution were greater proportionately at downgradient than upgradient monitoring points. The greatest differences between increases in pollution occurred between upgradient and downgradient points from parameters most indicative of ash contamination. In those cases the data sets showing increases at downgradient monitoring points comprised 73.5% of downgradient data sets for those parameters while the data sets showing increases at upgradient monitoring points comprised 44.4% of all upgradient data sets for those parameters. And finally, those monitoring points with the greatest increases in pollution were those specifically established in positions to monitor the effects of ash placement by discussion and analysis in the Module 25s of the permits.

Thus these percentages demonstrate a substantive degradation of water quality at mines where ash placement has occurred that is presumably being caused by the ash if the monitoring systems are functioning as designed. Absent further investigation of the ample and abundant rises in concentrations of ash parameters at ash monitoring points, one cannot state definitively as does the PADEP, that the use of coal ash in Pennsylvania

coal mines is posing no risk to water quality or that there is no evidence that coal ash has degraded water quality in a coal mine.

To the contrary, despite the shortcomings in monitoring systems that PADEP has permitted at these sites, there is voluminous evidence of this harm. Increases in TDS, specific conductance, sulfate, calcium, magnesium, sodium, chloride, fluoride, potassium and trace elements such as arsenic, selenium, lead, cadmium, chromium, zinc, nickel, copper, antimony, boron and molybdenum coupled with increases in alkalinity and decreases in acidity at ash monitoring points strongly suggest that ash is degrading water. Unabated increases in iron, manganese and aluminum could also be coming from ash given the high levels of these parameters in most ashes. Many of these constituents can be expected to leach in greater concentrations from ash over time in acidic environments as the alkaline buffering capacity of the ash is exhausted, dissolution of the ash particles occurs and these constituents become more soluble. This leaching has been documented in much shorter periods by research and occurs routinely in leach tests on coal ashes, particularly Class F ashes (ashes from eastern bituminous coals burned in conventional power plants).<sup>18</sup> What is needed is further investigation and enhanced monitoring to pin point the contributions that mining versus ash are making to the obvious degradation of water quality at these sites as tabulated in Tables 1, 3 and 4. Unfortunately rather than making such effort, at most sites once surface reclamation is completed, monitoring is being stopped in the midst of these increases in pollution. PADEP is sticking its head in the sand in the face of mounting evidence of this “inconvenient truth.”

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<sup>18</sup> Stewart et al. (1997, 2001). See also discussion in Managing Coal Combustion Residues in Mines, NRC, 2006 of research on ash leach tests in Chapter 3, pages 70 & 71, citing Kim, A.G., G.Kazonich, and M. Dahlberg. 2003. “Relative solubility of cations in class F fly ash.” *Environ. Sci. Technol.* 37:4507-4511.